Chiao Da Management Review
Vol. 29 No. 2, 2009
pp.131 -161

無形資產評鑑模型之建構與應用

Constructing and Employing the Appraising Model of Intangible Assets

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摘要：本研究並無試圖評估無形資產之絕對價值，而是想藉由價值驅動力(value drivers) 概念探討各公司無形資產之相對價值比重，本研究認為價值驅動力的概念將能清楚瞭解各公司無形資產是如何被創造。本研究將層級分析(AHP)法應用至無形資產之評鑑程序上，此乃因 AHP 法能夠將非財務性的價值驅動力加以量化並評估出其對無形資產之貢獻權比；本研究主要目的為：1、建構一嘗試性(tentative)之無形資產評鑑模型，協助企業正確評估公司價值比重並避免在衡量企業價值時因以財務報表為主要依據而產生盲點。2、有鑑於高科技產業無形資產佔總資產比例甚高，本研究乃以台灣新竹科學園區6大產業及一個案例模擬作為研究標的，以期實證本研究模型之可行性，並探討不同高科技產業間之無形資產之價值比重及評價應用。本研究之實證結

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果為建構不同科技產業理想之無形資產配置，顯示不同產業之無形資產特色，並可輔助企業評價及提升價值基礎管理成效。

Abstract: This paper does not intend to actually valuate intangible assets but focuses to investigate the relative value distribution of corporate intangible assets, and this links closely to the concept and application of value drivers. That is because we believe that drivers or attributes of the value significantly determine how virtual value of these intangibles can be created for companies. We apply the analytic hierarchy process (AHP) to the appraising process of intangible assets. The AHP method can mainly sort the non-financial value drivers in order according to their weighted contributions. The key purpose of this paper is to construct a tentative model for the evaluation of intangible assets, which helps business to more correctly appraise corporate value ratios and avoid bias due to mainly relying on financial statements when measuring an entity value. In addition, in view of the significant proportion of intangible assets over total assets in high-technology industries, this research then takes six industries in Hsinchu Science Park and one virtual case as the research objects in order to test the applicability of our model, as well as exploring the value weights of intangible assets and its evaluation amongst different high-technology industries. Besides, the empirical result of this paper is mainly to support business appraisal and thus improve the effectiveness of value based management.

關鍵字：無形資產；價值驅動力；層級分析(AHP)法；評鑑模型；高科技產業；企業評價；VIKOR

Keywords: Intangible Assets; Value Drivers; Analytic Hierarchy Process; Evaluation Model; Hi-tech Industry; Business Appraisal; VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR)

1. Introduction

Intellectual capital or intangible assets are recognized as the most important assets of many of the world's largest and most powerful companies; it is the foundation for the market dominance and continuing profitability of leading corporations. In addition, it is often the key objective in mergers and acquisitions, and knowledgeable companies are increasingly using licensing routes in order to transfer these assets to low tax jurisdictions. Nevertheless, the role of intangible assets in business is insufficiently understood. Accounting standards are generally not helpful in representing the worth of intangible assets in company accounts, and they are often under-valued, under-managed or under-exploited. Namely, despite the importance and complexity of intangible assets, there is generally little coordination between the different professionals dealing with these relating issues. Recently issued accounting standards have created the need for valuation of intangible assets for financial statement purposes. Arriving at these valuations can be a complicated process. This raises the question of which values remain hidden within internally developed intangibles. Therefore, the balance sheet undoubtedly has significant limitations in terms of reporting an entity's true value. Internally developed intangible assets, even those for which a fair value may be determinable, are not recognized in the financial statements. Investors and creditors recognize these limitations and presumably perform independent research and analysis in their investment and credit decisions.

Meanwhile, one of the most vexing problems in business valuation is the issue of valuing intangible assets. They come in many forms, including patents and trademarks, copyrights, mailing lists, exclusive contracts, royalty agreements, work-in-progress, proprietary designs, and many others. These assets and intellectual properties have a real value that can be estimated through investigation and objective calculation. Sveiby (2002) reviewed 28 intangible asset valuation methods, based on the frameworks of Luthy (1998) and William (2001), and classified them into four categories. However, there is still no universal valuation method. Studies regarding intangible assets evaluation involve the valuation determinants (Chiu and Chen, 2007), the evaluation methods (Johnson, 1999; Kaplan & Nortan, 2004; Dubin, 2007), and the relationship between intangible assets and share price (Chan et al., 2001; Johnson et al., 2002).

This paper, however, does not intend to actually valuate intangible assets but focuses to investigate the relative value distribution of corporate intangible assets, and this closely links to the concept and application of value drivers. This is because we believe that drivers or attributes of the value significantly determine how virtual value of these intangibles can be created for companies. We apply the Analytic Hierarchy Process (AHP) to the appraising process of intangible assets. The AHP method can mainly sort the non-financial value drivers in order according to their weighted contributions. Therefore, one of the key purposes of this paper is to develop a tentative model for the evaluation of intangible assets, which helps businesses to more correctly appraise corporate value ratios and avoid bias due to mainly relying on financial statements when measuring an entity's value. In addition, in view of the significant proportion of intangible assets over total assets in high-technology industries, this research, then, uses six industries in Hsinchu Science Park, Taiwan and one virtual case as its research objects to test the applicability of its model, as well as exploring the value weights of intangible assets and its evaluation amongst different high-technology industries.

2. Intangible Asset

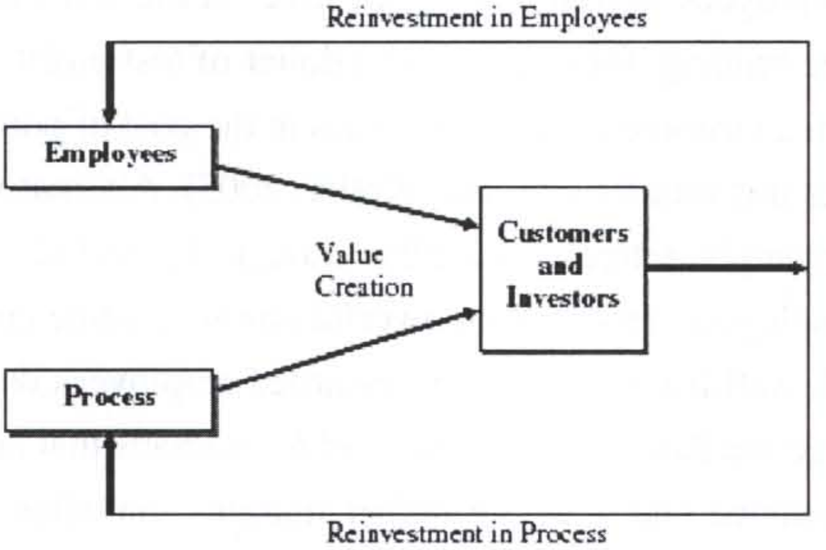
2.1 Value Creation

Corporations sometimes choose not to focus on value creation and, instead, unintentionally make decisions that systematically decrease the long-term value of their businesses. This is perhaps because managers tend to define their organizations' interests narrowly. This constricted view is powerfully reinforced by financial accounting systems that are well adapted to the industrial economy but are inadequate in the information economy. The accounting and finance conventions of the industrial age are effective at valuing tangible assets, but they largely ignore the value of harder-to-quantify assets, such as employee satisfaction, learning, R&D effectiveness, and customer loyalty (Mathis and Jackson, 2003). In the information age, intangible assets are far more important than the tangible assets that traditional accounting systems were designed to measure.

If management defines the organization's self interest (and consequently its goals) too narrowly – for example, to maximize this year's or this quarter's reported earnings, it will view this interest as being at odds with the needs of customers and employees. Given that perspective, in the short term, every dollar spent on employee training, for instance, is a dollar of lost profit. Every additional dollar earned from a customer, even if it comes at the cost of poor service or price gouging, improves this quarter's results (Kotler, 2003). Alternatively, if managers define their company's interests broadly enough to include the interests of customers and employees, an equally powerful spiral of value creation can occur. Highly motivated, well-trained, properly rewarded employees deliver outstanding service, while effective R&D investments lead to products that enjoy a significant value-adding advantage and generate higher margins. Satisfied, loyal customers (and new customers responding to word-of-mouth referrals) drive revenue growth and profitability for investors (Kotler, 2003).

One way to build an understanding of these dynamics is to identify the key capabilities, resources, and relationships that are the basic ingredients of value creation for a particular firm and to think of these ingredients as assets that either grow or diminish over time, depending on the way in which they are managed. This is, then, useful to map a company's key assets by building a "value-creation net" focused on employees, processes, customers, and investors (see Figure 1). A firm's capabilities and skills determine the degree to which the company can meet these requirements and provide a greater value than its competitors (Hamel, 1991). In building the value-creation net, managers should decide which assets are the most important drivers of the company's value-creation system. For example, employee learning and job satisfaction are two assets that could be tracked on the part of employees in the value-creation net. As managers identify the strategic assets that belong in each value-creation net, they also must articulate the relationships among these assets. By tracing the dynamics through which customer, employee, and process assets accumulate, interact, and ultimately drive profitable growth, a company will be well on its way to managing the fundamentals of value creation and avoiding the pitfalls of management by following a set of narrow financial measures.

Figure 1
Value-Creation Net



Source: Lin and Lin (2006, p.97)

2.2 Value Driver

Theoretically, an asset, whether tangible or intangible, is assessed through its expected future discounted cash flow. This is the basic principle of the discounted cash flow. From such premise, strategies drawn by a company may positively or negatively affect a given company's value. Consistent with this principle, Lev (2001) defines intangible assets as a right for future benefits that do not have a physical or financial body (stocks or debt securities).

In order to allow a better understanding of the intangible asset concept, it is necessary to present its classification. Sveiby (1997) points out that intangible assets comprise employee competence, internal structure, and external structure. Employee competence involves the capability to act in a wide variety of situations to create both tangible and intangible assets. The internal structure includes patents, concepts, models, and computer and administrative systems. The external structure includes relationship with customers and suppliers. Stewart (1999) argues that intangible assets include human assets, structural assets, and customer assets. Human assets are employees' problem-solving capability, which indicate the entire staffs' knowledge, skills, capability, experience, virtual ownership, practice community, and intangible interaction. Structural assets can provide the capability of knowledge management for an enterprise to innovate. Customer assets, indicating learning and trust to each other, are the relationship between stakeholders in terms of customer satisfaction, customer growth rate, and customer participation. And Lev (2001) categorizes intangible assets into marketing, technology, artistic, data processing, engineering, customer-related, contract, human capital, location, and goodwill. Table 1 depicts a summarized classification proposed by Kayo (2002) based on the above literature discussions.

Table 1

A Proposal for Classifying Intangible Assets

Type of intangible	Main intangible assets
Human assets	knowledge, talent, capabilities, skills, employee's experience, superior management, key employees, training and development, among others.
Innovation assets	research and development, patents, secret formulas, technological know-how, among others.
Structural assets	procedures, software, data bases, information systems, market intelligence, market channels, among others.
Relationship assets	brand, trademarks, copyrights, contracts with clients, suppliers, contract of licensing, franchise, among others.

Source: Kayo (2002, p.19)

Table 1 presents a taxonomy for the intangibles assets. Some authors consider such assets to be non-financial value-drivers. However, it is necessary to differentiate intangible assets from drivers that lead to the formation of their values. This means, intangible assets must not be considered as drivers themselves. Drivers must be attributes that would be responsible by the definition of the intangible assets' values. An example of a possible list of non-financial drivers of value is presented by Kalafut and Low (2001). These authors suggest a list containing nine drivers, which are the most critical ones in their researches.

These drivers are be innovation, quality, customer relation, management capabilities, alliances, technology, brand value, employee relations, and environmental and community issues.

Such drivers are part of what Kalafut and Low call the value-creation index. Non-financial drivers, as suggested by Kalafut and Low, are attributes that may be associated with different types of intangible assets. The higher or lower intensity in the relative importance of each driver may influence the formation of value for intangible assets. Non-financial drivers are of major importance in allowing the understanding of the nature of intangible assets. According to Feltham and Ohlson (1995), the value of intangibles can cause abnormal profits. Evidently, in order to allow such profit to occur, sales and services revenue must be maximized and several types of expenditures (costs and expenses) must be minimized in order for the sales to be maximized. It is necessary to understand why consumers buy a given product from a company and do not buy it from its competitor. What leads, for instance, a consumer to buy a luxury automobile, such as the Mercedes, and not to buy a popular car, such as a VW? It can be supposed that the consumer is interested in attributes, such as status, tradition, high-technology, stability, and comfort. These attributes form the so-called purchasing drivers. The two first drivers (status and tradition) have an essentially intangible nature. High technologies may have a tangible influence, such as the use of on-board computers. At last, stability and comfort are essentially tangible because they depend on physical attributes. Each type of asset, whether tangible or intangible, exerts differentiated influences on each driver. For instance, the brand may exert a major influence on the status and tradition drivers. As status and tradition are intangible drivers by their nature, it can be deducted that the brand is an intangible asset.

However, again, it is important to remember that the analysis of drivers is only part of the evaluation process of intangible assets. Once the process is complete, these drivers must be associated to economical-financial forecast results. For example, it can be used as a variation of the discounted cash-flow method combined with the EVA (Economic Value Added) concept.

3. Methodology

The main purpose of this study is to investigate the expected ratio distribution of intangible assets for different high-tech industries located in the science park. The AHP is adopted to help to construct the evaluation model for this purpose. A virtual case is then taken for testing the applicability of this model through the data processing of grey relational analysis and the VIKOR method.

3.1 Analytic Hierarchy Process (AHP)

This research primarily uses the Analytic Hierarchy Process (AHP) in order to explore the issues in question. For managerial purposes, it is important that the management succeeds not only in estimating the value of the intangibles, but also in identifying the relative contributions of the different drivers to the total of the company's intangibles. This way, the managerial strategies may be better planned in order to allow investments and efforts to be allocated as to contemplate the importance of the value drivers. In such context, the AHP proposed by Saaty (1996) appears to be an extremely useful mechanism that allows the change of the qualitative and subjective comparisons between drivers in quantitative and cardinal features.

The AHP method is a multi-criteria method that is analysis based on an additive weighting process, in which several relevant attributes are represented through their relative importance. AHP has been extensively applied by academics and professionals, mainly in engineering applications involving financial decisions associated with non-financial attributes (Saaty, 1996). In the specific case of the intangible asset's analysis, the AHP allows the "hierarchization" of subjective opinions in categories of drivers of value, making possible a quantitative treatment that leads to a numerical estimate of the relative importance of each driver.

Through AHP, the importance of several attributes is obtained from a process of paired comparison, in which the relevance of the attributes or categories of drivers of intangible assets are matched two-on-two in a hierarchic structure. Initially, the management must compare the several drivers following the verbal-judgment scale presented in the table below (Table 2). Intermediate values are possible, and they correspond to the intermediate importance relationships among attributes.

Table 2
Verbal Scale for Pairs of Compared Attributes

Scale	Definition	Description
1	Equally important	Two alternatives are equally important.
3	Moderately important	Experience and judgment moderately prefer to one alternative.
5	Strongly important	Experience and judgment strongly prefer to one alternative.
7	Very strongly important	Experience and judgment very strongly prefer to one alternative.
2, 4, 6, 8	The middle value between two continued scale	Intermediate value.

Source: Saaty (1980)

For instance, in comparing the relative importance between drivers A_i related to A_j, if the judgment is 9.00, the management considers that the attribute A_i is extremely more important than attribute A_j in generating intangible assets. With this procedure, the verbal judgment mechanism composed by the management's perceptions is transformed in numerical equivalents. Thus, the managers must perform the qualitative comparison of every driver among themselves, according to the previous table and, thus, obtaining the table below (Table 3).

Table 3
Matrix of Paired Comparison among n-Evaluation Criteria

Attribute	A_1	A_2	...	A_n
A_1	$X_{11} = 1$	X_{12}		X_{1n}
A_2	$X_{21} = 1/X_{12}$	X_{22}		X_{2n}
...				
A_n	$X_{n1} = 1/X_{1n}$	$X_{n2} = 1/X_{2n}$		$X_{nn} = 1$

In the AHP model, if the relative importance of A_i related to A_j is X_{ij}, the opposite comparison of attribute A_j related to attribute A_i is equal to $1/X_{ij}$. Obviously, the diagonal of the matrix of the comparison is equal to 1.00, since each driver is compared to itself. Considering the paired comparison's matrix and based on mathematical concepts of eigenvalues and eigenvectors, Saaty (1996) sets that the relative weights of each attribute may be calculated through the following equation:

$$W_i^{(j)} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}}, with\ w_i = \frac{\sum_{j=1}^{n} w_i^{(j)}}{n}$$

The relative weights may be submitted to a cardinal comparison. This way, the evaluation based on multiple criteria is performed weighting the indicators of attributes of each alternative by the relative weights. AHP allows the identification of a parameter on the consistence level of the relative importance of the attributes since subjective judgment may present decision biases. Such index reflects the coherence level of comparisons among attributes, and this is calculated through the following equations:

$$C.I. = \frac{\lambda - n}{(n-1)\beta}, com\lambda = \frac{\sum_{i=1}^{n} \alpha_i}{n}, \alpha_i = \frac{\sum_{j=1}^{n} x_{ij} \cdot w_i}{w_i}$$

$$C.R. = \frac{C.I.}{R.I.}$$

where [ ] = 0,0; 0,0; 0,58; 0,90; 1,12; 1,24; 1,32; 1,41; 1,45; 1,49 for n =1; 2; ...; 10 represents a consistent index (C.I.) of a random paired comparison matrix. The consistency ratio (C.R.) is measured by the ratio of C.I. to random index (R.I.). The determination of R.I. is shown in Table 4. Thus, AHP incorporates several attributes when evaluating alternatives and allows the monitoring of the managers' coherence related to the judgment of the relative importance of the attributes. The values of w_i correspond to the relative weights of each attribute A_i, and the index C.I. and C.R. represent coherence measurements of the comparative evaluation performed by the managers. Generally, it is considered that the results of the paired comparisons are coherent whenever the C.I. and the C.R. are lower than 0.10.

Table 4
Random Index

N	1	2	3	4	5	6	7	8
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41
N	9	10	11	12	13	14	15	
R.I.	1.45	1.49	1.51	1.48	1.56	1.57	1.59	

Source: Saaty (1980).

3.2 Data Processing of Grey Relational Analysis

Data processing of grey relational analysis conducts data set to fit the comparability before the grey relational generation (Deng, 1990; Chang et al., 1996). This method not only normalizes the data set into values from 0 to 1 but adjusts all factors' objectives to larger-the-better; thus, this method does not convert the original information and avoids non-definition of factors. It also eliminates the problem with different units of each factor. In order to conduct data processing, there exist three data processing methods: larger-the-better, small-the-better and nominal-the-best. This study adopts larger-the-better method to conduct data set in the virtual case analysis. The equations of these methods are as follows (Deng, 1990; Chang et al., 1996):

(1) If the expectancy is larger-the-better (e.g., the benefit), then it can be expressed by:

$$K_{it}^{*}=\frac{k_{it}-\min_{i} k_{it}}{\max_{i} k_{it}-\min_{i} k_{it}}$$

where k_{it} denotes the expert's evaluation of the tth company on the ith criterion.

(2) If the expectancy is smaller-the-better (e.g., the cost and defects), then it can be expressed by:

$$K_{it}^{*}=\frac{\max_{i} k_{it}-k_{it}}{\max_{i} k_{it}-\min_{i} k_{it}}$$

(3) If the expectancy is nominal-the-best value, then it can be expressed by:

$$K_{it}^{*}=\frac{\left|k_{it}-k_{obj}\right|}{\max_{i} k_{it}-k_{obj}}$$

where $\max_{i} k_{it} \geq k_{it} \geq \min_{i} k_{it}$

3.3 The VIKOR Method

The VIKOR method, which is one of compromise programming methods in multi-criteria decision making, is proposed by Opricovic (1998, 2002). This study employs VIKOR method to rank the companies' priority in the virtual case. The basic concept of VIKOR is to determine the compromise solution and the weight stability intervals for preference stability of the compromise solution obtained with the given weights (Opricovic & Tzeng, 2004). This method introduces the multi-criteria ranking index based on the particular measure of "closeness" to the "ideal" solution (Opricovic, 1998). The procedure of the VIKOR application is as follows (Opricovic and Tzeng, 2007; Chu et al., 2007).

(1) Step 1: calculate the normalized value.

For the process of normalized value, where K_{it} is the value conducted by the data processing of grey relational analysis; *i* and *t* denote the *i*th criterion and the *t*th company, respectively. The equation is as follows:

$$f_{it} = K_{it} \Big/ \sqrt{\sum_{i=1}^{m} K_{it}^2}, i = 1,2,\ldots,n; t = 1,2,\ldots,T$$

(2) Step 2: determine the best and worst values.

For all the criterion functions, the best value is f_i^* as opposed to the worst value f_i^-; that is, for criterion $i = 1,2,\ldots,n$, the best value f_i^* and the worst value f_i^- are defined as follows:

$$f_i^* = \max_t f_{it}$$

$$f_i^- = \min_t f_{it}$$

(3) Step 3: compute the values S_t and R_t.

The values S_t and R_t are defined as the following equations:

$$S_t = \sum_{i=1}^{n} w_i \left(f_i^* - f_{it}\right) / \left(f_i^* - f_i^-\right)$$

$$R_t = \max_i \left[w_i \left(f_i^* - f_{it}\right) / \left(f_i^* - f_t^-\right)\right]$$

where w_i denotes the weights of criteria.

(4) Step 4: compute the value *Q*.

The final value *Q* is as follows:

$$Q_t = v\left(S_t - S^-\right) / \left(S^* - S^-\right) + (1 - v)\left(R_t - R^-\right) / \left(R^* - R^-\right)$$

where $S^* = \max_t S_t$, $S^- = \min_t S_t$, $R^* = \max_t R_t$, $R^- = \min_t R_t$. S^- is a maximum group utility (majority rule), and R^- is the minimum individual regret of the "opponent"; v is introduced as a weight for the strategy of maximum group utility, whereas $1-v$ is the weight of the individual regret, usually $v = 0.5$ (Opricovic and Tzeng, 2007).

By sorting values Q_t, the companies' priority in the virtual case can be determined.

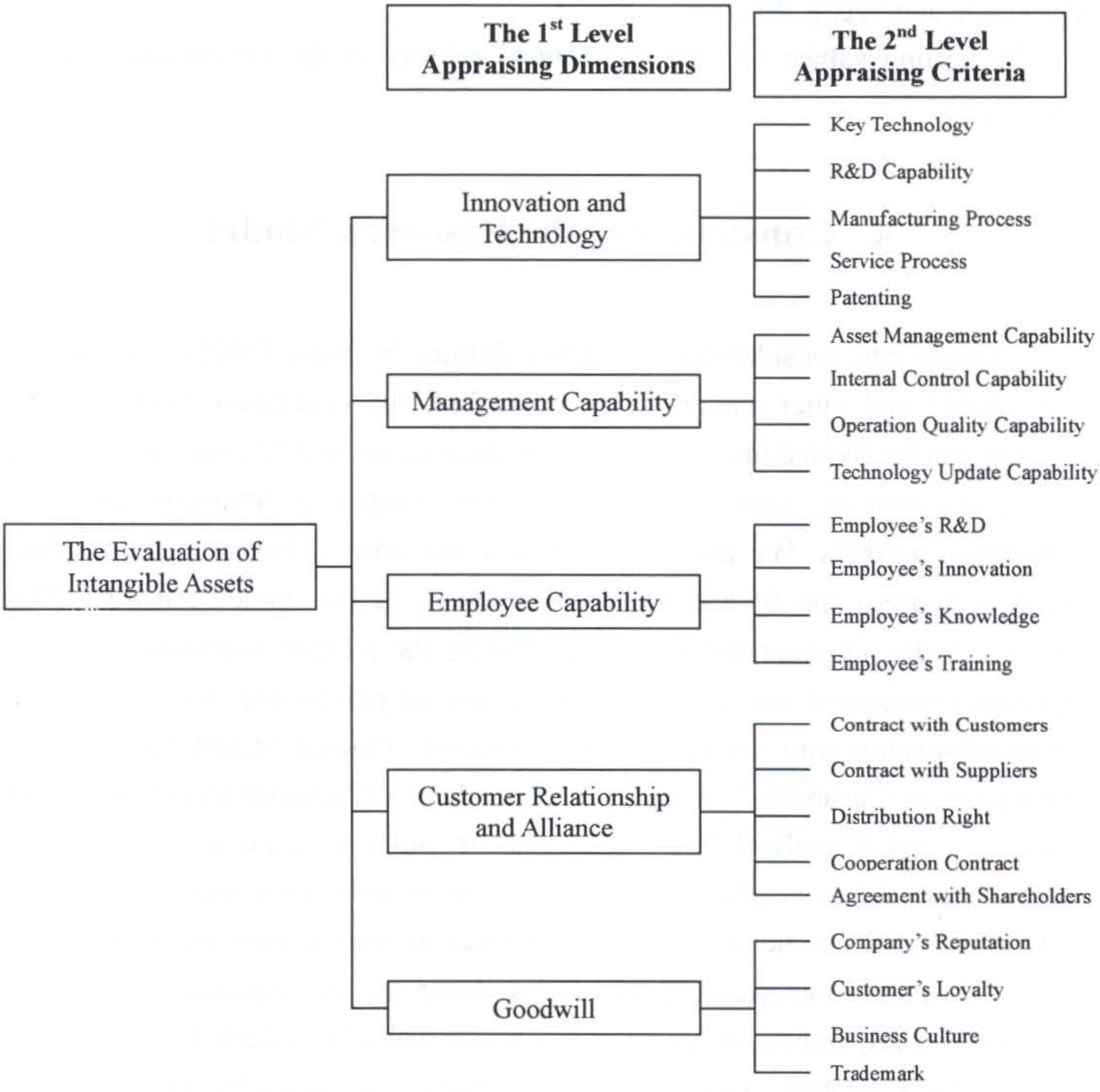
4. Constructing the Research Model

Taking into consideration categories defined by Kayo (2002), Kalafut and Low (2001) and other authors as noted before, the evaluation model of this research can be divided into five appraising dimensions and 22 appraising criteria for probing into the issue regarding the value weights of intangible assets in technology business. We also invite experts and other scholars in the relating fields to confirm the fit and the reasonableness of the model construct. The purpose of the questionnaire is to help allocate the relative importance of each appraising dimension and criterion while comparing pair by pair. First, we issued the questionnaires with five dimensions, including "Innovation and Technology," "Management Capability," "Employee Capability," "Customer Relationship and Alliance," and "Goodwill," to respondents in order to explore the perceived relative importance (weights). Second, again, we examined the appraising criteria underlying the five dimensions mentioned above in order to gain the respondents' perceived relative importance (weight). By doing so, the respondents' views of each relative importance of appraising criterion could be reflected and analyzed further. The evaluation model of intangible assets constructed by this research is depicted in Figure 2.

5. Empirical Analysis

5.1 Issuing and Recollecting of the Questionnaires

Figure 2
The Evaluation of Intangible Assets in Taiwan's High-tech Industries



The targets of this research questionnaire are the six industries in Hsinchu Science Park, Taiwan, including IC foundry industry, communication industry, computer and peripheral equipment industry, optoelectronic industry, precision machinery industry, and biotechnology industry. The experts interviewed are professional executives from each department of these industries, including operation, marketing, human resources, research and development, and finance, with work experience of more than 15 years. This paper is aimed to understand experts' perceptions regarding the weights of value drivers in different industries. Therefore, the AHP method is used during the survey, attempting to quantitatively rank these non-financial contributions. The implicit assumption underlying here is that genuine intangible asset values may vary between firms, but professional executives within the same industry should have a converged idea regarding the ways in which the intangible assets should be arrayed when they consider comparing the relative importance of the value drivers. Therefore, directly after obtaining the ideal measure of intangible assets surveyed by the AHP, the VIKOR method can be used by the management in order to assess how the virtual arrangement of the individual company's intangibles is diverged from the so-called ideal structure; this is particularly useful while encountering business mergers and acquisitions since it serves as a helpful reference for business valuation. In the AHP survey, a total of 328 copies of the questionnaire were issued, 142 copies recollected, and 118 copies with C.I./C.R. ratio less than 0.1 were selected to be effective analyzing samples. See Table 5 for statistics of recollecting status. Note that the ratio of effective questionnaires in IC foundry industry is not the highest; even though so, more copies were issued in this industry due to its large capital structure as well as numerous operation departments than other industries, which could reach more respondents.

5.2 AHP Weights

According to the investigation of weights (relative importance) of intangible asset appraising dimensions in this research, "technology innovation" has been considered the most important dimension of the five by professional executives in IC foundry, communication, computer and peripherals, and optoelectronic industries. The weights are 0.422 for optoelectronic industry, 0.385 for computer and peripherals industry, 0.337 for communication industry, and 0.277 for IC foundry industry. Because R&D and technology innovation are the major sources of competence in the above industries, the innovation and technology dimension is emphasized in order to correspond with the fast-changing market technological demand effectively. On the other hand, the precision machinery industry views the "goodwill" dimension to be most important and the weight of the dimension is 0.281. We believe that this is because the precision machinery industry trades mainly through the traditional business channel (B2B) that frequent trading and cooperation between enterprises and raises the importance of company goodwill in this industry. Then, "management capability" is thought to be the most crucial dimension in biotechnology industry with the weights at 0.346 due to its industry characteristics of high R&D investment risks. In other words, there are many other potential factors that may reduce the technology efforts, and thus, dimensions, such as asset management, laws and regulations, internal control, commercialization process, integration capability, and management capability, are much greater concerns in this industry than the technical concern.

The result of our research also reflects the fact that the relative importance of intangible asset attributes varies among technology industries. Take IC foundry, communication and optoelectronic industries for example. "key technology" and "R&D capability" are emphasized when they evaluate their intangible assets, and among which, the optoelectronic industry also pays much attention to the "internal control" criterion in order to accord with the characteristics of quality, innovation, and fast development that high-tech industries pursue. In addition, IC foundry, computer and peripherals, and precision machinery industries think highly of "goodwill" as well, and specifically, the precision machinery industry even places more emphasis on the "customer loyalty" criterion. Furthermore, "asset management capability," "operation quality capability," "technology update capability," "patent," and "employee R&D" criterion are highly valued in biotechnology industry to cohere with the industry's emphasis on criteria, such as management capability and development of patens. Finally, the top or second ranked intangible asset concern is indicated as "key technology" among five technology industries in our investigation, including IC foundry, communication, computer and peripherals, optoelectronic, and precision machinery industries. See Tables 6 and 7 for ideal value weights in the light of intangible assets appraising dimensions and criteria in each technology industry from our survey.

Table 5

Statistics of Questionnaires Recollected in Each Industry

Industry	Copies of Questionnaire Issued	Copies of Questionnaire Recollected	Copies of Effective Questionnaire	Percentages of Effective Copies
IC Foundry	220	90	83	37.73%
Communication	23	10	7	30.43%
Computer and Peripherals	36	14	10	27.78%
Optoelectronic	19	10	8	42.11%
Precision Machinery	14	9	5	35.71%
Biotechnology	16	9	5	31.25%
Total	328	142	118	35.98%

Table 6

The Weights of Appraising Dimensions of Intangible Assets in Different Technology Industries

Industry Category/ Dimension	Technology Innovation	Management Capability	Employee Capability	Customer Relationship	Goodwill
IC foundry	0.277 (1)	0.205 (2)	0.185 (3)	0.169 (4)	0.164 (5)
Communication	0.337 (1)	0.277 (2)	0.126 (5)	0.130 (3)	0.129 (4)
Computer and Peripherals	0.385 (1)	0.171 (2)	0.168 (3)	0.119 (5)	0.158 (4)
Optoelectronic	0.422 (1)	0.178 (3)	0.182 (2)	0.142 (4)	0.076 (5)
Precision Machinery	0.232 (2)	0.185 (3)	0.182 (4)	0.119 (5)	0.281 (1)
Biotechnology	0.191 (2)	0.346 (1)	0.150 (4)	0.186 (3)	0.126 (5)

Table 7
The Weights of Appraising Criteria of Intangible Assets in Different Technology Industries

	Appraising (Dimension) / Criterion/ Industry	IC foundry	Communication	Computer and Peripheral	Optoelectronic	Precision Machinery	Biotechnology
Innovation and Technology	Key Technology	0.095 (1)	0.111 (2)	0.151 (1)	0.131 (2)	0.110 (1)	0.041 (10)
	R&D Capability	0.063 (3)	0.116 (1)	0.062 (4)	0.134 (1)	0.053 (8)	0.033 (13)
	Manufacturing Process	0.041 (11)	0.060 (6)	0.052 (7)	0.067 (3)	0.023 (15)	0.032 (14)
	Service Process	0.035 (13)	0.022 (15)	0.049 (9)	0.042 (10)	0.018 (20)	0.028 (17)
	Patenting	0.040 (9)	0.028 (14)	0.072 (3)	0.047 (8)	0.028 (13)	0.057 (4)
Management Capability	Asset Management Capability	0.043 (10)	0.072 (4)	0.059 (5)	0.036 (13)	0.033 (11)	0.166 (1)
	Internal Control Capability	0.048 (7)	0.097 (3)	0.035 (12)	0.041 (11)	0.053 (8)	0.048 (6)
	Operation Quality Capability	0.059 (4)	0.045 (7)	0.027 (14)	0.045 (9)	0.058 (7)	0.070 (2)
	Technology Update Capability	0.055 (5)	0.063 (5)	0.049 (9)	0.056 (6)	0.040 (10)	0.063 (3)
Employee Capability	Employee R&D	0.066 (2)	0.037 (9)	0.056 (6)	0.061 (4)	0.069 (5)	0.056 (5)
	Employee Innovation	0.046 (8)	0,036 (10)	0.041 (11)	0.049 (7)	0.077 (4)	0.043 (8)
	Employee Knowledge	0.040 (11)	0.032 (11)	0.048 (10)	0.040 (12)	0.021 (18)	0.029 (16)
	Employee Training	0.033 (15)	0.020 (16)	0.023 (16)	0.032 (14)	0.015 (21)	0.022 (18)
Customer Relationship	Contract with Customers	0.051 (6)	0.036 (10)	0.050 (8)	0.057 (5)	0.024 (14)	0.048 (6)
	Contract with Suppliers	0.028 (19)	0.030 (13)	0.016 (20)	0.030 (15)	0.019 (19)	0.022(18)
	Distribution Right	0.028 (19)	0.015 (18)	0.019 (18)	0.018 (17)	0.031 (12)	0.045 (7)
	Cooperation Contract	0.032 (16)	0.031 (12)	0.018 (19)	0.017 (18)	0.022 (17)	0.030 (15)
	Agreement with Shareholders	0.030 (17)	0.018 (17)	0.015 (21)	0.022 (16)	0.023 (16)	0.042 (9)

Goodwill	Company's Reputation	0.063 (3)	0.039 (8)	0.082 (2)	0.036 (13)	0.084 (3)	0.032 (14)
	Customer's Loyalty	0.039 (12)	0.018 (17)	0.029 (13)	0.018 (17)	0.090 (2)	0.041 (11)
	Business Culture	0.034 (14)	0.060 (6)	0.025 (15)	0.014 (19)	0.064 (6)	0.035 (12)
	Trademark	0.029 (18)	0.012 (19)	0.022 (17)	0.008 (20)	0.044 (9)	0.019 (19)

5.3 Reliability and Validity

Our results in this section can be deemed trustworthy. Regarding the reliability, this research uses internal consistency reliability as the testing method. The CI and the CR of AHP are also applied to estimate the internal consistency reliability. The inequations, $C.I. \leq 0.1$ and $C.R. \leq 0.1$, are used to test the reliability of the questionnaire. In addition, the questionnaire meets the theoretical requirements with acceptable internal consistency reliability.

The validity is concerned with both nomological validity and content validity. Since this research integrates theories from other researchers (mainly Kalafut and Low, 2001), while developing the questionnaire on different levels, the contents of the questionnaire should be reasonable in terms of the nomological validity. Furthermore, under the review of several experts and scholars, the constructs and criterion are affirmed to have a clear expression and to effectively measure the objectives. Thus, the questionnaire should have a certain degree of content validity.

6. The Analysis of Virtual Case

After obtaining the ideal weights of intangible assets survey by AHP, the VIKOR method can be used to assess the way in which the distribution of specific company's intangible assets is diverged from the ideal structure; thus, this assessment can serve as a helpful reference for business valuation while encountering business mergers and acquisitions. Particularly, the VIKOR method can discriminate the relative importance of each criterion to obtain more authentic results with better quality. This research takes IC foundry industry as a virtual case to simulate an empirical analysis based on the research results for this industry conducted in the previous section.

6.1 The Description of Empirical Analysis Design

It is assumed that the intangibles of n companies in a certain industry are evaluated based on the ideal weights of 22 criteria in Table 7 in order to obtain the effective values of each company. These companies' effective values are conducted by the larger-the-better method of grey relational analysis, and each company's best and worst effective value on every criterion are generated by the VIKOR method. Finally, the distribution of evaluated companies' intangibles is assessed in order to rank their performance on the management of intangible assets in this specific industry. In the VIKOR method, the value Q_t could be the indicator of majority rule with bigger parameter v ($v > 0.5$) as opposed to minority rule with smaller v. Hence, the decision maker can adjust v according to the need, and usually $v = 0.5$.

6.2 The Virtual Case Analysis

The study takes IC foundry industry with the highest turnover in Hsinchu Science Park as an application case to the resulted intangible asset frame derived from the previous section. We invite five experts who are the mutual consultants of five selected IC foundry companies as the evaluators of the distribution of these intangibles in firms. The 5 consultants are the experts of "innovation and technology," "management capability," "employee capability," "customer relationship," and "goodwill" respectively. They are also quite aware of the actual arrangement of the five categories of intangibles for these evaluated companies. Hence, through the expert questionnaire, the five experts are invited to assess the allocation of intangible assets for the five companies in different noted aspects. The effective values for the 22 criteria are the larger the better; thus, the larger-the-better method is adopted to conduct the five companies' data of each criterion (see Table 8). The S_t and R_t value of the five evaluated companies are shown in Table 9. According to the results, company 1, 3 and 4's total evaluation values are over 0.5, which means the three companies' distribution of intangible assets is more efficient or more competitive than others in the industry (see Table 10).

6.3 Summary

This study takes IC foundry industry as an example to integrate theory and practice in order to demonstrate the applicability of the proposed evaluation model, as well as further comparing the proposed evaluation method with traditional method (simple average weight). Through the comparison, we find the difference between the two methods (see Table 11); that is, company 1 and company 3 have opposite priorities. Evaluated company 1, 3 and 4's VIKOR values and simple average weight (SAW) values are over 0.5 and 80, respectively. However, it is hard to distinguish good and bad among the evaluated companies since the five evaluated companies seem fine on the performance of intangible assets in terms of their SAW values approximately 80. In contrast, VIKOR method can clearly identify the difference in these evaluated companies because the VIKOR values of company 2 and company 5 are lower than 0.5. In addition, applying VIKOR method to rank not only avoids the bias of minority rule but reflects the most optimal viewpoints of majority rule.

7. Conclusions and Suggestions

This paper has constructed a tentative model for the evaluation of intangible assets, which helps businesses avoid bias due to mainly relying on financial statements when measuring an entity's value. In view of the significant proportion of intangible assets over total assets in high-technology industries, this research then uses six industries and a virtual case in Hsinchu Science Park, Taiwan as its research objects in order to test the applicability of its model, as well as exploring the value weights of intangible assets and its evaluation among different high-technology industries. According to the execution of the above research, we, thus, summarize the following research conclusion and managerial implications.

Table 8
The Best and Worst Effective Values for Evaluated Companies

Item/criterion		Effective value						
		Company 1	Company 2	Company 3	Company 4	Company 5	f_i^*	f_i^-
Innovation and Technology	Key Technology	75	80	88	85	70	88	70
	R&D Capability	90	80	85	85	70	90	70
	Manufacturing Process	90	86	85	87	70	90	70
	Service Process	90	84	85	85	70	90	70
	Patenting	90	80	85	85	70	90	70
Management Capability	Asset Management Capability	50	60	70	80	90	90	50
	Internal Control Capability	90	88	85	85	80	90	80
	Operation Quality Capability	90	80	85	85	80	90	80
	Technology Update Capability	90	70	85	85	80	90	70
Employee Capability	Employee's R&D	80	60	85	86	80	86	60
	Employee's Innovation	90	80	80	88	80	90	80
	Employee's Knowledge	90	82	85	85	80	90	80
	Employee's Training	90	50	80	89	80	90	50
Customer Relationship and Alliance	Contract with Customers	90	80	80	89	80	90	80
	Contract with Suppliers	90	83	80	80	85	90	80
	Distribution Right	95	70	85	90	80	95	70
	Cooperation Contract	85	90	85	75	70	90	70
	Agreement with Shareholders	88	85	70	50	90	90	50
Goodwill	Company's Reputation	90	90	90	75	85	90	75
	Customer's Loyalty	95	75	90	90	70	95	70
	Business Culture	90	90	90	70	90	90	70
	Trademark	75	90	70	80	85	90	75

Table 9
The S_t and R_t Values for Evaluated Companies

items/evaluated company /evaluation criteria		Company 1	Company 2	Company 3	Company 4	Company 5
R_t^*		0.071	0.066	0.051	0.063	0.095
S_t^*		0.168	0.586	0.380	0.390	0.705
Innovation and Technology	Key Technology	0.071	0.000	0.010	0.024	0.095
	R&D Capability	0.000	0.032	0.016	0.016	0.063
	Manufacturing Process	0.000	0.008	0.010	0.006	0.041
	Service Process	0.000	0.011	0.009	0.009	0.035
	Patenting	0.000	0.022	0.011	0.011	0.044
Management Capability	Asset Management Capability	0.043	0.032	0.022	0.011	0.000
	Internal Control Capability	0.000	0.010	0.024	0.024	0.048
	Operation Quality Capability	0.000	0.059	0.030	0.030	0.059
	Technology Update Capability	0.000	0.055	0.014	0.014	0.028
Employee Capability	Employee's R&D	0.015	0.066	0.003	0.000	0.015
	Employee's Innovation	0.000	0.046	0.046	0.009	0.046
	Employee's Knowledge	0.000	0.032	0.020	0.020	0.040
	Employee's Training	0.000	0.033	0.008	0.001	0.008
Customer Relationship and Alliance	Contract with Customers	0.000	0.051	0.051	0.005	0.051
	Contract with Suppliers	0.000	0.020	0.028	0.028	0.014
	Distribution Right	0.000	0.028	0.011	0.006	0.017
	Cooperation Contract	0.008	0.000	0.008	0.024	0.032
	Agreement with Shareholders	0.002	0.004	0.015	0.030	0.000
Goodwill	Company's Reputation	0.000	0.000	0.000	0.063	0.021
	Customer's Loyalty	0.000	0.031	0.008	0.008	0.039
	Business Culture	0.000	0.000	0.000	0.034	0.000
	Trademark	0.029	0.000	0.039	0.019	0.010

Table10
The Evaluation Result by the VIKOR Method

Evaluated company/ evaluation result and rank/v	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Company 1	1.000	0.955	0.909	0.864	0.818	0.773 (2)	0.727	0.682	0.636	0.591
Company 2	0.222	0.241	0.261	0.281	0.301	0.321 (4)	0.341	0.361	0.381	0.401
Company 3	0.913	0.905	0.897	0.889	0.881	0.873 (1)	0.865	0.858	0.850	0.842
Company 4	0.599	0.600	0.601	0.602	0.603	0.604 (3)	0.606	0.607	0.608	0.609
Company 5	0.000	0.000	0.000	0.000	0.000	0.000 (5)	0.000	0.000	0.000	0.000

Table 11
The Evaluation Methods and the Comparison

Evaluated company/ evaluation method/ evaluation value and ranking	VIKOR (v=0.5)	Traditional Evaluation Method (Simple Average Weight)
Company 1	0.773 (2)	86.1(1)
Company 2	0.321 (4)	78.6(4)
Company 3	0.873 (1)	83.8(2)
Company 4	0.604 (3)	83.1(3)
Company 5	0.000 (5)	78.3(5)

7.1 The Hierarchization of Value Drivers

The financial literature presents several alternatives for the intangible assets valuation. One such alternative is based on the discounted cash flow method. Through such criterion, the intangibles valuation may be described by at least four steps, which are as follows: (1) the total cash flow forecast (financial and economical results), (2) the identification and separation of tangible assets, (3) the intangible assets "hierarchyzation," and (4) the discount value of the intangible assets cash flow, with the appropriate cost of capital rate that reflects its risk level. The third step, intangible assets ordering, is complex and subjective. This procedure involves subjective analysis that may considerably influence the results of the valuation process. The concern of the subjectivism may be softened by applying the AHP method when determining the hierarchy of the value drivers. The purpose of this study is to show the application of the AHP method as a supporting instrument for the intangible assets valuation process. AHP allows quantitatively "hierarchizing" non-financial value drivers.

7.2 The Ideal Distribution Structure of Intangible Assets

The resulted weights in the structure of intangible asset evaluation constructed by this research represent the expected intangible asset distribution structure in each industry. Based on the resulted intangibles structure, the same industry management may accomplish research among the decision makers as to qualitatively evaluate several value drivers inside a company's context in order to establish a reference for resource distribution regarding business managerial decision making and, furthermore, to properly manage and accumulate its intangible assets.

7.3 The Improvement of Values-Based Management

Value Based Management (VBM) is the management approach that ensures corporations are managed consistently on value. VBM is dependent on the corporate purpose and the corporate values. As noted, the corporate purpose can either be economic (shareholder value) or can also aim at other constituents directly (stakeholder value). Evidence reveals that, under the culture of values-based management, employees can make better decisions with authorization and work more efficiently in their team due to the complete devotion, risk taking, and sharing of ownership of work by each employee. The values-based management can, therefore, combine employees' interests with value and profit/loss in business. Furthermore, the improper value management cannot provide the entity with clear objective direction. Thereafter, in order to maintain long-term business value, decision makers should realize the correct direction and coming challenges for the enterprise (Kelso and Adler, 1958). According to the analysis and mock demonstration in this paper, industries or even firms can more closely understand their strengths and weakness in the practice of vales-based management and, thus, frame ways for future improvement in order to assure sustainable business value.

7.4 Attributes of Intangible Assets

Our empirical research reflects that intangible asset attributes that technology industries emphasize are different. For example, IC foundry, communication, computer and peripherals, optoelectronic, and precision machinery industries think highly of "key technology," "R&D capability," and "employee R&D" criterion so as to accord with the characteristics of pursuing innovation and fast development in high-tech industries. Biotechnology industry, on the other hand, considers the criterion of "asset management capability," "operation quality capability," "technology update capability," "patents," and "employee R&D" critical because the industry faces higher R&D risks and uncertainty. However, most of the technology industries through our survey reveal that their "key technology" is the intangible asset criterion of the first or second rank. As a result, the dimensions and criterion of this research model can be viewed as a character reference of evaluating the high-tech intangible assets. More importantly, the value weights are coordinated with the attributes and needs of each industry in order to achieve diversity and solidity in appraising the intangible assets. Besides, the referred weights can help an entity formulate decisions for the purposes of mergers and acquisitions, with the addition of the calculation of economic value-added (EVA) of business, the genuine intangible asset values can be more completely valuated.

7.5 Support of Business Evaluation

Traditionally, in the merging process, a merged company has an intangible value estimated through the market and the book value of its assets. This is due to the fact that, usually, the inability of the merging price to reflect the genuine value of the merged firm comes from the simple concern of the company book value instead of covering the intangibles. The VIKOR method applied in this study can be employed to estimate candidate merged companies by merging companies, as exemplified in the virtual case, in order to obtain more objective business evaluation information than it derived from financial statement. However, in the real world, it is difficult to find experts who understand the arrangement of intangible assets in each evaluated company unless the evaluated companies are not so many. Therefore, it is suggested that the merged company uses the VIKOR method to self-evaluate. With the use of weight structure delivered by the AHP and VIKOR methods applied in this paper, the merged firm can carry out the self-evaluation, which can assist in traditional financial valuation, in order to proceed with a win-win situation for both sides of the merger case by reaching a more reasonable merging price.

8. Future Research Directions

In spite of the fact that our research model cannot thoroughly resolve all problems of intangible asset evaluation, none of the related literatures reach the consensus of the evaluation method. Nevertheless, the appraising model of intangible assets constructed by this research, which is based on multi-level and multi-criterion methods and with the approval of 118 professional executives, is said to be useful as a temporary reference for technology industries to plan and execute their intangible asset evaluation. On the other hand, it is advisable to expand the industry domain in future research, such as the comparison of intangible attributes and formations between technology industry and conventional industry; moreover, we can even make transnational comparisons, for instance, in terms of the same industry between nations. Do national policies or competitiveness have impacts on the relative weights of these intangible value drivers? If the answer is yes, what are the intents of the influence? These issues deserve further discussions and exploration in the future.

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