

VIKOR Method for Selecting Universities for Future Development Based on Innovation

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The purpose of this study is selecting type of university that can create its competitive advantages in a changing world. The study analyzes 25 related experiential professors. The VIKOR-based methodology is used to tackle the ranking of four types of universities. The study found that the rank of the university types is: Research-Intensive, Teaching-Intensive, Professional-Intensive, and Communal-Intensive. Discussions of research findings and suggestions for future research are provided.

Keywords: Innovation; University; VIKOR

With the birth rate continuing to drop, Taiwan joining the WTO, and competition from foreign universities, determining how to adjust original directions in traditional universities and to decide the correct type of new universities has become a crucial issue for survival in a changing world since these situations may significantly risk universities in Taiwan facing close down eventually. Some studies have indicated that universities often fail to implement operation (Glower & Hagon, 1998; Cuban, 1999), owing to a lack of participation by teachers and incorrect development directions (McLaughlin, cited in Rudduck, 1991). Researches on teachers are numerous; however, studies on universities still are scarce. In this regard, understanding the type of university that can compete in the future will be beneficial to both new and traditional universities in Taiwan today.

There are numerous definitions of innovation (Wolfe, 1994), as well as innovative indices to measure or upgrade the quality of an organization (Wu, 2006). In addition, a stream of literature has stated that if an organization cannot keep innovating, it would fail (Daft, 2004; Krause, 2004). Thus, utilizing innovation indices will be more reliable in determining if a selected university has future developmental ability.

There normally are two types of university: national university and private university. Nonetheless, experts indicate that universities can be separated into four categories: Research-Intensive, Teaching-Intensive, Communal-Intensive, and Professional-Intensive. Understanding the most competitive one for future development is necessary today in Taiwan. Based on above, the study first summarizes works related to innovation in R&D departments from most of universities as measuring indices, and then categorizes types of universities in Taiwan as measuring projects. By using selecting methodology, VIKOR, the study finally confirms the orders of university type which best to implement innovation and better to develop in the future.

Literature Review

Innovation

Innovation is about identifying and using opportunities to create new products, services, or work practices (Subramaniam & Youndt, 2005). Damanpour (1996) pointed out that innovation involves the adoption of an idea that is new for the organization that adopts it. Moon & Kym (2006) indicated that innovation is something useful to make, market, or change society. Innovation also has been defined as the product, service, or technical process that business units produced (Yen, & Chang, 2005). Robbins & Coulter (2002) defined innovation as the process that adopts new ideas and translates them into useful products or new processes. A body of literature has found that innovation is a key factor to the success of an organization (Farina & Kelly, 1983; Daft, 2004; Krause, 2004).

Based on studies, the ways to measure or upgrade quality are numerous, especially in technological organizations, as Table 1 (Chen & Chen, 2007); however, there is a lack of studies on universities. In this regard, the study built up a hierarchical evaluation structure and extracted 17 indices by summarizing the latest affairs in R&D department from universities, as well as interviewing relatively senior experts. In assessing indices' weights, the relevant experts participating were from academic institutions and industry. The average values of weights are presented in Table 2.

University Types in Taiwan

Based on formal classification, there are two types of universities in Taiwan: national university and private university. However, educational experts' indicate that, universities can be separated more precisely (Li, 2007). Thus, the study summarized four main types of universities: Research-Intensive (RU), Teaching-Intensive (TU), Communal-Intensive (CU), and Professional-Intensive (PU).

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Table 1 *Innovative Measuring Index on Technological Organization*

Innovative Indicators	Reference
Patent	Griliches (1990); Hall et al. (2000); Toivanen et al. (2002)
R&D Expense	Bosworth & Rogers (2001); Griliches (1990); Hall (1999)
Number of New Ideas	Van Buren (2000)
Number of New Products	Toivanen et al. (2002); Schoenecker & Swanson (2002)
Number of New Designs	Hall & Bagchi-Sen (2002); Van Buren (2000)
New Market and Customers' Development	Dzinkowski (2000)
Innovative Culture	Dzinkowski (2000); Van Buren (2000)
Number of R&D Workers	Guthrie & Petty (2000)
Innovative Reference Product	AcS et al. (2001)
Copyright and Brand	Bosworth & Rogers (2001)
Royalties Income	Guthrie & Petty (2000); Van Buren (2000)
Outer Tech Connection	Gambardella & Torriss (2000)

Table 2 *Indices Ranking by FAHP on Taiwanese Universities*

Indices	Research Patents	International Academic Communication	Number of R&D Members	NSC* ¹ Support	Journals Published	Government Tender Planning	Operation Electrification	Outsourcing	Affair Rotation
Weight	0.139	0.208	0.164	0.0459	0.224	0.012	0.0190	0.0045	0.0050
Indices	Information Study Camp	Refresher Classes	Number of Conferences	Number of International Students in School	Number of Chair Professors	Learning Organization	Specialization Organization	Totalitarian Organization	
Weight	0.03	0.0460	0.020	0.0191	0.0024	0.013	0.009	0.002	

1. *Research-intensive university (RU)*. A Research-Intensive University emphasizes the development of graduate schools and focuses on educational research. Today, based on the Board of Education's statistical information in Taiwan, there are seven such universities. In general, the scope of a Research-Intensive University always is expansive. Also, their budgets are greater than other types of university. In addition, Research-Intensive Universities' advantages include nearly fully-staffed ranks of professors and teachers, as well as extensive library resources.

2. *Teaching-intensive university (TU)*: A Teaching-Intensive University focuses on teaching students to achieve success at the bachelor level. However, such universities also emphasize four functions: education, promotion, service, and fostering full fields of talent. Teaching-Intensive Universities mainly include two types: normal schools and other universities that do not fit into the categories of the other three types of universities. A Teaching-Intensive University has some advantages: first, students can become pre-teacher in junior or elementary schools by take some critical educational subjects; second, some of such universities can have opportunities to interact with enterprises; and last, some of them may develop special characteristics based on their location.

3. *Communal-intensive university (CU)*: A Communal-Intensive University mainly offers practical skill classes or credits. Except for the function of connecting with universities, it has the advantages of increasing overall civic quality. A Communal-Intensive University's main characteristic is promoting education in the community. Mainly, the advantages are: first, offering practical skill classes or credits that suit the need of community democracy; and second, assisting community democracy through such services as a reading and lending library.

4. *Professional-intensive university (PU)*: A Professional-Intensive University is largely a technological institute. Based on its higher education macroscopic commitment, the highest level of the executive branch in Taiwan suggests that this type of universities ought to be separate from normal universities. What's more, such universities should focus on developing applied technology, combining with industries, and fostering technical

1. NSC: National Science Council, an institution which support educational research and tech development by giving appropriate finance.

talent to become unique professional universities. The most crucial advantage is that it has an almost complete educational resource to foster professional talent.

Based on the above analysis, we can summarize that each type of university has its own unique competitive advantages. However, with the birth rate still dropping, and competition from foreign universities, many universities in Taiwan face a crisis of their very existence. Therefore, developing the correct type of new university, and deciding how to change the focus of existing universities have become crucial issues. Nevertheless, related researches and literature on Taiwanese universities are rare; therefore, we believe that this research will be beneficial to the development of higher educational institutions.

VIKOR

The VIKOR method, developed by Opricovic & Tzeng (2002), is based on the compromise programming of multi-criteria decision making (MCDM). We assume that each alternative is evaluated according to a separate criterion function; the compromise ranking could be utilized by comparing the measure of closeness to the ideal alternative. The multicriteria measure for compromise ranking is developed from the L_p -metric, used as an aggregating function in a compromise programming method (Opricovic & Tzeng, 2002). The various J alternatives are represented as a_1, a_2, \dots, a_J . For alternative a_j , the rating of the i th aspect is denoted by f_{ij} ; i.e., f_{ij} is the value of i th criterion function for the alternative a_j ; n is the number of criteria. The VIKOR method development started with the form of L_p -metric shown as followed:

$$L_{p,j} = \left\{ \sum_{i=1}^n [w_i(f_i^* - f_{ij}) / (f_i^* - f_i^-)]^p \right\}^{1/p}$$

$$1 \leq p \leq \infty; j = 1, 2, \dots, J.$$

In the VIKOR method $L_{1,j}$ (represent S_j as follows) and $L_{\infty,j}$ (represent R_j as follows) are used to formulate ranking measure. The solution gained by $\min_j S_j$ is with a max group utility, and the solution gained by $\min_j R_j$ is with a mix individual regret of the ‘‘opponent.’’. The compromise solution F^c is a solution that is the closest to the ideal F^* , and compromise means an agreement established by mutual concessions, which shown as Fig. 1 by $\Delta f_1 = f_1^* - f_1^c$ and $\Delta f_2 = f_2^* - f_2^c$.

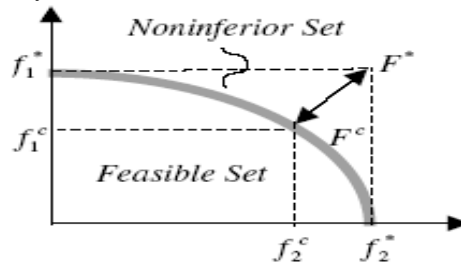


Figure1. VIKOR solutions.

There are five VIKOR calculation steps:

Step1. Decide the best f_i^* and the worst f_i^- values of all criterion functions $i = 1, 2, \dots, n$. If the i th function represents a benefit then:

$$f_i^* = \max_j f_{ij}, \quad f_i^- = \min_j f_{ij}.$$

Step2. Calculate the values S_j and $R_j; j = 1, 2, \dots, J$, by the equations

$$S_j = \sum_{i=1}^n w_i(f_i^* - f_{ij}) / (f_i^* - f_i^-), \quad \text{and} \quad R_j = \max_i [w_i(f_i^* - f_{ij}) / (f_i^* - f_i^-)],$$

where w_i are the weights of criteria, expressing their relative importance.

Step3. Calculate the values $Q_j; j = 1, 2, \dots, J$, by the relation

$$Q_j = v(S_j - S^*) / (S^- - S^*) + (1 - v)(R_j - R^*) / (R^- - R^*),$$

$$S^* = \min_j S_j, \quad S^- = \max_j S_j$$

$$R^* = \min_j R_j, \quad R^- = \max_j R_j$$

and v is introduced as weight of the strategy of the maximum group utility, here $v = 0.5$.

Step4. Alternatives ranking, sorted by the values S , R and Q , in decreasing order. The results are three ranking lists.

Step5. We propose as a compromise solution the alternative (d) which is ranked the best by the measure Q (min) if it satisfied the following two conditions:

1. $Q(a'') - Q(a') \geq DQ$ called acceptable advantage:

Where a'' is the alternative with second position in the ranking list by $DQ = 1/(J - 1)$; J is the number of alternatives.

2. Acceptable stability in decision making:

Alternative d has to be the best ranked by S or/and R . This solution is stable in a decision making process, which could be: when $v > 0.5$, $v \approx 0.5$, or $v < 0.5$. In this study, $v > 0.5$ is utilized.

If conditions could not satisfy fully, then a set of compromise solutions can be proposed:

1. Alternatives a' and a'' if only condition 2 is not satisfied, or

2. Alternatives a' ; $a'', \dots, a^{(M)}$ if condition 1 is not satisfied; and $a^{(M)}$ is determined by the relation $Q(a^{(M)}) - Q(a') < DQ$ for $\text{Max}M$.

The best alternative ranked by Q is the one with the minimum value of Q . The main ranking result is the compromise ranking list of alternatives, and the compromise solution with the advantage rate.

Ranking by VIKOR needs to be performed with different values of criteria weights, and analysis of the impact of criteria weights on proposed compromise solution. This determines the weight stability intervals by using the methodology cited in Opricovic (1998). The compromise solution gained with initial weights ($w_i, i = 1, \dots, n$) will be replaced if the value of a weight is not in the stability interval. The analysis of weight stability intervals for a single criterion is utilized for all criterion functions, with the given initial values of weights. By doing so, the preferred stability of a gained compromise solution may be analyzed using the VIKOR program.

VIKOR is a tool that benefits multicriteria decision making, in situations where the decision maker is unstable, or where there is no idea how to express one's preference, especially at the beginning of system design. Decision makers accept the obtained compromise solution because it provides a maximum "group utility," which is represented by $\text{Min} Q$ and a minimum of the individual regret represented by $\text{Min} R$.

Methodology

The study utilized evaluating weighted indices provided as Table 2, and built up the study framework as provided in Table 3. Then we contacted a sample of universities, with a total of 30 questionnaires sent to the related experiential professors by personal mail. Twenty-six were returned. After one questionnaire was discarded for statistical reasons, the overall response rate was 83 percent, or 25 questionnaires for analysis. Demographic Information is provided in Table 4.

Sixty-four percent of the respondents were male and 36 percent were female; nearly half (40 percent) of the respondents were above age 50, and 32 percent were 40–50 years old; 40 percent of the respondents had served for 20 years or more, and about 36 percent had served between 10 and 20 years. All (100 percent) respondents had reached the doctorate level, and about 96 percent of them were in academia.

After expert analysis of the questionnaires, the study summarized all the values and evaluated them using VIKOR. The findings are presented in Table 5. The VIKOR result stated that types of universities for future development are ranked as followed: Research-Intensive University (RU), Teaching-Intensive University (TU), Professional-Intensive University (PU), and Communal-Intensive University (CU).

Discussion

Different types of universities in Taiwan are intended mainly to give professional knowledge to students who have different interests. There rarely were such types of universities in the past; thus, both competition and changes have occurred. However, due to the continuing birth rate drop, Taiwan joining the WTO, and foreign universities' competition, universities in Taiwan faces speedy loss of their competitive advantage. As a result, universities in Taiwan today are searching for ways to keep or upgrade their competitive advantages. In accordance with above, the study utilizes VIKOR, a tool that benefits multicriteria decision making, and emphasizes on works related with innovation to find the prior of university type in Taiwan nowadays.

Table 3 Hierarchical Evaluation Structure

Goal	Evaluating Dimension	Evaluating Criteria	Evaluating Index	University Type	
Selecting University for Future Development	Technical Innovation	Academic Innovation	Research Patents	Academic	1 Research- Intensive University (RU)
			International Communication		
			Number of R&D Members		
		NSC Support	2 Teaching-Intensive University (TU)		
		Journals Published			
		Government Tender Planning			
	Managerial Innovation	Administrative Innovation	Operation Electrification	Academic	3 Communal-Intensive University (CU)
			Outsourcing		
			Affair Rotation		
		Member Innovation	Information Study Camp		4 Professional-Intensive University (PU)
			Refresher Classes		
			Marketing Innovation		
Marketing Innovation	Number of Conferences	Academic	4 Professional-Intensive University (PU)		
	Number of International Students in School				
	Number of Chair Professors				
Organizational Structure Innovation	Learning Organization		Academic	4 Professional-Intensive University (PU)	
	Specialization Organization				
	Totalitarian Organization				

Table 4. Demographic Information

Variable	Item	Distribution	Percentage	Variable	Item	Distribution	Percentage
1. Sexual	(1) Male	16	64	4. Educational Degree	(1) Bachelor	0	0
	(2) Female	9	36		(2) Master	0	0
2. Age	(1) Under 30	1	4		(3) Doctor	25	100
	(2) 30 ~40	6	24	5. Background	(1) Academia	24	96
	(3) 40 ~50	8	32		(2) Industrial	1	4
	(4) Above 50	10	40		(3) Gov Unit	0	0
3. Service Year	(1) Under 5	2	8				
	(2) 5-10	4	16				
	(3) 10-20	9	36				
	(4) Above 20	10	40				

Table 5. Ranking for Types of Universities

	(RU)	(TU)	(CU)	(PU)
S	0.027	0.373	1.050	0.707
R	0.005	0.070	0.280	0.209
Q	0.000	0.345	1.200	0.844
Rank	1	2	4	3

This study concludes that the professors in the sample believe that a Research-Intensive University is the most innovative type for future development, rather than the other three types of universities. Therefore, the study suggests that any newly built university should move toward the Research-Intensive University type by expanding to more departments and hiring more R&D members. Traditional universities trying to make more international academic interactions and applying NSC support to new researches will help them catch up to the advantages of the Research-Intensive University. The study argues that the Teaching-Intensive University ought to invite more international students or hire chair professors to diversify its knowledge, since its characteristic is “dig deeper but not wider.” The study asserts that this type of university could be more competitive if it brings these two indices into future developmental issues. The Professional-Intensive University type has more opportunities to connect with business; however, it ranked third. Thus, the study stated that this type of university can make more invisible innovations, such as new thought to accompany visible innovations, or applying more government tender planning to help upgrade its ranking. We cannot deny that the Communal-Intensive University has made contributions toward Taiwan. Nevertheless, to survive in this competitive world, that type of university must change its innate character due to they are focus on domestic development. The study argues that the Communal-Intensive University ought to adjust organizational structure by holding information study camps in the beginning, since this method is less difficult but often helpful.

To sum up, the value of the study for traditional universities is that knowing the ranking of its competitive ability (future development) lets it understand the actions needed for future development. Also, the study gives precise suggestions through innovative indices for developing or changing directions. The values for proposed

new universities are that, first, they are more aware of the most competitive types of universities to develop; and, second, they have gotten more ideas to help them become more competitive for future development.

The study deals mainly with universities in Taiwan; thus, it does not represent the overall scope of universities around the world. Therefore, future research could be conducted with a wide range. Besides, members' participation plays a critical role in implement any innovative change; therefore, future research could focus on members and try to find ways to motivate them in such university change, new and traditional one alike.

The four types of universities analyzed in this study are mainly in Taiwan today; however, educational experts in Taiwan are trying to develop a new type of university—an International-Intensive University—but it's not ready to be implemented yet. In this regard, future studies could add such new type of university to measure. As soon as it becomes available, there may be different and helpful findings for the Taiwanese higher educational field.

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