Enterprise partner selection for vocational education: analytical network process approach

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Abstract *One of the major purposes of implementing vocational education is to offer trained manpower to enterprises that meet the immense challenges of the global economic competition and unprecedented technological changes. Selecting an adequate enterprise, from the school's viewpoint, is a critical factor for implementing the vocational education system. This paper suggests applying the ANP approach in order to deal with the interdependence among criteria of different layers of the analysis process to select the suitable partner enterprise where students can gain experience. The paper describes the cooperation patterns between schools and enterprises as well as the criteria which should be considered and the corresponding attributes used to evaluate the potential enterprises.*

1. Introduction

In an era of information explosion, the success of education and development of the economy are two sides of the same coin. The vocational and university streams are usually considered as two types of high-level education systems. While university education is not geared to any specific occupation, but rather concentrates on an academic discipline, vocational education usually focuses on occupational training. Heijke and Koeslag (1999) compare the position of graduates from these two types of higher education systems in the labor market based on three theories: the human-capital theory (Schultz, 1961; Becker, 1962), the job-competition model (Thurow, 1975, 1979), and the job-matching theory (Hartog, 1992; Sattinger, 1993), in the Netherlands. Their empirical study indicates that it is important to establish a separate occupational domain for these two types of education, each of which has comparative advantages. Despite the fact that qualifications acquired in university education are transferable to a broad range of occupations, vocational education mainly targets the small- and medium-sized enterprise sector, which traditionally has a poor record of investment in education and training (Matlay and Hyland, 1999).

The success of the vocational education system depends on the partners addressing the three key components (Harmon, 2000): school-based learning, which focuses on career exploration and counseling student major career selection, and curricula integrating academic and vocational learning; work-based learning which includes job

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training, paid work experience, work place mentoring, and instruction in general workplace competencies; and connecting activities creating a bridge between students at school and the workplace. Based on the understanding of this requirement, it is impracticable to change the partner enterprises frequently if both sides of this cooperation run into problems. The alignment of schools and enterprises is supposed to be at the level of strategic thinking, and requires sufficient understanding and support from both sides. The contract or agreement has to be signed by both sides, indicating that they really want to be partners.

In Taiwan, Republic of China, the flourishing economy is mostly based on the contributions of middle and small enterprises. In all, 98 percent of the enterprises in Taiwan come under this category. Even though they comprise the major economic activity of Taiwan, they do not attract the attention of academia. Most of the research studies are concentrated on the larger companies. For example, Kao and Lee (1996, 1998) and Kao *et al.*, 1997 have proposed an integration model for manpower forecasting as well as analyzing the demand for industrial management manpower from the viewpoints of quantity and skill. Their research studies are all based on the top 100 companies in the manufacturing sector. Owing to financial difficulties, the middle- and small-scale enterprises do not have the capability to train their employees. Moreover, students just out of school do not have the training to handle high-skill jobs, and so the employers are finding it increasingly difficult to get trained workers, especially at entry-level positions (Harmon, 2000). To provide help for these enterprises and students, the government in Taiwan has proposed some solutions. Establishment and development of vocational education systems offering well-trained human resources to these enterprises is among them.

The Ministry of Education (MOE) in Taiwan is responsible for organizing the vocational education system and certifies the setup of departments as well as the enrollment of students in each department. In general, complete studying phases consist of three levels of schools, i.e. senior high schools (three years), junior colleges (two years), and senior colleges (another two years). In each phase, students receive different, but planned training; they might end the studying to work or pursue the higher levels of education. The MOE evaluates the associated schools of each level every three years and uses the evaluation result as the basis of allocating the funds and grants. Employment of students as well as the grants obtained from public and/or private sectors plays the major role in evaluation process. Schools evaluated are required to develop collaboration with enterprises that provide practical training for students and offer real-life cases for the classes. In addition, the enterprises help teaching, offer projects and grants for research in schools. The results of those projects are then a feedback to enterprises for application. The trained students are sources of human resources for the partner enterprises and demonstrate that the "win-win" collaboration must be setup at the long term between schools and partner enterprises. Therefore, selecting adequate enterprises to guarantee cooperation is a critical factor in implementing the vocational education system. In this paper, we applied the analytical network process (ANP) approach to select the partner enterprise. This approach has been applied to many similar problems. Sarkis and Sundarraj (2002) showed how the ANP model combined with another optimization model could be used to conduct a comprehensive evaluation of the factors affecting the job location at a digital equipment corporation. Another application can be found in the paper by Sarkis (1998)

in which he used the ANP technique to integrate the elements and attributes of corporate environmental management into a strategic assessment system. To select an adequate enterprise, the cooperation patterns, criteria and attributes for evaluating the potential enterprises have to be identified before the ANP approach is implemented. In Section 2, the cooperation patterns between schools and enterprises are examined. In Section 3, the criteria and corresponding attributes are presented and used to evaluate the performance of each of the potential enterprises. In Section 4, the ANP approach is developed and verified by a numerical example and Section 5 comprises a final conclusion to this study.

2. Cooperation patterns

There are three phases in the vocational education system in Taiwan: basic professional skills training in senior high schools, specialized professional skills training in junior colleges, and advanced discipline education in senior colleges. Some basic research orientation courses are offered in the last phase for interested students who wish to pursue higher degrees at graduate schools or find jobs in research institutes. There are also three cooperation patterns between schools and enterprises, each emphasizing a different aim. We refer to the first pattern of cooperation as practical training and skill certification. In this pattern of cooperation, the enterprises provide the opportunity of practical training for students; however, the schools help the employees to obtain basic professional skill certification. Another pattern of cooperation is that enterprises provide opportunities for teachers to participate in operating enterprises to improve their practical skills. At the same time, the schools would provide some special (possibly short-term) advanced professional courses that can be considered as "on-the-job training" for employees to improve their skill level. Top managers from the partner enterprises are invited to design and teach the curriculum in order to satisfy special company requirements. This pattern of cooperation is referred to as participating and skills improvement. In the final pattern of cooperation, enterprises leave developing techniques and operating management to the schools. In the meantime, the school constructs an "incubator centre" which includes various professional departments that can provide the necessary professional services for these cooperating enterprises. We refer to this as research and technique development pattern of cooperation. Regardless of which phase exists in the vocational school, they all have to select the enterprises that can give the appropriate practical knowledge. This purpose can be achieved only if proper coordination between the school and the partner enterprise exists. The school needs to determine which enterprise would help it achieve its objective.

3. Criteria and their attributes for partner selection

Selecting proper enterprises is very important for the vocational education system. We consider the following five criteria and their corresponding attributes to evaluate the suitability of candidate enterprises.

(1) *The future prospects of the enterprise.* This criterion considers the overall prospects of the industry (OPI) to which the enterprise belongs, the reinvestment proportion of the profit (RPP) that the enterprise earned in the last year, and the level of capacity utilization (LCU).

(2) *The core technique of the enterprise.* In this criterion, we consider the speed of the technical creation (STC) in the last five years of the enterprise, the capital investment in R&D (CRD), and the present technical level (PTL) of the enterprise.

(3) *The business scale of the enterprise.* This criterion is related to the average annual revenue (AAR) in the last five years of the enterprise, the rank of the enterprise (ROE) in relation to the last annual revenue, and the number of employees (NOE) the enterprise had hired.

(4) *The goodwill of the enterprise.* In this criterion, the reputation of the trademark (RTM) of the enterprise, the quality of the product (QOP), and the customer service that the enterprise provides (CSP) are considered.

(5) *The understanding of vocational education and attitude of the top managers of the enterprise.* In the latter criterion, we have to think about the human resource development (HRD) policy of the enterprise, the level of education (LOE) for the overall employee in the enterprise, and the support from the top manager (STM).

We have now explored the different patterns of cooperation and criteria and the correspondent attributes for evaluating the potential enterprises. The relative weight for each of these criteria must be identified before it can be applied to the evaluation. Since the weighting process is influenced by the cooperation patterns, the traditional analytical hierarchical process that neglects mutual effects of different layers of the decision model is not adequate. For example, in the pattern of practical training and skills certification, the prospects of the enterprises may play a larger role than in the pattern of research and technical development because the enterprise with flourishing economic prospects creates other capacity requirements, which, in turn, offer students the opportunities to gain experience. In addition, focusing on certain criteria would affect the development of a cooperative relationship. If a higher priority is set on the major competency in technique, the cooperative relationship may be forced into the pattern of research and technique development because the school can provide incubator environment for developing the core technique for the enterprises. Thus, it can be seen that the intention to select cooperation patterns determines the role of criteria and the attitude for evaluating the criteria affecting their selection. Hence, the cooperative relationship and the evaluation criteria interact with each other simultaneously. The situations of these three patterns and five criteria impact the overall goal of vocational education system as shown in Figure 1.

4. The ANP approach for enterprise selection

For the purpose of dealing with this dynamic environment, the ANP approach is applied: it is capable of handling interdependence among different layers of criteria by obtaining the composite weights to develop a "supermatrix". A major difference between the analytical hierarchy process (AHP) and the ANP approaches is that the AHP assumes that the system's elements are not correlated and are unidirectionally influenced by a hierarchical relation. However, the ANP approach eliminates these limitations and allows a feedback relationship among the criteria at different levels and interdependence between the criteria at the same level through the development of a "supermatrix" (Saaty, 1996). To elicit preferences of various components and attributes, the decision-maker compares two components at a time with respect to a "control "criterion.

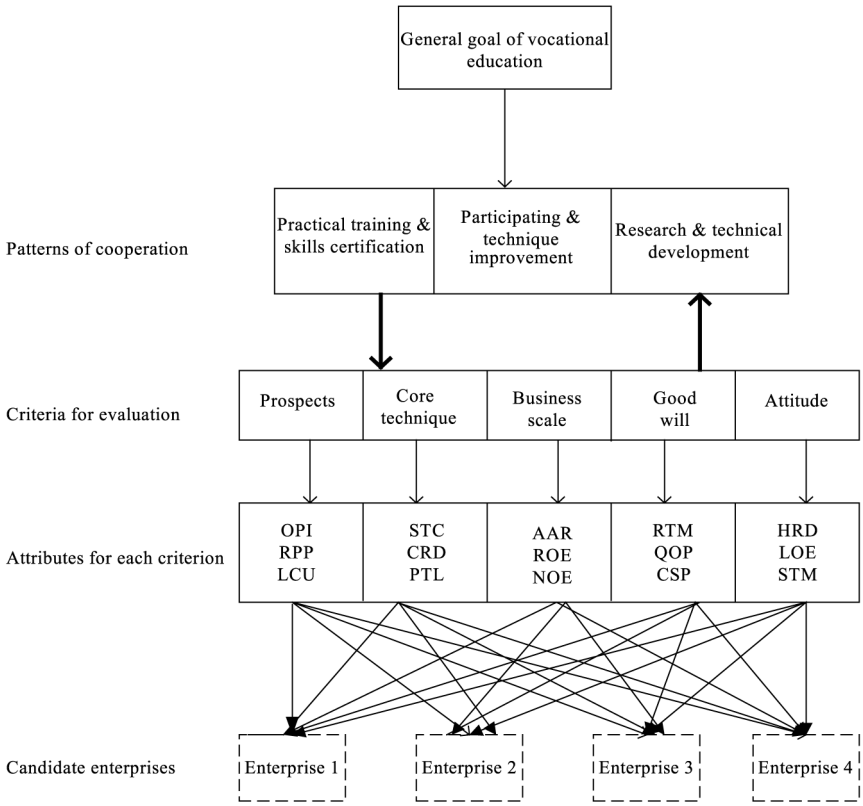

Figure 1.
The relationship for cooperation patterns, criteria, and attributes

In ANP, like AHP, pairwise comparisons of the elements at each level are conducted with respect to their relative importance toward their control criterion. The control criterion for these pairwise comparisons can be the criteria at the upper or lower levels. This is the fundamental requirement for developing the supermatrix in the ANP. The pairwise comparison for the component at one level with respect to the control criterion is expressed in the matrix form of Table I (to which the numbers were transferred by linguistic means). Once the pairwise comparisons are completed, the local priority vector w is computed as the unique solution to:

$$Rw = \lambda_{\max} w$$

Control criterion	Criterion 1	Criterion 2	...	Criterion m	Relative weights w
Criterion 1	Indifferent	Very unimportant	...	Unimportant	w_1
Criterion 2	Very important	Indifferent		Very important	w_2
⋮	⋮	⋮	⋮	⋮	⋮
Criterion m	Important	Very unimportant	...	Indifferent	w_m

Table I.
Pairwise comparison matrix of the components at a level for a specific control criterion

where λ_{max} is the largest eigenvalue of R. Saaty and Takizawz (1986) provided several algorithms for approximating the vector w. In this paper, a two-stage algorithm proposed by Meade and Sarkis (1998) is used as the process for averaging over normalized columns and is applied to approximate the vector w. This is represented as:

$$w_i = \frac{\sum_{j=1}^{m} \left(\frac{R_{i,j}}{\sum_{i=1}^{m} R_{i,j}} \right)}{m} \quad (1)$$

In the assessment process, the problem of transitivity or consistency of the pairwise comparisons must be considered. Saaty (1988) has provided an explanation on inconsistencies in the relationships and their calculations. In our example, it is assumed that the pairwise comparisons are consistent.

We now apply the ANP framework to a problem of enterprise selection for a vocational education system. The scores 1, 2, 3, 4, 5, 6, 7 mean absolutely unimportant, very unimportant, unimportant, indifferent, important, very important, and absolutely important, respectively. A pairwise comparison matrix of the criteria for practical training and skill certification cooperation pattern is presented in Table II. In this relationship, from the school's point of view, the high-ranking manager's attitude is considered as more important than the prospects of the enterprise. This is partially due to the major subjects in this cooperation pattern which consider the enterprise's intention to providing students with the opportunity of practical training; however, the schools help the employees of enterprises to obtain the basic professional certification. The attitude of the higher or top manager plays a critical role at this stage. The priority vector is obtained by using the equation (1) with the data in Table II. The relative weight vector for each pattern is normalized and the results are shown in Table III. This table shows the relative impact on the different patterns of cooperation.

Table II.
Criteria pairwise comparison matrix for the practical training and skill certification cooperation pattern

Practical training and skill certification	Prospects	Core technique	Business scale	Good will	Attitude	Relative weights w
Prospects	4	6	5	3	2	0.198
Core technique	2	4	3	1	1	0.106
Scale	3	5	4	2	1	0.140
Good will	5	7	6	4	3	0.254
Attitude	6	7	7	5	4	0.302

Table III.
The A matrix formed by the relative weights of the five criteria for the three cooperation patterns

A matrix	Practical training and skill certification	Participating and technical improvement	Research and technical development
Prospects	0.198	0.261	0.264
Core technique	0.106	0.183	0.211
Business scale	0.140	0.142	0.112
Good will	0.254	0.171	0.141
Attitude	0.302	0.243	0.272

The impact of various patterns of cooperation on the prospects of enterprises is shown in Table IV. Note that the cooperation pattern of research and technical development influences the prospects of enterprises more than the other two patterns. Each of the three patterns has the analogous result of relative weights vector, as shown in Table IV. Altogether these vectors form matrix B, which is shown in Table V. The next step is to form the "supermatrix" which allows a solution for the effects of interdependence between the criteria at different levels of the system. We assume, in this example, that the impacts of criteria in the same cluster are not significant. The corresponding area in the "supermatrix" is assigned a value of zero. Hence, the two compiled matrices A and B are now combined to form the "supermatrix" M as shown in Table VI. In the long term, the "supermatrix" converges to the stable values given in Table VII, which will be used for further analysis. Let us glance at the data in Table VII. With any of the three cooperation patterns, the attitude of the higher managers of enterprises and the prospects of enterprises have relatively heavier weights for the decision-maker. In the meantime, the decision-maker emphasizes the cooperation phase of practical training of students and skill certification for employees based on the evaluation of the relative importance of the three patterns of cooperation with respect to the five criteria.

The next step is to analyze the relative importance of weights for the attributes of each criterion. In our example, we assume that the criteria and the attribute levels are not interdependent. A similar pairwise comparison is made in the previous paragraph to obtain the relative weights of the five criteria under a specific control cooperation pattern. Another five comparison matrices have to be developed for this analysis. Table VIII shows the attribute's pairwise comparison matrix with respect to the first criterion of the future prospects of the enterprise. This table shows that the overall prospects of the industry is the most important when considering the future of the enterprises. This is because the global environment of economy affects the long-term

Table IV.
The cooperated relationships pairwise comparison matrix for the criterion of prospects of enterprises

Prospects	Practicaltraining and skill certification	Participating and technique improvement	Research and technical development	Relative weights
Practical training and skill certification	4	3	1	0.208
Participating and technique improvement	5	4	3	0.342
Research and technical development	7	5	4	0.450

Table V.
The B matrix formed by the relative weights of the three cooperation patterns for the five criteria

B matrix	Prospects	Core technique	Business scale	Good will	Attitude
Practical training and skill certification	0.208	0.291	0.467	0.238	0.393
Participating and technique improvement	0.342	0.303	0.323	0.290	0.256
Research and technical development	0.450	0.406	0.210	0.472	0.351

Super matrix M	Practical training and skill certification	Participating and technique improvement	Research and technical development	Prospects	Core technique	Business scale	Good will	Attitude
Practical training and skill certification	0	0	0	0.208	0.291	0.467	0.238	0.393
Participating and technique improvement	0	0	0	0.342	0.303	0.323	0.290	0.256
Research and technical development	0	0	0	0.450	0.406	0.210	0.472	0.351
Prospects	0.198	0.261	0.264	0	0	0	0	0
Core technique	0.106	0.183	0.211	0	0	0	0	0
Business scale	0.140	0.142	0.112	0	0	0	0	0
Good will	0.254	0.171	0.141	0	0	0	0	0
Attitude	0.302	0.243	0.272	0	0	0	0	0

Table VI.
The initial "supermatrix" formed by matrices A and B

Super matrix M	Practical training and skill certification	Participating and technique improvement	Researching and technical development	Prospects	Core technique	Business scale	Good will	Attitude
Practical training and skill certification	0	0	0	0.312	0.312	0.312	0.312	0.312
Participating and technique improvement	0	0	0	0.300	0.300	0.300	0.300	0.300
Researching and technical development	0	0	0	0.388	0.388	0.388	0.388	0.388
Prospects	0.243	0.243	0.243	0	0	0	0	0
Core technique	0.170	0.170	0.170	0	0	0	0	0
Business scale	0.130	0.130	0.130	0	0	0	0	0
Good will	0.185	0.185	0.185	0	0	0	0	0
Attitude	0.273	0.273	0.273	0	0	0	0	0

Table VII.
The long term converged "supermatrix" at M^{21}

profitability of each individual company. The status of the order reception may just reflect a short-term market situation. It can be overcome by some adequate manipulation.

The final step of the analysis is the alternative evaluation. Each potential enterprise needs to be evaluated based on each attribute considered with respect to each criterion.

This is completed by making a pairwise comparison of the performance of each potential enterprise with respect to each attribute. The scores 1, 2, 3, 4, 5, 6, 7 mean bad, very poor, poor, indifferent, good, very good, and excellent, respectively. Since there are 15 attributes in this illustrative example, an additional 15 4×4 pairwise comparison matrices are required for evaluation. In Table IX, the first attribute of the overall prospects of the industry to which the enterprise belongs is compared to four potential enterprises. Enterprise 1 is assumed to perform better with respect to the attribute of the overall prospects of the industry to which it belongs than the other potential enterprises. Equation (1) is applied again to calculate the priority vector in the matrix. Consequently, the adequate enterprise is selected by calculating the "desirability index" D_i which is defined by:

$$D_i = \sum_{j=1}^{s} \sum_{k=1}^{k_j} p_j q_{kj} r_{ikj}, \tag{2}$$

where p_j is the relative important weight for criterion j; q_{kj} is the relative important weight for attribute k of criterion j; and r_{ikj} is the relative impact of potential enterprise i on attribute k of criterion j.

The potential enterprise with the largest desirability index should be selected for the vocational education system. In the example, the results of the enterprise selection analysis are shown in Table X. Let us consider the information given in Table X. Enterprise 1 obtains better scores on core techniques and attitude of its higher managers as evaluated by the decision-maker. This outcome is different from that of the other three enterprises. For example, enterprise 2 is stronger at business scale, future prospect and core technique, and so on. To combine the other information from decision-makers, which is shown in Table X, we find that, for the time being, the decision-maker emphasizes the cooperation pattern of research and technical

Prospects	Overall prospects of the industry (OPI)	Reinvestment proportion of profit (RPP)	Level of capacity utilization (LCU)	Relative weights
Overall prospects of the industry (OPI)	4	3	7	0.383
Reinvestment proportion of profit (RPP)	5	4	3	0.349
Level of capacity utilization (LCU)	1	5	4	0.268

Table VIII. The attributes pairwise comparison matrix for the criterion of the future prospects of the enterprise

OPI	Enterprise 1	Enterprise 2	Enterprise 3	Enterprise 4	Relative weights
Enterprise 1	4	6	7	5	0.352
Enterprise 2	2	4	5	3	0.216
Enterprise 3	1	3	4	2	0.148
Enterprise 4	3	5	6	4	0.284

Table IX. Pairwise evaluation matrix of candidate enterprises for each of the attributes

Table X.
Desirability index calculation for candidate enterprises

Criteria	Weight	Attributes	Weight	Enterprise 1		Enterprise 2		Enterprise 3		Enterprise 4	
				Weight	Score	Weight	Score	Weight	Score	Weight	Score
Prospects	0.243	OPI	0.383	0.352	0.0315	0.216	0.0194	0.148	0.0133	0.284	0.0255
		RPP	0.349	0.304	0.0248	0.278	0.0227	0.196	0.0160	0.221	0.0180
		DCU	0.268	0.128	0.0080	0.358	0.0225	0.297	0.0186	0.219	0.0137
Core technique	0.170	STC	0.412	0.364	0.0255	0.252	0.0177	0.186	0.0130	0.198	0.0139
		CRD	0.198	0.237	0.0080	0.359	0.0121	0.166	0.0056	0.238	0.0080
		PTS	0.390	0.201	0.0133	0.331	0.0219	0.289	0.0192	0.179	0.0119
Business scale	0.130	AAR	0.318	0.351	0.0145	0.247	0.0102	0.176	0.0073	0.226	0.0093
		ROE	0.295	0.315	0.0121	0.219	0.0084	0.186	0.0071	0.280	0.0107
		NOE	0.387	0.153	0.0077	0.369	0.0186	0.282	0.0142	0.196	0.0099
Good will	0.185	RTM	0.408	0.235	0.0177	0.286	0.0216	0.203	0.0153	0.276	0.0208
		QOP	0.304	0.288	0.0162	0.193	0.0109	0.241	0.0136	0.278	0.0156
		CSP	0.288	0.366	0.0195	0.285	0.0152	0.201	0.0107	0.148	0.0079
Attitude	0.273	HRD	0.351	0.377	0.0361	0.124	0.0119	0.187	0.0179	0.312	0.0299
		LOE	0.187	0.236	0.0120	0.195	0.0100	0.312	0.0159	0.257	0.0131
		STM	0.462	0.364	0.0459	0.195	0.0246	0.175	0.0221	0.266	0.0335
Desirability index					0.2930		0.2474		0.2098		0.2418

development (see the relative weighting in Table VII). This, in turn, emphasizes that the essential features of this pattern of cooperation are the attitude of higher managers and the core technique of the enterprise. This synchronizes the superiority of the enterprise 1. Consequently, the results point to selection of enterprise 1, which has the highest desirability index of 0.2930.

4.1 Illustration of application

Retailing industry is facing severe competition with the advent of globalization and franchisation. Therefore, the Chain-store Association of Taiwan, Republic of China, appealed to the government to address this issue by launching the program that can train employee with greater expertise within the enterprise. In response, the Ministry of Education of Taiwan selected three colleges to take charge of the appeal in 1998. National Chinyi Institute of Technology (NCIT) was one of the three schools and established a new department named Department of Distribution & Management that integrates the resources of the Department of Industrial & Management, the Department of Business & Administration, and Information Management. Major programs of the new department focus on the management of monetary flow, information flow, product flow and logistics. After the selection of partner enterprises the teachers who are associated with the programs are assigned to the selected partner enterprises for pre-teaching training, and participate in the operations of the store as well as the planning of sale policy. This participation proves to be valuable for curriculum design and practice teaching in class. At the mean time, top managers of the selected partner enterprises are invited to propose their ideas based on the practical needs. Consequently, a two-year training program is determined. The program requires students to study in school for the first semester, where they will learn basic business concepts and practical operations. After finishing this semester, they will go to partner enterprises for practical training, where teachers have to audit each partner enterprise and solve students' problems. Meanwhile, students are required to report their work to school once a month during this semester. After the practical training, students continue their second year programs that focus on the expertise training containing the management of monetary flow, information flow, product flow and logistics. Since students have finished practical training and gained experience, thorough discussion for these topics is possible in class. We refer to this program as a "sandwich" program. Employees who are potential to be supervisors will be assigned to join the on-job training courses as a result of the program involving approval and validation process by the partner enterprise. In total, this program has trained about 250 employees, 40 percent of them working at the enterprise where practical training takes place, and 30 percent of them working at the related enterprises. To reinforce the cooperation between school and partner enterprises, NCIT has established a Graduate Institute of Distribution Technology and Management since 2003. Issues of business operations and management arising from the partner enterprises will be the major topics for research in this institute.

5. Conclusion

To guarantee the skills capability of a student who graduated from the vocation education system, the selection of an adequate partner enterprise is essential. The ANP approach, which considers the interdependence among different layers of analytic

processes, is applied to select the enterprises which would raise the general effectiveness of the vocational education system. To implement the ANP approach, different cooperation patterns and criteria and their corresponding attributes for evaluating the performance of each potential enterprise have to be examined beforehand. The interdependence between the cooperation patterns and the criteria is emphasized in the ANP approach. The cooperation pattern influences the weightings of criteria. On the other hand, emphasizing specific criteria would affect the cooperation pattern the school intends to implement. This dynamic situation is handled by running a supermatrix comprised by a set of pairwise comparisons.

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