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A value-created system of science (technology) park by using DEMATEL

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ABSTRACT

Under the impact of globalization effects, enterprises tackle the rapid change of market circumstances and find suitable places for production, R&D and marketing, which contribute to the creation of clusters of various industries. In this study, we differentiate the decisive factors effecting enterprises in choosing the right places for production, R&D and marketing. We also provide proposed development strategies and operation models for the authorities of science (technology) park to advance the parks' value. This study compares various industrial clusters using the DEMATEL (Decision Making Trial and Evaluation Laboratory) technique to establish industrial structures. To do this, four aspects are considered: human resources, technology resources, invest environments and market development. These aspects encompass 28 evaluation criteria to determine the establishment attributes of clusters. Two well-known industrial cluster parks, the Neihu technology park and the Hsinchu science park as example, both in Northern Taiwan, are our case studies for this project. The Neihu technology park is the industrial cluster of R&D and marketing. The Hsinchu science park is the industrial cluster of production and manufacture. The DEMATEL technique is used to determine the relationship between the evaluation criteria and establish their value structures. The key performance criteria could be sieved out and shall be further improved. The conclusions shall propose development strategies and operation models for vendors or the authorities of science (technology) parks to advance the parks' value.

1. Introduction

The flourishing progress of both economic liberalization and information technologies have contributed to the trend of enterprise globalization. The enterprise faces competition against not only domestic companies, but also international companies. In order to transcend other competitors, the enterprise has to strengthen its competitive advantage by manipulating global brains and resources. The appearance is that many famous international enterprises around the world had moved their production bases into developing countries. Through resource re-allocation actions, these international enterprises can intensify their resources on R&D and marketing activities of products or service, but they still have to tackle two difficult issues: (1) to meet customers' needs, the best solution for enterprises is to produce goods fitting customers' needs/demands and to set up sales units near customers; (2) to maintain key competitive competency, these enterprises look for outsourcing of standard production procedures and services in order to reduce operating costs (Iammarino & McCann, 2006; McCann & Arita, 2006; McCann et al., 2002; Ng & Tuan, 2003). These enterprises will not meet customer's needs/demands unless they adjust and organize their production, R&D and marketing bases opportunely. The best way to accomplish this is to consider the optimal allocation of global markets and resources, and to look for suitable production places, R&D and marketing bases around the world. Thus, enterprises can manipulate global brains and resources to reduce their production costs, raise the operating performance and enhance enterprises' competitive competency. A comprehensive literature review has revealed that studies industrial clusters formed regarding the development process of industrial parks, export processing zones, science parks and technology parks, has its' contributions and backgrounds. One sentence is not enough to describe how every industrial cluster has been formed; however, we can say that contributions of parks (or various industrial clusters) change with time (Durão et al., 2005; Guerrieri & Pietrobelli, 2004).

Porter, scholar of Harvard University, discovered studies that traditional industrial clusters are based on comparative economic interests or advantages, natural resources and cheap labor costs were the contributions to form industrial clusters. However, instead of natural resources and cheap labor costs, today, continuous innovative actions inside industrial clusters become the main contribution. Therefore, the contributions of industrial clusters are changed from natural resources and cheap labor costs to the innovation ability of clusters. This is why we want to propose

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the value-created system of science (technology) parks (Porter, 1998; Porter, 2000). The good industrial clusters or science (technology) parks can grow and develop continuously only basing on the value-created system. If the functions of the value-created systems of science (technology) parks are reduced or lost, the science (technology) parks will face the trouble of firms' moving-out.

In these years, some researches which illustrate the development of industry cluster between Taiwan and China (Chen & Huang, 2004; Chen et al., 2006; Hu et al., 2005; Ku et al., 2005; Lai & Shyu, 2005; Lee & Yang, 2000; Tan, 2006). These researches illustrate the innovation and development model (Chen et al., 2006; Hu et al., 2005; Ku et al., 2005; Lai & Shyu, 2005; Tan, 2006), and the choice behavior of location (Chen & Huang, 2004) across the Taiwan Strait. So in this research, we try to understand the relationship of value-created system of science (technology) park, and divided the value-created system into four aspects (i.e., human resource (HR), technological resource (TR), investment environment (IE), and market development (ME). Eventually, this paper will generalize the whole value-created system of science (technology) from four major value-created functions and propose the overall analysis. Lin, Tung, and Huang (2006) adopted the DEMATEL method as an analysis technique. The DEMATEL method is an analytic technique of relationship structure, it can find the critical aspect/criteria of the complex structure system. Tzeng et al. (2007) illustrated that DEMATEL method can construct the evaluation dimensions and find out the key driving criteria of various science (technology) parks. The key driving criteria could be sieved out for further improvement. The conclusion could provide some development strategies and operation models for the authorities of science (technology) parks to advance the parks' value. The manufacture-oriented Hsinchu science park and the R&D, marketing-oriented Neihu technology park is applied to empirical implementation.

This paper is organized as follows: In Section 2, the development process of science (technology) parks, and four aspects/dimensions (i.e., human resource (HR), technological resource (TR), investment environment (IE) and market development (ME) are introduced. In Section 3, the theory of DEMATEL technique is proposed and a simple case is applied to demonstrate the analysis process. In Section 4, empirical studies of two Taiwan science (technology) parks are illustrated to be compared and analyzed. In Section 5, the conclusions and remarks for the two parks are proposed to apply to their future development plans.

2. Industry clusters and value-created systems on science (technology) parks

Porter (1998) discovered that industry clusters could raise the competitive advantage for enterprises resulting from clusters of productivity, clusters of innovation, and clusters of new business formation. In the clusters of productivity concept, this research extracted five criteria (as shown in Table 1) which could contribute industry clusters to increase productivity. In the clusters of innovation concept, Porter considered that clusters could help enterprises understand customers' needs and use clusters resources to innovate more easily. In the clusters of new business formation concept, Porter considered that clusters could help enterprises to find the gaps of needs to present products or services, and it could also help new businesses to find suitable suppliers and customers in the clusters. Furthermore, Porter (2000) generalized the sources of the competitive advantage of clusters. Furman et al. (2002) revised Porter's (2000) researches and provided the model of innovation-oriented national industry clusters with four evaluation aspects (as shown in Table 1). Chan and Lau (2005) pointed out that technology incubator programs of the science park provided different benefits for start-up companies in different stages. In the set-up office period, the programs could provide the rental subsidy and shared general resources costs. In the start marketing period, the programs could provide training resources, market network relation, proposed customer database, and legal or business advice. In the start to sell period, the programs could provide public images, media relations, market networks, and venture capital. Lin et al. (2006) elucidated the industry cluster effect from the view of the dynamic system and considered that human resources, technology, money and the market were the four major influential aspects that affected industry cluster effect. Base on those above studies, four aspects/dimensions: (1) human resources (HR), (2) technological resource (TR), (3) investment environment (IE) and (4) market development (ME) are applied in our paper and illustrated in following Subsections.

Table 1
The comparative research of value-created system for industry cluster.

Porter (1998)
(1) High qualified employees and suppliers,
(2) Access to specialized information,
(3) Complementary relationships,
(4) Access to institutions and public goods
(5) Better motivation and performance measurements
Porter (2000)
(1) Factor (input) conditions (i.e., natural resources, human resources, capital resources, the physical infrastructure, the administrative infrastructure, the information infrastructure, the scientific and technological infrastructure)
(2) Demand conditions (i.e., the local demand, the future expected local demand, the maturity of local customers, and the local demand that could be globalized)
(3) Firm strategies and rivalry conditions (a local context that encourages appropriate forms of investment and sustained upgrading and vigorous competition among locally based rivals.)
(4) The related and supporting industries (i.e., the existing capability, local suppliers and the existing industrial competition).
Furman et al. (2002)
(1) Factor (input) conditions
(a) High quality human resources, especially scientific, technical, and managerial personnel
(b) Strong basic research infrastructure in universities
(c) High quality information infrastructure
(d) An ample supply of risk capital
(2) Demand conditions,
(a) The demand and the maturity of local customers
(b) The future expected local demand
(3) Context for firm strategy and rivalry
(a) A local context that encourages investment in innovation-related activity
(b) Vigorous competition among locally based rivals
(4) Related and supporting industries
(a) The capability of local suppliers and related companies
(b) Presence of clusters instead of isolated industries
Lin et al. (2006)
(1)Human resources, (2)Technology, (3) Money, (4) Market
Our paper
(1) Human resources (HR), (2) Technological resource (TR), (3) Investment environment (IE), (4) Market development (ME)

2.1. The human resource aspect

Many studies regarding industry cluster and science (technology) parks have pointed out that industry cluster contributions are influenced by human resources (Furman et al., 2002; Lin et al., 2006; Porter, 1998, 2000). Porter (1998, 2000) considered that high quality human resources could help industry clusters to raise productivity. Meanwhile, human resources were always one of the competitive advantages of the industry cluster. Furman et al. (2002) defined clearly that high quality human resources meant brains of technology and management. Lin et al. (2006) considered that human resources contain the demands of professional staff, the number of research institutions, the channel of personnel training, the quantity of human resources, the number of high quality personnel, the number of high quality and quantity of administrative human resources, the innovation ability, and the new business would affect the advantage of the industry cluster.

2.2. The technological resource aspect

Researchers have utilized research resources to strengthen the function of the value-created in industry clusters. Fukugawa (2006) considered that the major contribution of the science park was providing new technology-based firms (abbreviated NTBF) the linkage with local higher education institutes (HEIs) and research institutes, and also provided the service of incubation for the NTBF. The science park has combined functions of the traditional industry park and incubation center, and thus NTBF could obtain research resources and desired technologies from the assistance of R&D institutes. Therefore, NTBF could easily find suitable strongholds to commercialize their technologies. This is what experts called "science park model". Hu et al. (2005) took the Hsinchu science park (Taiwan) as an example to explain the contributions as to why the science park could form the cluster of NTBF. The research pointed out that R&D and incubation institutes could cultivate NTSF. Because these NTBF lacked enough R&D resources in the start-up period, they must rely on technology transfer and IP licenses from the R&D institute. Some NTBF even built long collaborative relationships with R&D institutes, such as collaboration and joint research. Besides, some NTBF were spin-offs from departments of R&D institutes originally, and therefore, network relationships existed with R&D institutes. The network relationship could help NTBF reducing the communication cost between NTBF and R&D institutes, and the uncertain risk of technology development. Therefore, NTBF could keep the competitive advantage of technology by the close network relationship with the R&D institutes. Lin et al. (2006) considered that the penetration of technology, the number of research institutions, the diversification of university departments, the industrial information, the entrepreneurial technology level, the entrepreneurial competitive advantage, the entrepreneurial profitability, the desire for external cooperation, and the industrial scale would influence the effect of the industrial cluster.

2.3. The investment environment aspect

Some studies have pointed out the importance of the investment environment for the industry cluster (Furman et al., 2002; Porter, 1998, 2000). Three main influential contributions were: the investment infrastructure, the effective of law and policy and the economies of scale of the industry. In the investment of infrastructure, Porter (1998) considered that research institutes, the professional information and public properties could help the industry cluster to raise productivity. The general investment of infrastructure should consider physical infrastructure, administrative infrastructure, information infrastructure, and technology infrastructure. In reference to law and policy, Porter (2000) and Furman et al. (2002) considered that local law and policy could encourage the investment in innovation and push the industry to upgrade continuously. Lin et al. (2006) considered that the investment environment, complete regulation, infrastructure, material supply system, investment cost, investment incentives, substantial investment, local productivity, restriction of local resources, opportunity of earning profits, loans available from financial institutions, fund raising ability, debt ratio, reinvestment ability, and innovation ability would influence the competitive advantage of the industry cluster.

2.4. The market development aspect

Many studies considered that the function of market development is relevant close to industrial clusters (Furman et al., 2002; Porter, 1998, 2000). The main discussion focused on those three aspects (i.e., manufacturers and customers, manufacturers and suppliers, and manufacturers and manufacturers). In reference to manufacturers and customers, Porter (1998, 2000) considered that the cluster could help enterprises easily understand customers' needs/demands and utilize clusters' resources for proceeding with innovation activities. Therefore, enterprises could discover the gaps among existing products and/or services and customers' needs, and new enterprises could select suitable suppliers and customers in the cluster. Besides, the maturity, the needs and the anticipated needs of local customers, and the globalized needs would influence the market development of the industry cluster.

In reference to manufacturers and suppliers, Porter (1998, 2000) considered that high quality suppliers could help enterprises from the cluster to raise their productivity. The ability of the related and supporting industries and the relationship between enterprises and local suppliers would influence the market development of the industry cluster. In reference to manufacturers, he considered that existing network relationship between enterprises could also create competitive advantages for the cluster. The industry' relationship encompassed both the complementary and competitive relationship. The complementary relationship could create the new industry cooperation model, and the competitive relationship could improve production efficiency and raise the competitive ability. Chan and Lau (2005) considered that science park could provide supporting of training resources, market networks, customer data bases, legal advice, business advice, public image, media relations, the market network, and the venture capital for NTBF during the market development period. Lin et al. (2006) proposed that the penetration of technology, the number of research institutions, the diversification of university departments, the industrial information, the entrepreneurial technology level, the entrepreneurial competitive advantage, the entrepreneurial profitability, the desire for external cooperation, and the industrial scale would influence the effect of the industrial cluster.

2.5. Value-created concept, influential relationship of network structure

In this study, the value-created system is divided into the aspect level and the criteria level. Firstly, the research analyzed four main aspects: human resources, technology resources, investment environment and market development. The relationship of aspects/criteria, and eventually the value-created systems of science/technology parks are considered. Besides, DEMATEL method is used to construct the relationship structure of aspects/criteria, it can help find the critical aspects/criteria of complex structure system. The DEMATEL technique was the best suitable method for building the relevant structure map. The DEMATEL technique relieved the limitation of the relationship matrix about the assumption of the symmetrical relationship. Therefore, some recent studies considered the DEMATEL techniques for solving complicated relationship structure problems (Hori & Shimizu, 1999; Huang et al., 2007; Lin & Wu, 2008; Liou et al., 2007; Liou et al., 2008; Seyed-Hosseini et al., 2006; Tsai and Chou, 2009; Tzeng et al., 2007; Wu, 2008; Wu & Lee, 2007).

3. Building the value-created system of science (technology) park

This section divides into two Subsections. In Section 3.1, the degree of satisfaction and weights to the science park are analyzed. In Section 3.2, the DEMATEL technique is proposed and introduced. A simple example is illustrated to demonstrate the proposed techniques.

3.1. The analysis of satisfaction degree and importance degree of science (technology) park

A survey of the satisfaction degree and importance degree of criteria (Table 2) would be conducted and the surveyed data would be normalized into the same measuring scales. According to the results of the surveyed data, the criteria would be divided into four categories as follows: the first category is the high satisfaction degree with the high importance degree as a symbol of ○(+,+). The second category of criteria is a high satisfaction degree with a low importance degree as a symbol of ●(+,−). The third category of criteria is low satisfaction degree with low importance degree as a symbol of △(−,−). The fourth category of criteria is low satisfaction degree with high importance degree as a symbol of X(−, +). In this study, the strategy of the value-created system of science (technology) park is proposed to accomplish this and improve those criteria falling into the fourth category [X(−, +)], we necessarily improve those criteria falling into the third category [△(−,−)]. The fourth category criteria are key factors affect the whole satisfaction degree of the science park. In reference to the third category criteria, a higher importance degree would affect the whole satisfaction degree of the science (technology) park in the short run.

3.2. Explaining the proposed DEMATEL technique for building a value-created system

In this subsection, the proposed DEMATEL technique is used to build the relationship structure of the value-created system of science (technology) parks. Decision makers often meet the relationship problems of criteria with dependence and feedback when they use/improve criteria in real situations/environments. For example, Criteria A influences Criteria B, so Criteria B cluster can be further improved if we improve Criteria A. Thus, we shall distinguish those key criteria first and then we can effectively improve the total satisfaction degree. When decision makers meet many criteria which need improvement, the best solution is to find the key criteria which influence the other criteria most. Therefore, the best improvement could be fulfilled based on these ideas. The DEMATEL technique was initiated for a Science and Human Affairs Program by the Battelle Memorial Institute of Geneva between 1972 and 1976. It was established to solve complex problems. It can elevate the understanding of the issues, groups of interacted factors, criteria and provide a feasible solution by building a hierarchical relevant network system. This technique has been widely applied for solving complex studies (Hori & Shimizu, 1999; Huang et al., 2007; Lin & Wu, 2008; Liou et al., 2007, 2008; Seyed-Hosseini et al., 2006; Tsai and Chou, 2009; Tzeng et al., 2007; Wu, 2008; Wu & Lee, 2007), such as user interface (Hori & Shimizu, 1999), reprioritization of failures in a system failure mode and effects analysis (Seyed-Hosseini et al., 2006), developing global managers' competencies (Wu & Lee, 2007), evaluating performance in e-learning programs (Tzeng et al., 2007), the innovation policy portfolios for Taiwan's SIP mall industry(Huang et al., 2007), choice of knowledge management strategy (Wu, 2008), causal analytic method for group decision making(Lin & Wu, 2008); airline safety measurement (Liou et al., 2007), safety management system of airlines (Liou et al., 2008); and selection management systems of SMEs (Tsai and Chou, 2009).

Table 2
Description of criteria for the science (technology) park value-created system.

Aspects/Criteria	Description for criteria
1. Human resource	
1.1. Supply of qualified personnel	The supply of qualified personnel will help the exploration of business
1.2. Human brain cultivation organizations	Human brain cultivation organizations will provide sufficient training courses required by enterprises
1.3. Quality of R&D engineers	Qualified engineers will upgrade the ability of R&D results
1.4. New jobs creation	Talented personnel will apply for a good job
1.5. Incubator resources	Sufficient incubation resources will contribute to the establishment of new start-up companies
2. Technology resource	
2.1. Quality of research institution	The quality of research institutions will influence obtaining technologies of enterprises
2.2. Cooperation between industries and academics	The better the cooperation, the easier the gain of new technologies
2.3. Circulation of industry information	Faster circulation of information will enhance the competitive abilities of enterprises
2.4. Quality of enterprises	Good stationed enterprises will contribute proposals to enter the park
2.5. Occasion for enterprises cooperating	Higher cooperating chances will improve the ability of technology R&D of enterprises
3. Investment environment	
3.1. The scale of industries	The scale of industries will affect the scale of industrial value chains
3.2. The territory of science park	More enterprises could enter the park with larger territories
3.3. Incentives for investment	Good incentives will raise the intention of enterprises to enter the park
3.4. Informational infrastructure construction	Good information infrastructure will raise the intention of enterprises to enter the park
3.5. Legislation and government policy	Exact and precise legislation and government policies will raise the intention of enterprises to enter the park
3.6. Operation costs	Low operating costs will raise the intention of enterprises to enter the park
3.7. Regional traffic networks	Better traffic networks will raise the intention of enterprises to enter the park
3.8. Regional development outlook	Better development outlook will raise the intention of enterprises of entering the park
3.9. Living utilities	Better living utilities will raise the intention of enterprises to enter the park
3.10. Regional infrastructure construction	Well infrastructure construction will raise the intention of enterprises to enter the park
4. Market development	
4.1. Benefit of economies of scale	More stationed enterprises can contribute to attain economies of scale and raise the efficiency of manufacture and operation
4.2. Supply networks	Closer networks will tighter the relationship and reduce the operating cost
4.3. Competition status	Fierce competition status will enhance the competitive ability
4.4. Reputation	The performance of stationed enterprises will affect the reputation of the park
4.5. Completion of supply chain	Clarified industry division will enhance the supporting firms and tighten the industrial supply chain
4.6. Bargaining power	Bargaining power will affect the procurement power
4.7. Quality of outsourcing providers	Better qualified outsourcing providers will raise the intention of enterprises to enter the park
4.8. Prospects of industries	Brightening prospects of industries will raise the intention of enterprises to enter the park

3.3. The illustrative steps of the DEMATEL technique

The steps of the DEMATEL technique are described as follows: Section 3.3.1 calculates the original average matrix, Section 3.3.2 calculates the direct influence matrix, Section 3.3.3 calculates the indirect influence matrix, Section 3.3.4 calculates the full direct/indirect influence matrix, and Section 3.3.5 finds the interrelationship between entwined aspects/ criteria of the value-created system of science (technology) park.

3.3.1. Calculates the original average matrix

Respondents were asked to indicate the influence that they believe each aspect exerts on each of the others according to an integer scale ranging from 0 to 4 (going from "No influence (0)," to "extreme strong influence (4)"). A higher score from a respondent indicates a belief that insufficient involvement in the problem of aspect i exerts a stronger direct influence on the inability of aspects/criteria j, or, in positive terms, that greater improvement in i is required to improve j. From any group of direct matrices of respondents, it is possible to derive a mean matrix $\boldsymbol{A}$, Table 2. Each aspect of this average matrix will be in this case, the mean of the same aspects in the different direct matrices of the respondents. As shown in Fig. 1, the aspect of human resource (HR) is strongly influenced by the aspect of technology resource (TR). Comparably, the aspect of technology resource (TR) is moderately affected by the aspect of human resources (HR), as shown in Table 3.

3.3.2. Calculates the direct influence matrix

The initial direct influence matrix $\boldsymbol{D}$, as shown in Table 4 can be obtained by normalizing the average matrix $\boldsymbol{A}$, in which all principal diagonal aspects are equal to zero. Based on matrix $\boldsymbol{D}$, the initial influence which an aspect exerts and receives from another is shown. The aspect of matrix $\boldsymbol{D}$ portrays a contextual relationship among the aspects of the system and can be converted into a visible structural model—an impact-digraph-map—of the system with respect to that relationship. For example, in Section 4.2, the respondents are asked to indicate direct links. The digraph map helps to understand the structure of the aspects.

In Table 3, the average matrix $\boldsymbol{A}$ is a 4×4 matrix. It can be created from Eqs. (1) and (2). Table 4, the value of the aspect of the direct influence matrix $\boldsymbol{D}$ is 0 and each maximal value of the sum of columns and rows is 1. The sum of each of the columns and rows of the direct influence matrix $\boldsymbol{D}$ yields the degree of direct influence of each aspect that can be gained, Table 5. As shown in Table 5, the degree of direct influence of the aspect of technology resource is the most important one. Comparably, the aspect of human resource is the lowest one

$$\boldsymbol{D} = s\boldsymbol{A}, s > 0 \tag{1}$$

where

$$s = \min_{i,j}\left[1/\max_{1\leqslant i\leqslant n}\sum_{j=1}^{n}|z_{ij}|, 1/\max_{1\leqslant j\leqslant n}\sum_{i=1}^{n}|z_{ij}|\right] i,j = 1,2,\ldots,n \tag{2}$$

and $\lim_{m\to\infty} \boldsymbol{D}^m = [0]_{n\times n}$, where $\boldsymbol{D} = [d_{ij}]_{n\times n}, 0 \leqslant d_{ij} < 1, 0 < \sum_{j=1}^{n} d_{ij}, \sum_{i=1}^{n} d_{ij} \leqslant 1$, and only one row sum or column equal 1.

3.3.3. Calculates the indirect influence matrix

The indirect influence matrix can be gained from following Eq. (3), as shown in Table 6. A continuous decrease of the indirect effects of problems is along the powers of matrix, e.g. $\boldsymbol{D}_2, \boldsymbol{D}_3, \ldots, \boldsymbol{D}_m$. This guarantees convergent solutions to matrix inversion.

$$\boldsymbol{ID} = \sum_{i=2}^{\infty} \boldsymbol{D}^i = \boldsymbol{D}^2(\boldsymbol{I} - \boldsymbol{D})^{-1} \tag{3}$$

3.3.4. Calculates the full direct/indirect influence matrix

The full direct/indirect influence matrix $\boldsymbol{T}$—the infinite series of direct and indirect effects of each aspect—can be obtained by the matrix operation of $\boldsymbol{D}$. The matrix $\boldsymbol{T}$ presents the final structure of aspects after the continuous process (see Eqs. (4)–(8)).

Table 3
The mean matrix $\boldsymbol{A}$.

Aspects	HR	TR	IE	MD	Total
Human resource (HR)	0.00	**3.30***	2.57	2.70	8.57
Technology resource (TR)	**2.91***	0.00	3.00	3.00	8.91
Investment environment (IE)	2.30	2.91	0.00	3.04	8.26
Market development (MD)	2.78	2.96	3.13	0.00	8.87
Total	8.00	**9.17**	8.70	8.74	–

Table 4
The direct influence matrix $\boldsymbol{D}$.

Aspects	HR	TR	IE	MD	Total
Human resource (HR)	0.00	0.36	0.28	0.29	0.93
Technology resource (TR)	0.32	0.00	0.33	0.33	0.97
Investment environment (IE)	0.25	0.32	0.00	0.33	0.90
Market development (MD)	0.30	0.32	0.34	0.00	0.97
Total	0.87	**1.00**	0.95	0.95	–

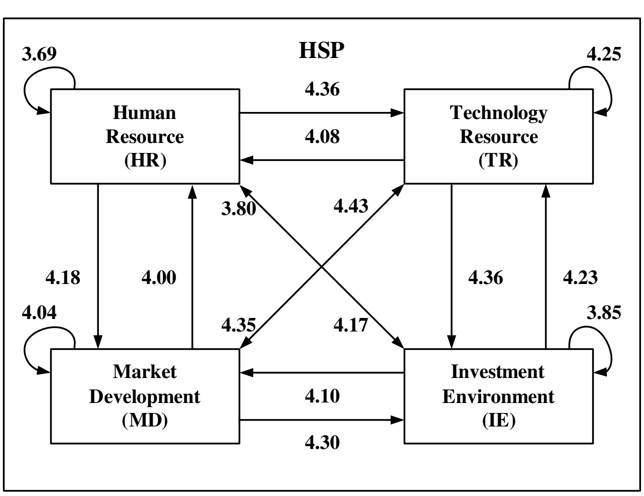

Fig. 1. Figure of full direct/indirect influence matrix.

Table 5
The degree of direct influence.

Aspects	Sum of rows	Sum of columns	Sum of columns and rows	Degree of influence
Human resource (HR)	0.93	0.87	**1.80**	**4**
Technology resource (TR)	0.97	1.00	**1.97**	**1**
Investment environment (IE)	0.90	0.95	1.85	3
Market development (MD)	0.97	0.95	1.92	2

Table 6
The indirect influence matrix.

ID	HR	TR	IE	MD	Total
Human resource (HR)	3.69	4.00	3.89	3.89	15.47
Technology resource (TR)	3.76	4.25	4.03	4.02	16.06
Investment environment (IE)	3.55	3.91	3.85	3.77	15.09
Market development (MD)	3.70	4.11	3.96	4.04	15.81
Total	14.70	**16.28**	15.73	15.72	

Setting a threshold value, P, to filter the obvious effects denoted by the aspects of matrix $\boldsymbol{T}$, is necessary to explain the structure of the aspects. Based on the matrix $\boldsymbol{T} = [t_{ij}]_{n \times n}$, each aspect, t_{ij}, of matrix $\boldsymbol{T}$ provides information about how aspect i influences aspect j. If all the information from matrix $\boldsymbol{T}$ converts to the impact-digraph-map, the map will be too complex to show the necessary information for decision-making. To obtain an appropriate impact-digraph-map, the decision-maker must set a threshold value for the influence level. Only some aspects, whose influence level in matrix $\boldsymbol{T}$ is higher than the threshold value, can be chosen and converted into the impact-digraph-map. The threshold value is decided by the decision-maker or, in this paper, by experts through discussion. Like matrix $\boldsymbol{D}$, contextual relationships among the aspects of matrix $\boldsymbol{T}$ can also be converted into a digraph map. If the threshold value is too low, the map will be too complex to show the necessary information for decision-making (Fig. 1). If the threshold value is too high, many aspects will be presented as independent aspects without showing the relationships with other aspects. Each time the threshold value increases, some aspects or relationships will be removed from the map.

After the threshold value and relative impact-digraph-map are decided, the final influence result can be shown. For example, the impact-digraph-map of a factor is the same as Figs. 2 and 4 aspects that exist in this map. The full direct/indirect influence matrix ($\boldsymbol{T}$) could be gained as Eqs. (4)–(6).

$$\boldsymbol{T} = \boldsymbol{D} + \boldsymbol{I}\boldsymbol{D} \tag{4}$$

$$\boldsymbol{T} = \sum_{i=1}^{\infty} \boldsymbol{D}^i = \boldsymbol{D}(\boldsymbol{I} - \boldsymbol{D})^{-1} \tag{5}$$

$$\boldsymbol{T} = [t_{ij}], \; i,j = 1,2,\ldots,n \tag{6}$$

$$\boldsymbol{d} = \boldsymbol{d}_{n\times 1} = \left[\sum\nolimits_{j=1}^{n} t_{ij}\right]_{n\times 1} \tag{7}$$

$$\boldsymbol{r} = \boldsymbol{r}_{n\times 1} = \left[\sum\nolimits_{i=1}^{n} t_{ij}\right]'_{1\times n} \tag{8}$$

where superscript 0 denotes transposition. Suppose r_i denotes the row sum of the ith row matrix $\boldsymbol{T}$, then r_i shows the sum of direct and indirect effects of aspect/criterion i on the other aspects/criteria. If c_j denotes the column sum of the jth column of matrix $\boldsymbol{T}$, then c_j shows the sum of direct and indirect effects that aspect/criterion j has received from the other factors. Furthermore, when $j = i$, $(d_i + r_i)$ provides an index of the strength of influences given and received, that is, $(d_i + r_i)$ shows the degree that the factor i plays in the problem. If $(d_i - r_i)$ is positive, then factor i is affecting other factors, and if $(d_i - r_i)$ is negative, then factor i is being influenced by other factors (Liou et al., 2007; Tzeng et al., 2007). If $d_i - r_i > 0$, it yields the degree of affecting others is stronger than the degree to be affected (Table 8).

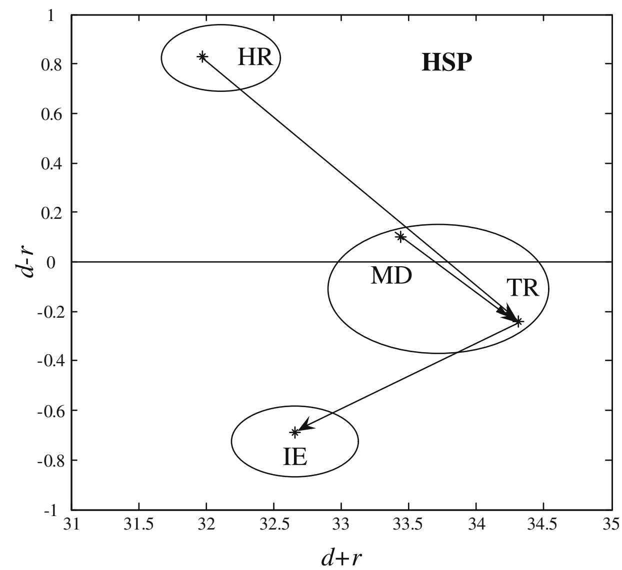

Fig. 2. The interrelationship between entwined criteria (d + r/d − r).

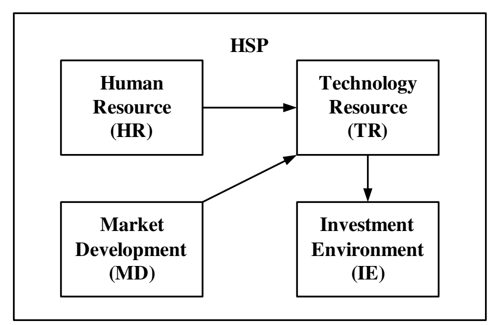

Fig. 3. Value-created system of science (technology) network structure map.

3.3.5. Finds the interrelationship between entwined criteria

According to the factor analysis results, some experts were invited to discuss the relationship and influence level of criteria under the same factor/aspect, and to score the relationship among

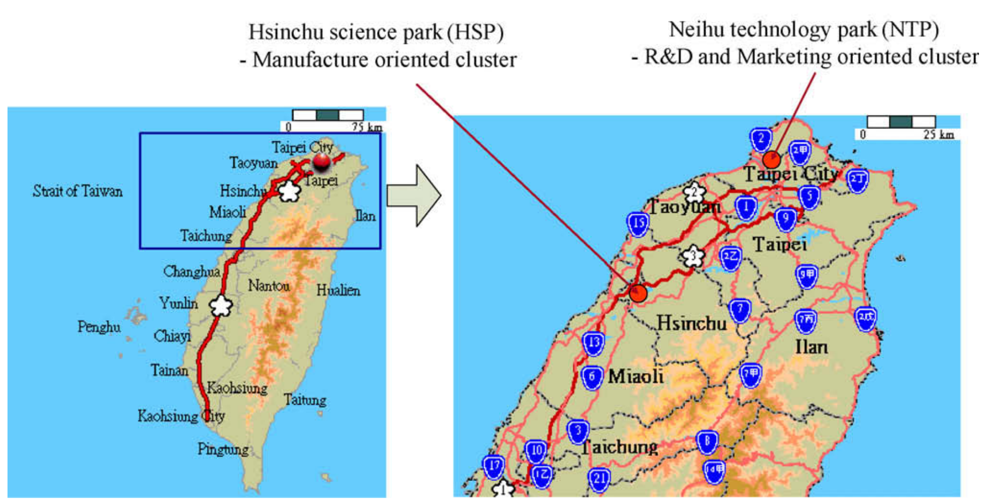

Fig. 4. Locations of HSP and NTP in Taiwan.

Table 7
The full direct/indirect influence matrix (***T***).

Threshold value = 4.35	HR	TR	IE	MD	***d***
Human resource (HR)	3.69	**4.36***	4.17	4.18	16.40
Technology resource (TR)	4.08	4.25	**4.36***	**4.35***	17.04
Investment environment (IE)	3.80	4.23	3.85	4.10	15.99
Market development (MD)	4.00	**4.43***	4.30	4.04	16.77
r	15.57	17.28	16.68	16.67	–

Table 8
The degree of full direct/indirect influence.

Aspects	Sum of columns {***d***}	Sum of rows {***r***}	Sum of columns + rows {***d*** + ***r***}	Sum of columns − rows {***d***−***r***}
Human resource (HR)	16.40	15.57	31.97	**0.83**
Technology resource (TR)	17.04	17.28	**34.31**	−0.24
Investment environment (IE)	15.99	16.68	32.66	−0.69
Market development (MD)	16.77	16.67	33.44	**0.10**

criteria based on the DEMATEL method. Factors were divided into different types, so the experts could answer the questionnaire in areas they were familiar with. In order to limit information loss from the DEMATEL method results (Table 7 and Fig. 1), threshold values ($P = 4.35$) were decided after discussion with these experts and an acceptable impact-digraph-map was found (Figs. 2 and 3). Figs. 2 and 3. The human resource aspects are the main net influence aspect, the investment environment aspect is the main affected aspect, and the technology resource aspect is the main total influence aspect (Fig. 2).

4. Empirical case of value-created system for science (technology) park

In this Section, two empirical cases of real clustered parks will be proposed to analyze the value-created system of different industrial clusters. The study is divided into four subsections. Section 4.1 deals with the history of development and progress of two science parks. Section 4.2 describes results of the questionnaires and the analysis of the degree of satisfaction and importance regarding the two empirical cases. Section 4.3 discusses the comparative analysis of the science (technology) parks and the four aspects among them.

4.1. Background descriptions

In this section, two empirical cases of real clustered parks will be proposed to analyze the value-created system of different industrial clusters. The Hsinchu science park (abbreviated HSP) in Taiwan (Fig. 4) is an important industrial cluster of production and manufacturing, while the Neihu technology park (abbreviated NTP) is an important industrial cluster of R&D and Marketing. We review the forming process of HSP, which is near universities, National Chiao Tung University (abbreviated NCTU), National Tsing Hua University (abbreviated NTHU) and R&D institution Industrial Technology Research Institute (abbreviated ITRI). Therefore, these institutions provide many high quality human resources of technology and management, and create many famous international enterprises by technology transferring, spin-offs or spin-ins. Meanwhile, the government encourages NTBF's R&D and production activities by constructing essential infrastructure and giving preferential tax rebates. Since NTBFs have got the support of human resources, technology resources, and investment, they can compete with other international enterprises in the worldwide markets. These NTBFs who invest their profits in R&D and production, not only expand the scale economics of science parks which is expensive, but also attracts an international enterprises' view on the successful operation model of HSP.

The Neihu Technology park was originally the "Taipei Neihu industry park" in June, 1991, while some companies of the information and software service industry, the electric component industry, and the telecommunications industry we built their headquarters and/or R&D centers there. It renamed "Taipei Neihu Technology Park" in December, 1991. NTP was built and invested in by private funds. Through reviewing the establishment, the key success attributes are as follows: in the initiation, many ICT companies established their headquarters and/or R&D centers in NTP. It also attracted others to do the equivalent actions for lower land cost or cheaper rental in NTP than in downtown Taipei. As more and more native or international enterprises clustered at NTP, the benefit of economies of scale appeared. NTP has gradually become the largest R&D and Marketing cluster park in Taiwan because of its excellent investment environment and closed network relationship (Fig. 4).

4.2. The compared analysis of satisfaction and importance degree of criteria

We integrate some research and discuss these aspect/criteria with some experienced managers, senior engineers, and marketing staffs of HSP/NTP, then get our questionnaires respondents by interview questionnaires during 2007. The questionnaires respondents are experienced managers, senior engineers, and marketing staffs of HSP, and the staffs of ITRI. There were 23 questionnaires received. Among them, 69.57% worked at the administrative level, such as company's managers or ITRI's directors, and 30.43% worked at the non-administrative level, such as company's engineers and staffers under the position consideration (Table 9). Under the industrial classification consideration, 4.35% were in the PC/peripherals industry, 17.39% were in IC design industry, 4.35% were in the telecommunications industry, 8.70% were in the optoelectronics industry, 56.52% were in the integrated circuits industry, 8.70% were in the incubation and R&D service of ITRI (Table 10).

There were 11 usable questionnaires. As shown in Table 11, 36.36% were at the administrative level, such as company's managers and 63.64% were at the non-administrative level, such as company engineer and staffers, under the position consideration. As shown in Table 12, 9.09% worked in the PC/peripherals industry, 45.45% worked in the telecommunication industry, 36.36% worked in the information and software service industry and 9.09% worked in the precision machinery industry under the industrial classification consideration.

The analysis of satisfaction degree of the criteria is as follows (Tables 13 and 14). In HSP, the mean of satisfaction is 6.56 (the ceiling point = 10), the maximum point is 7.43 (TR2) which is the most satisfied criterion, the minimum point is 5.57 (MD8) which is the most unsatisfied criterion, and the standard deviation is

Table 9
The data description of HSP (by position).

Positions	Number	Rate (%)
1. Executive (company's manager and ITRI director)	16	69.57
2. Not executive (company's engineer and staff)	7	30.43
Total	23	100

Table 10
The data description of HSP (by industrial classification).

Classifications	Number	Rate (%)
1. PC/ Peripherals	1	4.35
2. IC design	4	17.39
3. Telecommunication	1	4.35
4. Optoelectronics	2	8.70
5. Integrated circuits	13	56.52
6. Incubation and R&D service (ITRI)	2	8.70
Total	23	100

Table 11
The data description of NTP (by position).

Appointments	Number	Rate (%)
1. Executive t (company's manager and ITRI director)	4	36.36
2. Not executive (company's engineer and staff)	7	63.64
Total	11	100.00

Table 12
The data description of NTP (by industrial classification).

Industries	Number	Rate (%)
1. PC/ Peripherals	1	9.09
2. Telecommunication	5	45.45
3. Information & software service	4	36.36
4. Precision machinery	1	9.09
Total	11	100.00

Table 13
Satisfaction and importance degree of value-created system (HSP).

Aspects	Criteria	MS	SS	MI	SI	(SS.SI)
Human resource	HR1. Supply of qualified personnel	7.17	1.37	**8.64**	2.29	○(+,+)
	HR2. Human brain training organizations	6.70	0.31	7.55	0.16	○(+,+)
	HR3. Quality of R&D engineers	6.70	0.31	8.36	1.75	○(+,+)
	HR4. New job creation	6.74	0.41	7.09	−0.73	○(+,+)
	HR5. Incubator resources	6.26	−0.65	6.73	−1.44	△(−,−)
Technology resource	TR1. Quality of research institution	6.57	0.02	8.18	1.40	○(+,+)
	TR2. Cooperation between industries and academics	**7.43**	1.95	8.00	1.04	○(+,+)
	TR3. Dispersion of industry information	6.91	0.79	7.55	0.16	○(+,+)
	TR4. Quality of enterprises	6.83	0.60	7.55	0.16	○(+,+)
	TR5. Occasion for enterprises cooperating	6.87	0.69	7.91	0.87	○(+,+)
Investment environment	IE1. Scale of industries	7.04	1.08	7.82	0.69	○(+,+)
	IE2. Territory of science park	6.30	−0.56	7.09	−0.73	△(−,−)
	IE3. Incentive for investment	6.39	−0.36	7.73	0.51	X(−, +)
	IE4. Informational infrastructure	6.39	−0.36	7.36	−0.20	△(−,−)
	IE5. Legislation and government policy	6.13	−0.94	7.91	0.87	X(−, +)
	IE6. Operating cost	6.22	−0.75	7.91	0.87	X(−, +)
	IE7. Regional traffic network	5.65	−2.00	7.27	−0.37	△(−,−)
	IE8. Regional development outlook	6.17	−0.85	7.09	−0.73	△(−,−)
	IE9. Living requirements	6.00	−1.23	**6.55**	−1.79	△(−,−)
	IE10. Regional infrastructure	5.91	−1.42	7.36	−0.20	△(−,−)
Market development	MD1. Economies of scale	7.04	1.08	7.36	−0.20	●(+,−)
	MD2. Supply networks	6.74	0.41	7.00	−0.91	●(+,−)
	MD3. Competition status	6.83	0.60	7.27	−0.37	●(+,−)
	MD4. Reputation	6.52	−0.08	7.00	−0.91	△(−,−)
	MD5. Completion of supply chain	7.17	1.37	7.82	0.69	○(+,+)
	MD6. Bargaining power	6.52	−0.08	7.45	−0.02	△(−,−)
	MD7. Quality of outsourcing providers	6.78	0.50	6.82	−1.26	●(+,−)
	MD8. Scale of region market	**5.57**	−2.19	6.64	−1.61	△(−,−)
	Average	6.56	0.00	7.46	0.00	
	Maximum	7.43	1.95	8.64	2.29	
	Minimum	5.57	−2.19	6.55	−1.79	
	Standard deviation	0.45	1.00	0.51	1.00	

Note 1: ○(+,+) is the criteria of high satisfied degree and high importance degree, ●(+,−) is the criteria of high satisfied degree but low importance degree, △(−,−) is the criteria of low satisfied degree and low importance degree, X(−, +) is the criteria of low satisfied degree but high importance degree.
Note 2: MS, SS, MI, SI which separately means satisfied value, standardized satisfied value, important value, standardized satisfied value.

0.45. In NTP, the mean of satisfaction 6.53 (the ceiling point = 10), the maximum point is 7.18 (IE4) which is the most satisfied criterion, the minimum point is 5.55 (HR2) which is the most unsatisfied criterion, the standard deviation is 0.41. IE4 (Informational infrastructure) is the highest score (7.18) or most satisfied criterion of NTP, and HR2 (Human brain training organizations) is the lowest score (5.55) or least most satisfied criterion of NTP.

In the part of the importance degree of criteria, the average score of the importance degree of criterion is 7.46 (the perfect point = 10) of HSP. The highest point is 8.64, the lowest point is 6.55 and the standard deviation is 0.51. HR1 (Supply of qualified personnel) is the highest score (8.64) or most important criterion of HSP, and IE9 (Living requirements) is the lowest score (6.55) or least most important criterion of HSP. The average score of the importance degree of criterion is 8.13 (the perfect score = 10) of Neihu Technology park (NTP), the highest score is 9.09, the lowest score is 7.00, and the standard deviation is 0.49. IE3 (Incentive for investment) is the highest score (9.09) or most important criterion and TR2 (Cooperation between industries and academics) is the lowest score 7.00 or least most important criterion of NTP (Tables 13 and 14).

Thus, we concluded that the authorities of HSP should focus on improving IE3 (Incentive for investment), IE5 (Legislation and government policy), IE6 (Operating cost). Under those three criteria, the importance degree is higher than the average value, but satisfaction degree is lower than the average value (Fig. 5). However, authorities of NTP should focus on improving TR4 (Quality of enterprises), IE2 (Territory of science park), IE7 (Regional traffic network), IE8 (Regional development outlook). Under the four criteria, the importance degree is higher than the average value, but the satisfaction degree is lower than the average value (Fig. 5).

This research analyzes the criteria of the value-created system, and suggests and plan of improvement. In Hsinchu science park (HSP), authorities should pay attention to IE5 (Legislation and government policy), IE6 (Operating costs) and IE3 (Incentives for investment), because the three criteria were more important than the average value, but satisfied the criteria a degree lower than the average value. Then authorities should also pay attention to IE7 (Regional traffic network), IE10 (Regional infrastructure), IE8 (Regional development outlook), IE4 (Informational infrastructure) and IE2 (Territory of science park), MD6 (Bargaining power) and MD4 (Reputation), because these criteria were satisfied a degree lower than the average value, but the importance degree is higher.

In Neihu technology park (NTP), authorities should pay attention to IE2 (Territory of science park), IE7 (Regional traffic network), TR4 (Quality of enterprises) and IE8 (Regional development outlook), because the four criteria are more important than the average value, but were satisfied a degree lower than

Table 14
Satisfaction and importance degree of value-created system (NTP).

Aspects	Criteria	MS	SS	MI	SI	(SS.SI)
Human resources	HR1. Supply of qualified personnel	6.55	0.04	8.09	−0.09	●(+,−)
	HR2. Human brain training organizations	**5.55**	−2.40	7.27	−1.76	△(−,−)
	HR3. Quality of R&D engineers	6.09	−1.07	7.91	−0.46	△(−,−)
	HR4. New job creation	6.91	0.93	7.91	−0.46	●(+,−)
	HR5. Incubator resources	6.55	0.04	7.64	−1.01	●(+,−)
Technology resource	TR1. Quality of research institution	5.73	−1.95	7.45	−1.39	△(−,−)
	TR2. Coopertion between industries and academics	5.73	−1.95	**7.00**	−2.31	△(−,−)
	TR3. Dispersion of industry information	6.18	−0.85	8.00	−0.27	△(−,−)
	TR4. Quality of enterprises	6.36	−0.40	8.18	0.10	X (−, +)
	TR5. Occasion for enterprises cooperating	6.91	0.93	8.45	0.66	○(+,+)
Investment environment	IE1. Scale of industries	6.73	0.48	8.36	0.47	○(+,+)
	IE2. Territory of science park	6.09	−1.07	8.82	1.40	X (−, +)
	IE3. Incentive for investment	6.82	0.70	**9.09**	1.96	○(+,+)
	IE4. Informational infrastructure	**7.18**	1.59	8.91	1.58	○(+,+)
	IE5. Legislation and government policy	6.55	0.04	8.73	1.21	○(+,+)
	IE6. Operating cost	6.55	0.04	8.27	0.29	○(+,+)
	IE7. Regional traffic network	6.27	−0.63	8.55	0.84	X (−, +)
	IE8. Regional development outlook	6.45	−0.18	8.45	0.66	X (−, +)
	IE9. Living requirements	6.55	0.04	8.18	0.10	○(+,+)
	IE10. Regional infrastructure	6.91	0.93	8.55	0.84	○(+,+)
Market development	MD1. Economies of scale	6.82	0.70	8.09	−0.09	●(+,−)
	MD2. Supply networks	6.55	0.04	7.91	−0.46	●(+,−)
	MD3. Competition status	6.36	−0.40	7.64	−1.01	△(−,−)
	MD4. Reputation	7.00	1.15	7.91	−0.46	●(+,−)
	MD5. Completion of supply chain	6.73	0.48	7.64	−1.01	●(+,−)
	MD6. Bargaining power	6.73	0.48	7.82	−0.64	●(+,−)
	MD7. Quality of outsourcing providers	7.09	1.37	8.45	0.66	○(+,+)
	MD8. Scale of region market	6.91	0.93	8.45	0.66	○(+,+)
	Average	**6.53**	0.00	**8.13**	0.00	
	Maximum	**7.18**	1.59	**9.09**	1.96	
	Minimum	**5.55**	−2.40	**7.00**	−2.31	
	Standard deviation	**0.41**	1.00	**0.49**	1.00	

Note 1: ○(+,+) is the criteria of high satisfied degree and high importance degree, ●(+,−) is the criteria of high satisfied degree but low importance degree, △(−,−) is the criteria of low satisfied degree and low importance degree, X(−, +) is the criteria of low satisfied degree but high importance degree.
Note 2: MS, SS, MI, SI which separately means satisfied value, standardized satisfied value, important value, standardized satisfied value.

the average value. Authorities should also pay attention to HR3 (Quality of R&D engineers), TR3 (Dispersion of industry information) and MD3 (Competition status), because these criteria were satisfied a degree lower than the average value, but the importance degree is higher (Fig. 5).

4.3. The analyses and discussions of network structure for value-created system

In HSP, human resource (HR) is the key performance aspect ($d-r$ is the highest) of the value-created system. The investment environment (IE) is the main aspect which is affected ($d-r$ is the lowest) by the value-created system (Fig. 6). The aspect of the technology resource (TR) could be improved by enhancing the aspect of HR, or the aspect of the market development (MD). Therefore, the best strategy for raising the value of HSP is to improve HR.

In NTP, the aspect of MD is the key performance aspect ($d-r$ is the highest), and the aspect of HR is affected ($d-r$ is the lowest) by the value-created system (Fig. 6). The aspect of the IE could be improved by enhancing the aspect of MD, and the aspect of IE will further influence the aspect of TR and HR. The improved IE will stimulate the MD upgrade, and the improved TR will stimulate IE upgrade. Therefore, the best strategy for raising the value of NTP is to improve MD. If we want to improve these four aspects of the value-created system, we need to understand the network structure Following the four aspects of the value-created system will be discussed in detailed.

4.3.1. The aspect of human resource

In reference to human resources (HR), the results of the analysis are a little bit different between HSP and NTP. Human brain training organizations (HR2) ($d-r=1.55$) and new job creation (HR4) ($d-r=0.30$) are the main key performance aspects of the value-created system in HSP. New job creation (HR4) ($d-r=1.44$) and incubator resources (HR5) ($d-r=1.29$) are the key performance aspects of the value-created system in NTP. In HSP (Fig. 7), human brain training organizations (HR2) will influence the quality of R&D engineers (HR3) and the supply of qualified personnel (HR1). Otherwise, the supply of qualified personnel (HR1), human brain training organizations (HR2) and quality of R&D engineers (HR3) are interworked and would positively affect incubator resources (HR5). New job creation (HR4) will directly stimulate the development of incubator resources (HR5). Eventually, improved HR5 would enhance the supply of qualified personnel (HR1) and quality of R&D engineers (HR3). Those feedback and corrections in relationship construct enhances the HR network system of HSP (Table 15 and Fig. 7).

The HR network system of NTP is represented in Fig. 7. New job creation (HR4) will influence the supply of qualified personnel (HR1), human brain training organizations (HR2) and the quality of R&D engineers (HR3). Incubator resources (HR5) will influence the supply of qualified personnel (HR1). In other words, new job creation (HR4) and incubator resources (HR5) are the core competency of NTP. They would stimulate the development of supply of qualified personnel (HR1), Human brain training organizations (HR2) and quality of R&D engineers (HR3). However, in HSP, supply of qualified personnel (HR1), human brain cultivation organizations (HR2) and quality of R&D engineers (HR3) could stimulate the upgrade of incubator resources (HR5). Therefore, the human development strategies of HSP are to build good human brain cultivation organizations, such as universities and R&D institutions, and to encourage internal start-ups or spin-offs. However, the human resource development strategies of NTP are to build good incubations (industrial colleges or industrial incubator). Therefore, qualified personnel would be clustered here (Table 16 and Fig. 7).

4.3.2. The aspect of technology resource

In relation to the aspect of technology resources, the results of the analysis were different between HSP and NTP. Quality of research institutions (TR1) ($d-r=0.48$) and dispersion of industry information (TR3) ($d-r=0.45$) were found to be the main key performance aspects in HSP. Quality of enterprises (TR4) ($d-r=1.21$) and occasion for enterprises cooperating (TR5) ($d-r=0.71$) are the main key performance aspects in NTP. The network of technology resources of HSP is shown in Fig. 8. Quality of research institutions (TR1) will influence the occasion for enterprises cooperating (TR5). Quality of research institutions (TR1), dispersion of industrial information (TR3), quality of enterprises (TR4) and occasion for enterprises cooperating (TR5) will influence cooperation

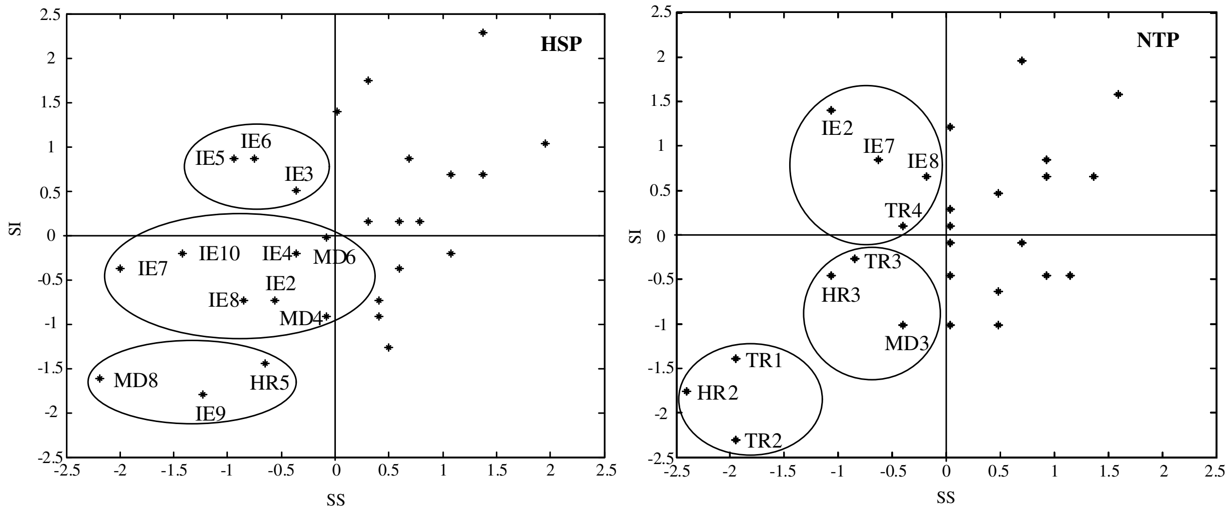

Fig. 5. Improvement strategy of value-created system (HSP/NTP).

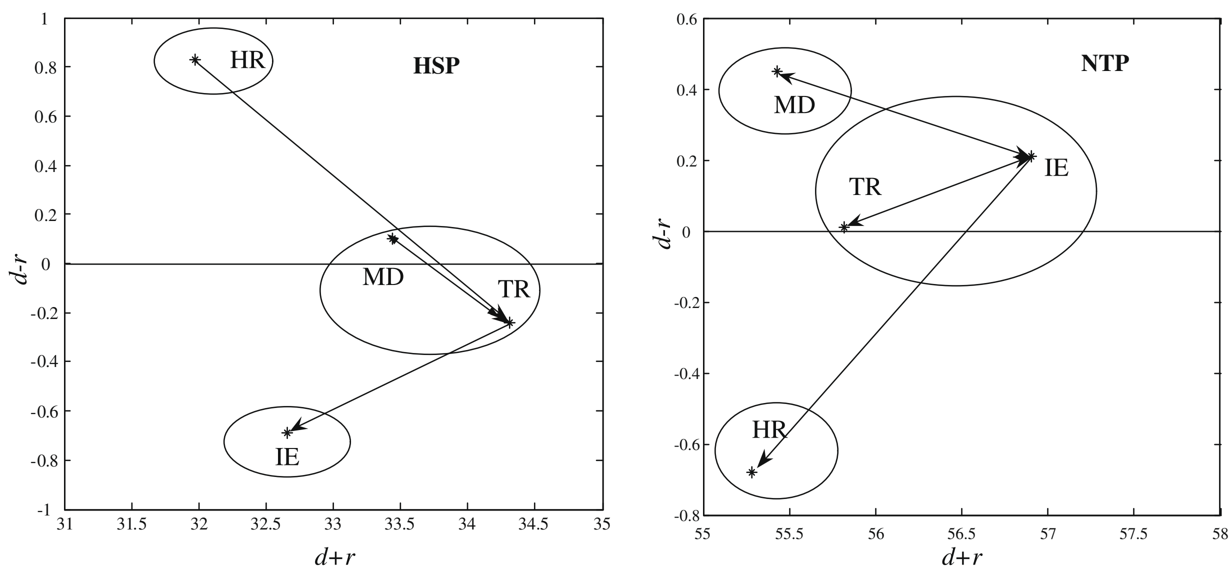

Fig. 6. Network structure of value-created system (HSP/NTP).

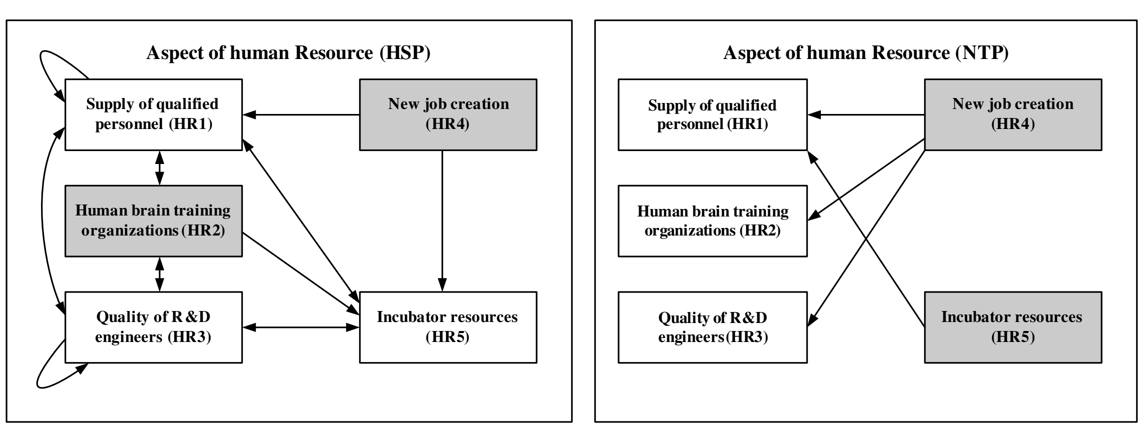

Fig. 7. Network structure of human resource aspect (HSP/NTP).

Table 15
The full influence matrix of human resource aspect (HSP).

Threshold value = 2.38	HR1	HR2	HR3	HR4	HR5
Supply of qualified personnel (HR1)	**2.65***	**2.50***	**2.81***	2.31	**2.87***
Human brain training organizations (HR2)	**2.90***	2.33	**2.81***	2.28	**2.85***
Quality of R&D engineers (HR3)	**2.78***	**2.43***	**2.49***	2.20	**2.78***
New job creation (HR4)	**2.38***	2.11	2.30	1.77	**2.38***
Incubator resources (HR5)	**2.56***	2.25	**2.49***	2.08	2.37

Table 16
The full influence matrix of human resource aspect (NTP).

Threshold value = 3.55	HR1	HR2	HR3	HR4	HR5
Supply of qualified personnel (HR1)	3.24	3.34	3.38	3.13	3.09
Human brain training organizations (HR2)	3.36	3.11	3.30	3.05	3.04
Quality of R&D engineers (HR3)	3.48	3.43	3.21	3.14	3.14
New job creation (HR4)	**3.65***	**3.56***	**3.55***	3.11	3.27
Incubator resources (HR5)	**3.55***	3.53	3.48	3.27	3.04

Table 17
The full influence matrix of technology resource aspect (HSP).

Threshold value = 3.80	TR1	TR2	TR3	TR4	TR5
Quality of research institution (TR1)	3.50	**3.92***	3.61	3.70	**3.80***
Cooperation between industries and academics (TR2)	3.75	3.77	3.69	3.75	**3.87***
Dispersion of industry information (TR3)	3.63	**3.84***	3.38	3.61	3.75
Quality of enterprises (TR4)	3.59	**3.80***	3.52	3.41	3.72
Occasion for enterprises cooperating (TR5)	3.58	**3.81***	3.54	3.59	3.52

between industries and academics (TR2). The improved cooperation between industries and academics (TR2) will enhance the occasion for enterprises cooperating (TR5). Those feedback and correction relationships construct the TR network system of HSP (Table 17 and Fig. 8).

The network of technology resources of NTP is shown in Fig. 9. Occasion for enterprises cooperating (TR5) was found to influence the quality of the research institution (TR1). Cooperation between industries and academics (TR2), quality of enterprises (TR4), and occasion for enterprises cooperating (TR5) will influence dispersion of industrial information (TR3). Those feedback and correction relationship construct the TR network system of NTP (Table 18 and Fig. 8).

HSP could strengthen the development of cooperation between industries and academics (TR2) by improving the quality of the research institution (TR1) and dispersion of industry information (TR3). Therefore, the best technology development strategies of HSP are to enhance the ability of R&D institutions, encourage R&D institutions to proceed with technology transferring and technology licensing, to develop the mechanism of collaboration between industries and academics which could contribute to the cooperation or new product development between R&D teams and enterprises. NTP could strengthen the development of TR by improving the quality of enterprises and occasion for enterprises cooperating. Therefore, the best technology development strategies of NTP are to attract the international business setting of their R&D centers and headquarters. This can be done by the preferential tax policy and investment incentive policy, to encourage enterprises of NTP improving the efficiency of dispersion of industrial information by enterprises cooperation, and to increase cooperation opportunities between NTP's enterprises and R&D centers for enhancing the opportunities and results of technology commercialization.

4.3.3. The aspect of investment environment

In reference to the aspect of the investment environment, the results of analysis were different between HSP and NTP. The network of the investment environment of HSP is shown in Fig. 9. Legislation and government policy (IE5) ($d - r = 0.88$), informational infrastructure (IE4) ($d - r = 0.37$), and regional traffic network (IE7) ($d - r = 0.26$) are positively-affected criteria in HSP. However, the regional development outlook (IE8) ($d - r = -0.53$), scale of industries (IE1) ($d - r = -0.43$), living requirements (IE9) ($d - r = -0.35$), and regional infrastructure (IE10) ($d - r = -0.05$) are negatively-affected criteria. Therefore, the best improvement strategy for HSP is to improve the key criterion "Legislation and government policy (IE5)" firstly, which influences the other criteria most, and is affected by other criteria least. Secondly, HSP should improve the regional traffic network (IE7), informational infrastructure (IE4), and territory of science park (IE2) (Table 19 and Fig. 9). In other words, HSP should complete the policy incentives to attract enterprises that reside inside, and constantly construct traffic networks, informational infrastructure and sufficient land for enterprises' further expanding or developing.

The network of the investment environment of NTP is shown in Fig. 9. Territory of science park (IE2) ($d - r = 1.36$), legislation and government policy (IE5) ($d - r = 0.95$) and regional traffic networks (IE7) ($d - r = 0.57$) are positively-affected criteria in NTP. However, incentive for investment (IE3) ($d - r = -1.29$), regional development outlook (IE8) ($d - r = -0.97$), regional infrastructure (IE10) ($d - r = -0.45$), scale of industries (IE1) ($d - r = -0.35$), informational infrastructure (IE4) ($d - r = -0.34$), and living requirements (IE9) ($d - r = -0.01$) are negatively-affected criteria. Therefore, the best improvement strategy for NTP is improving the key criterion "Territory of science park (IE2)" firstly, which influences other criteria most, and is affected by other criteria least. Secondly, NTP should improve legislation and government policy (IE5), operation

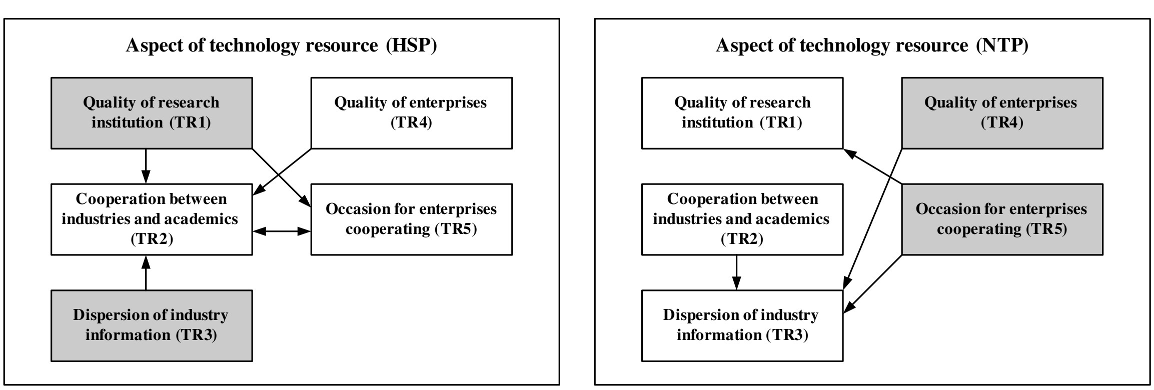

Fig. 8. Network structure of technology resource aspect (HSP/NTP).

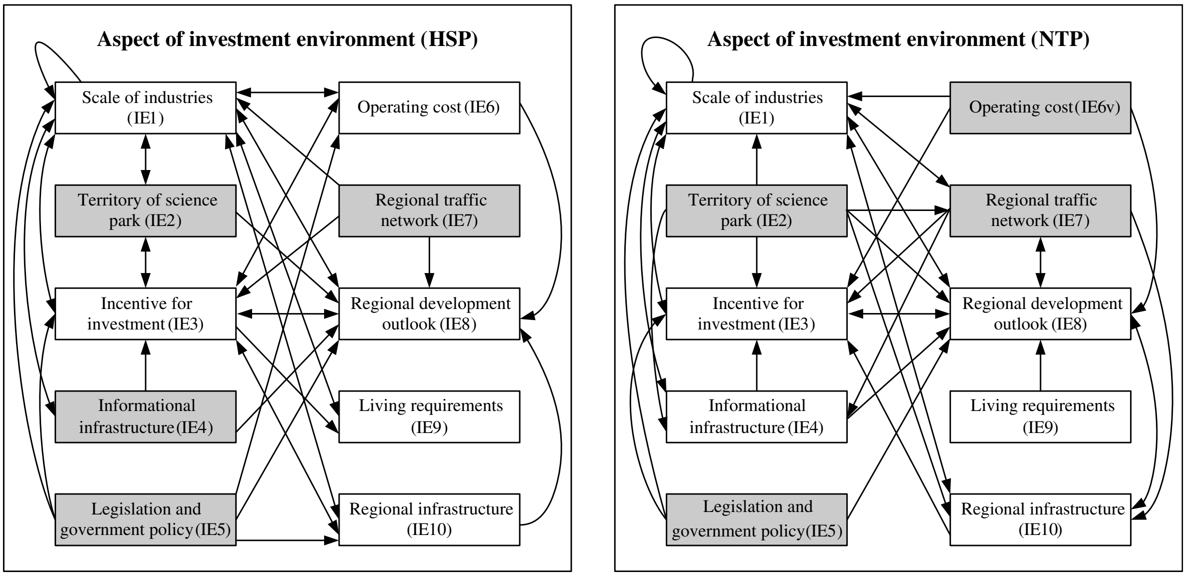

Fig. 9. Network structure of investment environment aspect (HSP/NTP).

Table 18
The full influence matrix of technology resource aspect (NTP).

Threshold value = 2.87	TR1	TR2	TR3	TR4	TR5
Quality of research institution (TR1)	2.57	2.71	2.86	2.48	2.62
Cooperation between industries and academics (TR2)	2.83	2.55	**2.90***	2.53	2.68
Dispersion of industry information (TR3)	2.74	2.66	2.65	2.47	2.64
Quality of enterprises (TR4)	2.85	2.77	**2.97***	2.40	2.74
Occasion for enterprises cooperating (TR5)	**2.87***	2.83	**3.03***	2.64	2.59

costs (IE6), and the regional traffic network (IE7) (Table 20 and Fig. 9). In other words, NTP should expand its territory first for the enterprises' urgent demand of residing inside. The next steps to follow are listed in the next paragraph. NTP should lose the limitation for residence. Therefore, related cooperation firms and outsourcing supporting firms could reside inside the park, contributing to attain the economies of scale. Otherwise, NTP should reduce enterprises' operating costs by the benefit of economies of scale and improve the regional traffic network for better transportation.

4.3.4. The aspect of market development

In reference to the aspect of market development, the results of the analysis are a little bit different between HSP and NTP. The network of market development of HSP is shown in Fig. 10. Scale of region market (MD8) ($d - r = 0.46$), benefit of economies of scale (MD1) ($d - r = 0.31$), reputation (MD4) ($d - r = 0.31$), and comple-

Table 19
The full influence matrix of investment environment aspect (HSP).

Threshold value = 2.01	IE1	IE2	IE3	IE4	IE5	IE6	IE7	IE8	IE9	IE10
Scale of industries (IE1)	**2.06***	2.00	**2.13***	**2.05***	1.91	1.93	**2.08***	**2.18***	1.97	**2.10***
Territory of science park (IE2)	**2.18***	1.89	**2.13***	**2.06***	1.91	1.93	**2.07***	**2.17***	1.97	**2.09***
Incentive for investment (IE3)	**2.03***	1.87	1.92	1.94	1.81	1.82	1.96	**2.05***	1.85	1.99
Informational infrastructure (IE4)	**2.07***	1.89	**2.06***	1.87	1.82	1.82	1.96	**2.07***	1.88	2.00
Legislation and government policy (IE5)	**2.03***	1.88	**2.03***	1.95	1.71	1.82	1.95	**2.04***	1.86	1.96
Operating cost (IE6)	**2.02***	1.86	**2.01***	1.94	1.79	1.71	1.93	**2.01***	1.83	1.94
Regional traffic network (IE7)	**2.16***	1.99	**2.13***	**2.07***	1.89	1.93	1.97	**2.17***	1.97	**2.10***
Regional development outlook (IE8)	**2.12***	1.92	**2.09***	2.01	1.84	1.87	**2.01***	2.00	1.92	**2.03***
Living requirements (IE9)	2.00	1.84	1.98	1.90	1.77	1.79	1.92	**2.01***	1.73	1.93
Regional infrastructure (IE10)	**2.07***	1.91	**2.06***	1.99	1.84	1.86	1.99	**2.08***	1.90	1.91

Table 20
The full influence matrix of investment environment aspect (NTP).

Threshold value = 0.53	IE1	IE2	IE3	IE4	IE5	IE6	IE7	IE8	IE9	IE10
Scale of industries (IE1)	**0.55***	**0.54***	**0.61***	**0.53***	0.50	**0.55***	0.50	**0.61***	**0.53***	**0.56***
Territory of science park (IE2)	**0.58***	0.39	**0.53***	0.44	0.42	0.47	0.44	**0.55***	0.49	0.49
Incentive for investment (IE3)	**0.66***	**0.53***	0.51	0.52	0.49	**0.55***	0.49	**0.61***	**0.53***	**0.56***
Informational infrastructure (IE4)	**0.60***	0.48	**0.56***	0.39	0.44	0.52	0.45	**0.56***	0.48	0.52
Legislation and government policy (IE5)	**0.63***	0.52	**0.59***	0.49	0.39	**0.53***	0.47	**0.58***	0.49	**0.54***
Operating cost (IE6)	**0.59***	0.47	**0.54***	0.46	0.42	0.40	0.43	**0.54***	0.46	0.48
Regional traffic network (IE7)	**0.57***	0.47	**0.53***	0.43	0.42	0.46	0.36	**0.54***	0.49	0.49
Regional development outlook (IE8)	**0.61***	0.49	**0.56***	0.46	0.45	0.49	0.46	0.47	0.49	0.51
Living requirements (IE9)	0.52	0.45	0.49	0.42	0.39	0.43	0.43	0.51	0.37	0.46
Regional infrastructure (IE10)	**0.60***	0.48	**0.55***	0.47	0.43	0.50	0.46	**0.56***	0.50	0.43

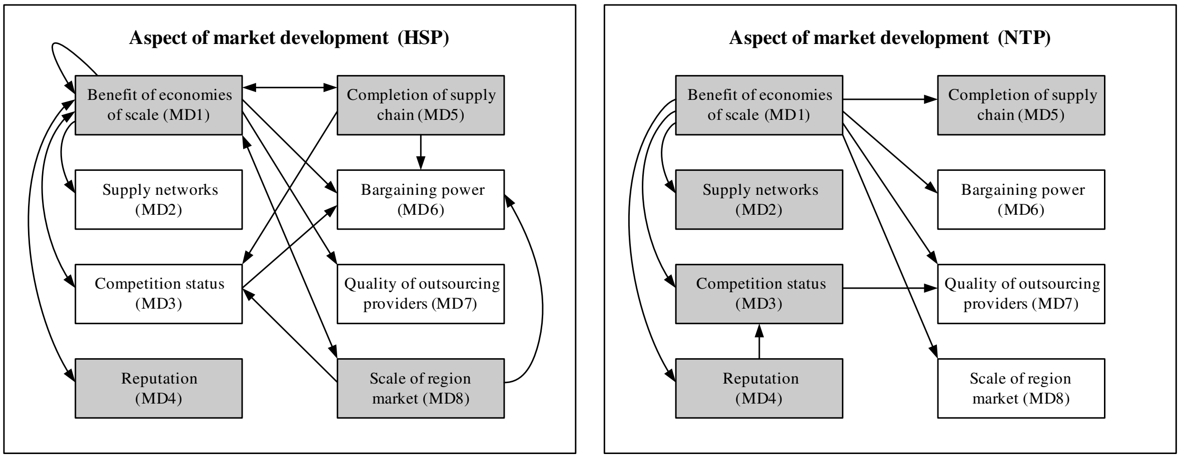

Fig. 10. Network structure of investment market development aspect (HSP/NTP).

tion of supply chain (MD5) ($d-r=0.30$) are positively-affected criteria in HSP. However, the bargaining power (MD6) ($d-r=-0.76$), quality of outsourcing providers (MD7) ($d-r=-0.37$), competition status (MD3) ($d-r=-0.18$), and supply networks (MD2) ($d-r=-0.07$) are negatively-affected criteria. Therefore, the best improvement strategy for HSP is improving the key criterion "scale of region market (MD8)" firstly, which influences other criteria most, and is affected by other criteria least. Secondly, HSP should improve the benefit of economies of scale (MD1), reputation (MD4), and completion of the supply chain (MD5) (Table 21 and Fig. 10). In other words, enterprises supply not only regional markets, but also worldwide markets, with the trend of globalization. Sufficient land for houses and equipment building means sufficient opportunity for capacity expanding. Furthermore, when the industry becomes mature, enterprises of the park could attain economies of scale of the supply chain through vertical integration. Therefore, the cost of transportation and transactions could be lowered through such a logistical network, and the competitive ability of products will be raised.

The network of market development of NTP is shown in Fig. 10. The benefit of economies of scale (MD1) ($d-r=0.80$), supply networks (MD2) ($d-r=0.23$), competition status (MD3) ($d-r=0.11$), reputation (MD4) ($d-r=0.11$) and completion of supply chains (MD5) ($d-r=0.01$) are positively-affected criteria in NTP. However, the scale of regional market (MD8) ($d-r=-0.57$), bargaining power (MD6) ($d-r=-0.46$) and quality of outsourcing providers (MD7) ($d-r=-0.23$) are negatively-affected criteria. Therefore, the best improvement strategy for NTP is to improve the key criterion "Benefit of economies of scale (MD1)" firstly, which influences other criteria most, and is affected by other criteria least. Secondly, NTP should improve supply networks (MD2), competition status (MD3), reputation (MD4) and completion of the supply chain (MD5). In other words, NTP raises the economies of scale through attracting more enterprises to reside inside. Meanwhile, NTP should also contribute enterprises to mutual collaboration and lower transaction costs via the network relationship. Besides, many supporting firms reside inside for internal international companies. Those supporting firms compete with each other for worldwide orders, and therefore raise not only their global competency, but also boost the reputation of NTP (Table 22 and Fig. 10).

Table 21
The full influence matrix of market development aspect (HSP).

Threshold value = 1.01	MD1	MD2	MD3	MD4	MD5	MD6	MD7	MD8
Benefit of economies of scale (MD1)	**1.03***	**1.02***	**1.10***	**1.01***	**1.08***	**1.14***	**1.05***	**1.06***
Supply networks (MD2)	0.97	0.75	0.92	0.83	0.90	0.94	0.87	0.88
Competition status (MD3)	**1.03***	0.91	0.87	0.89	0.96	**1.01***	0.95	0.94
Reputation (MD4)	**1.01***	0.87	0.95	0.76	0.92	0.97	0.91	0.91
Completion of supply chain (MD5)	**1.08***	0.96	**1.02***	0.92	0.88	**1.04***	0.97	0.98
Bargaining power (MD6)	0.99	0.86	0.95	0.84	0.91	0.84	0.88	0.89
Quality of outsourcing providers (MD7)	0.98	0.83	0.92	0.82	0.89	0.93	0.77	0.87
Scale of region market (MD8)	**1.09***	0.95	**1.02***	0.92	1.00	**1.04***	0.97	0.86

Table 22
The full influence matrix of market development aspect (NTP).

Threshold value = 1.61	MD1	MD2	MD3	MD4	MD5	MD6	MD7	MD8
Benefit of economies of scale (MD1)	1.53	**1.61***	**1.66***	**1.64***	**1.62***	**1.62***	**1.69***	**1.65***
Supply networks (MD2)	1.56	1.41	1.56	1.53	1.52	1.53	1.58	1.54
Competition status (MD3)	1.58	1.56	1.48	1.56	1.55	1.56	**1.62***	1.56
Reputation (MD4)	1.55	1.52	1.57	1.42	1.51	1.52	1.59	1.54
Completion of supply chain (MD5)	1.52	1.50	1.54	1.52	1.38	1.49	1.55	1.51
Bargaining power (MD6)	1.47	1.43	1.48	1.46	1.44	1.33	1.49	1.44
Quality of outsourcing providers (MD7)	1.55	1.52	1.58	1.54	1.52	1.52	1.46	1.53
Scale of region market (MD8)	1.48	1.44	1.48	1.45	1.45	1.43	1.47	1.34

5. Conclusions

In this paper, we would like to build the value-created system of science (technology) park. In the early development progress of HSP, HR is supported by technology transferring abroad and foreign cultivation. Later, NCTU, NTHU and ITRI played a role in brain cultivation and training. From the positive point of view, HSP provides a platform for spin-offs, spin-ins or product commercialization initiated by academia or ITRI. Relatively, academa and R&D institutes created well informed people. From the negative point of view, the R&D requests from HSP would disperse R&D resources of R&D institutes which should focus their resources on fundamental R&D. Therefore, those R&D institutes would hire new R&D human brains to cover the leakage on fundamental R&D. In the short run, the gap of the shortage of R&D brains seems to have vanished. However, in the long run, with the trend of globalization, R&D brains would move freely between various R&D institutes. Once the high turnover rate of R&D institutes happens, the gap of the shortage of R&D brains would be larger. That would have negative effects not only on decreasing the self R&D ability of inside enterprises, but also on weakening the penetration effect of R&D institutes. The best solution to solve the dilemma is suggested as follows. For enterprises, HSP can build its own R&D abilities. Those R&D institutes should focus on fundamental R&D and diffuse their fruitful results to enterprises for solving their R&D problems by technology transferring or collaboration. Therefore, the hit of misallocation of R&D resources could be lower down.

In reference to HR, through reviewing the development progress of NTP, the human power came from various channels. Therefore, it is important to build the mechanism of brain cultivation for continuously attracting talent to work in NTP. Enterprises generally agree that they should set up their own R&D centers for brains cultivating and training, but less enterprises fulfill the ideal. The government should afford the inducements of mutual R&D for enterprises. This is especially important for small NTBFs. In the early stages, those R&D centers and incubators afford commercial R&D projects to support the operation of NTBFs. In the long run, cooperation models for enterprises and related human resources platforms should be constructed not only to gather talents and technologies but also to solve the problems of shrinking the gap of talents and technologies gradually.

In reference to TR, in the early development process of HSP, R&D and technologies services were supported by foreign technology transferring or licensing, and so far, have been replaced by NCTU, NTHU and ITRI. As enterprises have built their own R&D abilities, ITRI has changed its roles from R&D supporting to technology services and incubation services. The TR strategies of HSP should be considered thoroughly to prevent the problems of resource misallocation and wastes. Specialty oriented and shared resources are the main thought. Academa should focus on innovated R&D demanded to be implemented within 20–30 years. ITRI should develop industrial technologies needed to be implemented within 10 years. Leading companies of HSP should develop commercialized technologies via collaboration or cross-licensing is needed to be implemented within 5 years. Eventually, ITRI shall play the roles of technologies integration and incubation services. It will find the required technologies and patents from universities and license these technologies and patents via a fair transaction system. ITRI should utilize those licensed technologies and patents to spec-in industry products or to cultivate new start-ups. This not only relieves the concerns regarding insufficient foresight of R&D inputs but also solves the problems concerning a shortage of R&D resources for new start-ups. In HSP, R&D and technologies services derived from foreign technology transferring or licensing, and famed domestic R&D units. It is nice that multinational enterprises and domestic firms could build their own R&D abilities nearby. However, other HSP enterprises are facing a shortage of technology supporting. Though the government might not set up to national R&D institutes nearby, it can build institutes that resemble the ITRI College to execute MOEA R&D projects and plan industrial technologies sharing community. Enterprises could collaborate or share their technology information via a mechanism. New start-ups could execute partial MOEA projects for funding, and become a member in their R&D value chain. The MOEA project encourages the internationally famous enterprises to set-up R&D centers in Taiwan. Through such measures, NTBFs could cooperate with such international enterprises and enroll themselves in the regional cooperation value chain.

In reference to investment environment, the investment strategy is different between HSP and NTP. HSP is backed by government's policies, so the government shall operate it actively. The government shall improve local infrastructures (information infrastructures and regional traffic networks), and enlarge the territory for larger capacity for residing inside the park. Therefore, all HSP's enterprises could obtain the benefit of economies of scale through the cooperation network. NSP was formed naturally by the cluster of enterprises. The government shall enlarge the territory for the larger capacity for residing inside, lose the limitation of stationed enterprises to enlarge the scale of industries, improve regional traffic networks to promote the transportation efficiency, and enhance regional infrastructure construction. The common strategy of HSP and NTP is of expanding its scale for pursuing economies of scale. HSP is improving its infrastructure first and enlarging its territory later. However, NTP is doing this inversely.

In reference to market development, exporting was found to be the driving force for market development in the beginning. HSP's enterprises competed with international competitors by their production and operation efficiency. Those enterprises have to be continuing re-allocating their resources, keeping high value-added products and outward low value-added ones. Therefore, HSP has changed its strategy from technologies input to technologies output. Enterprises must continuously copy the successful production models and processes to those areas of low-cost resources (land or labor), and earn high profits by expanding the scale of investment. HSP must keep actions of technology upgrades and innovation continuously, and become the benchmark park of the production process which needs lots input of human and technology resources.

NSP is formed naturally by the cluster of enterprises, and then international markets are their main target. NTP which is without clusters of production and marketing attracts the information software service industry, electronic component industry and telecommunication industry to reside inside and forms its working model. The continuous residence of international firms also attracts the residence of enterprises in the industry value chain. NTP is near Taipei city which is the political and commercial center in Northern Taiwan. The information infrastructures and transportation systems were built well. Those environments and conditions are good for setting up the operations headquarters and the R&D center of international enterprises. NTP shall position its function of regional services integration center here. NTP could utilize its abilities of R&D and marketing, integrate Taipei's financial system and the production base (like HSP) and apply the local logistical systems (Taoyuan (Taipei) international airport and Keelung port). Therefore, NTP could become the regional operations center for international enterprises.

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