# “Application of FAHP in the measurement model of intellectual capital in service industry”


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# Application of FAHP in the measurement model of intellectual capital in service industry

## Abstract

In the era of knowledge economy, intellectual capital is becoming more and more important. Intellectual capital has been substituted for traditional tangible assets, for examples: land, machinery equipment and capital. Intellectual capital has become the most important competitive factor for business. The measure mode of intellectual capital can help business itself and external investors. The company can find and foster competitive advantage by the inside intellectual capital reports. External investors can find the future of companies by the number or amount of intellectual capital. Although authors have made clear that methods for using the intellectual capital have been provided, but only for measuring integral intellectual capital. Additionally, the emphases found in intellectual capital activities in various industries are different. Moreover, there are still few related researches in our country. It is for these reasons that the proposed study will design a model, suitable for use by service industry in Taiwan, to measure the intellectual capital. An empirical analysis for the measuring model will be conducted. The main goal of this research is to develop and construct a localized measuring model suitable for the task of making evaluations of intellectual capital in Taiwanese service industry. In addition to research relevant literature on the subject, the steps involved in the construction of our measuring model will include opinions consultation of the experts, scholars and practitioners in intellectual capital theory in Taiwan. Through fuzzy analytic hierarchy process, multivariate analysis of variance and factor analysis, to create a weighted of measurement indicator, in order to confirm the indicator and intellectual capital cause and effect relationship, and finally to construct this research's intellectual capital measurement model. After finishing the construct of intellectual capital model, the empirical study concludes the most important dimension to measure intellectual capital including: customer relationship management (CRM), professional capability and strategic management capability.

**Keywords:** intellectual capital, service industry, fuzzy AHP, measurement.
**JEL Classification:** G32, L25, L84.

## Introduction

The measurement and calculation of intellectual capital are very important for enterprises. Stewart (1994) has clearly pointed out that intellectual capital can be measured and that there is a set of methods or tools for practical use on items ranging from the total value of the intellectual capital to the values of human capital, structural capital and customer capital. The current tool developed for measuring intellectual capital can calculate the value of intellectual capital in the form of currency and can match the existing accounts to measure the stock of intellectual capital. This method is limited to the overall measurement of intellectual capital, which can be divided into a monetary valuation model and a non-monetary valuation model. However, the dimensions of intellectual capital lack a measurement model. This study seeks to construct a multivariate measurement model of human capital, structural capital and customer capital to correct for this absence of a model.

As we enter the twenty-first century, the evolution of industrial development and the development of human technology and civilization interact. The economy faces two challenging but important developmental trends: first, the role of knowledge is becoming more and more important as the human economy developmental stage enters the so-called knowledge economy; second, the service industry's proportion of GDP in important countries continues to grow, which indicates the arrival of the service economy or the post-industrial society. However, in the era of the knowledge economy, the service industry is developing in a new environment wherein industries are globalized, service-based, networked, knowledge-based, high-speed, and quality-focused. The service industry is becoming increasingly important in every country's economy; for example, in Taiwan, the service industry has been developing rapidly and has become an important structural industry. Therefore, given the decline of traditional industries and the plateaued state of high-tech industrial development, the service industry has accelerated its development. In addition, few people have explored the core value of the service industry, intellectual capital; thus, the exploration of intellectual capital in a competitive environment is a valuable research topic.

However, the methods used to analyze the service industry's intellectual capital are complicated. Formulas or personal experiences are usually applied in traditional measurement systems, but the human mind suffers from ambiguity and uncertainty, so there are limitations to this method. Therefore, this study uses a fuzzy analytic hierarchy process (AHP) method to verify and analyze the service industry's intellectual capital.

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The previous literature on intellectual capital can be categorized into two major areas. The first analyzes intellectual capital by studying first principles: the concept, the definition, and the component elements of intellectual capital, as well as a general introduction of its content, among other things. The second examines intellectual capital from the perspective of measurement; e.g., specific assessments and modeling of intellectual capital, and how to manage such models. This study will focus on constructing and demonstrating a measurement model of the service industry's intellectual capital. Through a rigorous research process, we will conduct an in-depth exploration of the nature, significance, dimensions, and measurement indices of the Taiwanese service industry's intellectual capital. This study will use a fuzzy AHP method to obtain the relative weight of the evaluation index used in the service industry's intellectual capital measurement model and to establish an evaluation index weight system for the service industry's intellectual capital measurement model.

## 1. Literature review

To date, there is no consistent definition of intellectual capital. However, intellectual capital can be summarized as the sum of intangible assets. It can create a competitive advantage for a company, efficiently systemize the company's information, and create value for the company. From a financial viewpoint, intellectual capital has yet to establish a comprehensive evaluation system. However, even if intellectual capital cannot be recognized in a financial statement, the capital markets will eventually reflect their assessment of a company's intellectual capital.

**1.1. The classification of intellectual capital.** Scholars have different points of view regarding the content and composition of intellectual capital. In general, although experts and scholars have different views on the classification of the term, intellectual capital still uses human capital, structural capital, and relationship capital as the foundational concepts and the basis for developing other categories.

According to scholars, the appropriate classification of intellectual capital is represented in the following order, as shown in Table 1.

Table 1. Classification of intellectual capital

| Dimension | Reference code |
|---|---|
| Human capital | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 |
| Structural capital | 1, 2, 3, 4, 5, 6, 7, 8, 11, 12, 13, 14, 15, 16, 17, 18, 20 |
| Customer capital | 1, 2, 5, 7, 8, 14, 19, 20 |
| Relationship capital | 3, 10, 13, 15, 16, 17 |
| Intellectual property rights | 4 |
| Market capital | 4, 9 |
| Infrastructure | 4, 9 |
| Intellectual capital | 9 |
| Ownership capital | 9 |
| Organizational capital | 6, 10, 14, 19 |
| Innovation capital | 7, 14 |
| Process capital | 7, 14 |

Table 2. Reference codes

| | |
|---|---|
| 1. Skandia AFS (1994) | 11. Roos et al. (1997) |
| 2. Stewart (1994) | 12. Sveiby (1998) |
| 3. Bontis (1996) | 13. Molyneux (1998) |
| 4. Brooking (1996) | 14. Bassi & Van (1999) |
| 5. Hubert (1996) | 15. Bontis (1999) |
| 6. Petrash (1996) | 16. Johnson (1999) |
| 7. Edvinsson & Malone (1997) | 17. Lynn (1999) |
| 8. Grantham & Nichols (1997) | 18. Joia (2000) |
| 9. Booth (1998) | 19. Dzinkowski (2000) |
| 10. Lynn (1998) | 20. Pablos (2002) |

**1.2. The measurement of intellectual capital.** *1.2.1. The monetary valuation model.* **Market/book value method.** According to Stewart (1994), when calculating the value of a company in the past, market value was often acquired by multiplying the value per share and the total number of current shares. Thus, the simplest method for calculating a company's intellectual capital is to subtract the company's book value from the market value of the company and add the remaining balance returns to the company's intangible assets. However, this simple method has considerable disadvantages: (1) there are significant changes in the stock market every day, and the company's stock will change with different situations. If the company's share price falls 5% due to an increase in the government's bank rate, the value of the company's intellectual capital will decrease by 5% even though no such change actually occurred; (2) for the book value and market value in general, high is reported as low. To encourage businesses to invest more, the government allows companies to declare a higher depreciation rate. As a result, the assets and the debts of the company will not be effective in creating bias in the assessment of the intellectual capital's value. Therefore, to address the shortcomings of this method and to increase the reliability of the difference between market value and book value, we must disregard the original figure and replace it with the market value/book ratio. This method has the advantage of insulating the value from the interference of external factors such as the fluctuating interest rate and the unstable stock market. At the same time, managers and investors can have clear ideas perceptions of the company's actual performance, which allows for easier comparisons within the same industry.

**Tobin's *Q* value measurement.** Tobin's *Q* ratio investment theory was proposed by the economist James Tobin in 1968. The theory uses the *Q* ratio to explain business investment decisions; by examining the market value and replacement cost ratio of the corporate assets, we can understand whether the company has the necessary demand for certain capital investments. The advantage of the *Q* ratio is that we can rule out other economic factors and independently measure the business investment decisions. The formula is as follows:

*(Book value of total assets – book value of shareholders' rights + special book value + common stock value) ÷ book value of the total assets.*

$Q > 1$ represents higher growth potential for the company, and $Q < 1$ represents lower growth potential for the company. Intellectual capital reflects the difference between a company's market value and a company's book value; in other words, this difference is the company's intellectual capital value. Therefore, the higher is the *Q* value, the more intellectual capital the company has.

**Calculating intangible value (CIV).** This method was proposed by the "NCI" Research Center at Evanston, Illinois to solve the problem of calculating the value of intangible assets. The research group at the "NCI" Research Center believes that a company's market value is not just reflected by the physical entity's assets but also partly by the company's intangible assets. To identify these additional intangible assets, the research group made small adjustments to the previous method used to calculate the brand assets and applied it to the overall company. They believe that intangible assets are the means that a company uses to win against a company with tangible assets in other industries.

**Intellectual capital equation (IC).** Edvinsson & Malone (1997) have proposed the following equation for calculating intellectual capital (intellectual capital equation): *the organization's intellectual capital* = $c \times i$, where *c* is the absolute value of intellectual capital and the unit is currency, and *i* is the efficiency coefficient of the intellectual capital that the organization uses. Organizations often perform more efficiently and effectively if they understand what IC they possess and how to configure their IC to create organizational value (Marrand Roos, 2005).

*1.2.2 The non-monetary valuation model.* Balanced scorecard (BSC)

Kaplan & Norton (1996) have proposed the concept of the BSC. The purpose of the BSC is to transform the organization's mission and strategy into a set of comprehensive performance measures (i.e., a strategic measurement and management system). The measurements of the Balanced Scorecard encompass four dimensions: finance, customers, internal processes, and learning and growth. Integrated financial and non-financial information can reflect the enterprise value, the intellectual capital and the importance of social responsibility.

In the modified BSC model, the financial perspective is replaced by a fiduciary perspective. The fiduciary perspective reflects the objectives of constituents such as donors and taxpayers. Kaplan and Norton (2004) argue that both financial and customer stakeholders need to be satisfied concurrently in nonprofit and public organizations. Therefore, both customer and fiduciary perspectives are located on the same level above the other two perspectives. Figure 2 shows the four linked perspectives in the modified BSC model.

Applying Kaplan and Norton's (2006) original argument of the chain of cause-and-effect relationships in the nonprofit context, nonprofit employees and volunteers' skills are improved through training programs (learning and growth perspective). They are then able to deliver better services (internal perspective), which, in turn, simultaneously leads to greater satisfaction from customers (customer perspective) and funding providers (fiduciary perspective). Satisfied customers and funding providers will logically lead to accomplished nonprofit missions (Kaplan and Norton, 2004).

**Intellectual capital quantification formula (intellectual capital = capacity × commitment).** Organizations often perform more efficiently and effectively if they understand what IC they possess and how to configure their IC to create organizational value (Marrand Roos, 2005). IC is generally taken to encompass three primary interrelated components: human capital (HC), structural capital (SC) and relational capital (RC) (Dzinkowski, 2000). Thus the IC concept is different to the BSC approach as it stresses the importance of human resource elements (Bontis and Serenko, 2009b; Kong and Thomson, 2009). The stock of IC is used to help realizing the historical monetary value of IC generated by the organization, and the flow of IC is related to the understanding and managing of the organization's capacity to enhance organizational performance now and in the future (Boedker et al., 2005).

Any intellectual resource that can contribute to value added for the organization can be categorized as IC (Kong, 2008; Stewart, 1998; Sullivan, 1999).

According to Ulrich (1998), the previous focus of investment in intellectual capital was not correct. He instead has proposed a specific formula to measure intellectual capital: *intellectual capital* =

*capacity* × *commitment*. This formula clearly defines that intellectual capital is the product of a staff's overall capacity and commitment to the organization. In Ulrich's measure, he does not use financial indicators as the main criteria for measurement; instead he uses the assessment capability and commitment of the company, organization, or individual as the basic unit.

Table 3. Comparison of intellectual capital assessments

| Method | Defined content | Advantages | Disadvantages |
|---|---|---|---|
| Equity market value ratio | Market value of equity / book value of equity | Simple and easy to calculate | The market value of the company is vulnerable to factors other than intangible assets |
| Tobin's Q value measurement | Market value / company's replacement cost | Excludes other economic factors and independently measures the corporation's investment decisions | It is difficult to get the information of a company's replacement cost |
| CIV pricing of intangible assets | The assessment of company's intangible assets | Compares financial information<br>The high and low CIV values represent an important message<br>CIV helps the investor's judgment | Complicated calculation process<br>Financial information must be ready before being calculated<br>It is not applicable if the company's assets' return is lower than the industry's average value |
| Intellectual capital equation IC | *Intellectual capital* = *I*×*C*,<br>*I* is efficiency factor,<br>*C* is measurement value | The intellectual capital value calculated is close to the feasible value<br>Indicators through layers of simplifying process<br>Efficiency factor varies according to the existing value | Index selection is affected by subjective judgments<br>The need to create a large pool of measurement indicators |
| BSC | Transform the organization's mission and strategy into a set of comprehensive performance measurement | Used in important planning for management processes, including vision, communication, planning and setting targets, and calibrating action plans, feedback and learning | The company's performance is measured by four main points: (1) finance; (2) customers; (3) internal processes; (4) learning and growth. Indicators are determined based on the company's strategic objectives |
| Intellectual capital quantified formula (*intellectual capital* = *capacity* × *commitment*) | *Intellectual capital* = *capacity* × *commitment* | Use the company, unit or individual as the basic unit of assessment<br>Employees can self-assess their progress and commitment to the organization and themselves to record the growth of intellectual capital<br>Individual assessment can be combined with group assessment to form the overall measurement of intellectual capital | Narrow measurement of capability commitment<br>Specific indicators of ability and commitment in all areas are insufficient |

## 2. Research methods

**2.1. Metric development and process.** *2.1.1. Preliminary assessment framework and dimensions.* The main purpose of this study is to build a measurement model of intellectual capital for the service industry in Taiwan. Our goals include helping the measurement of intellectual capital in the service industry, improving the planning and implementation of intellectual capital management, aiding companies in building their competitive advantages, and helping companies achieve sustainable development. In this study, the dimensions and items for the data in the first draft are mainly from the following: Skandia AFS (1994), Stewart (1994), Bontis (1996), Brooking (1996), Hubert (1996), Petrash (1996), Edvinsson & Malone (1997 ), Grantham & Nichols (1997), Booth (1998), Lynn (1998), Molyneux (1998), Sveiby (1998), Molyneux (1998), Bassi & Van (1999), Bontis (1999), Joia (2000), Dzinkowski (2000), Pablos (2002).

In addition, data were extracted from theories and views on intellectual capital by various scholars and interviews of experts, scholars, and business executives. Human capital includes various human resource elements, including attitude, competencies, experience and skills, and, perhaps most importantly, the innovativeness and talents of people (Bontis, 2002; Choo and Bontis, 2002; Fletcher et al., 2003; Guerrero, 2003; Roos and Jacobsen, 1999; Roos et al., 1997).

A higher level of human capital is often associated with more innovative ideas, greater productivity and higher incomes or compensation (Wilson and Larson, 2002). Accordingly, human capital is an important organizational resource as it assists organizations to innovatively respond to environmental changes by sensing the need for changes, developing innovative strategies to meet the changes and efficiently implementing the strategies for complex and dynamic environments (Wright et al., 1994). In other words, human capital is a source of innovation and strategic renewal (Bontis, 2002; Bontis et al., 2000; Webster, 2000).

According to the initial summary of this study, the three most common categories are human capital, structural capital, and customer capital. Of all the categories, human capital, structural capital and customer capital are the main dimensions for intellectual capital. The formulation of the initial framework is shown in Figure 1.

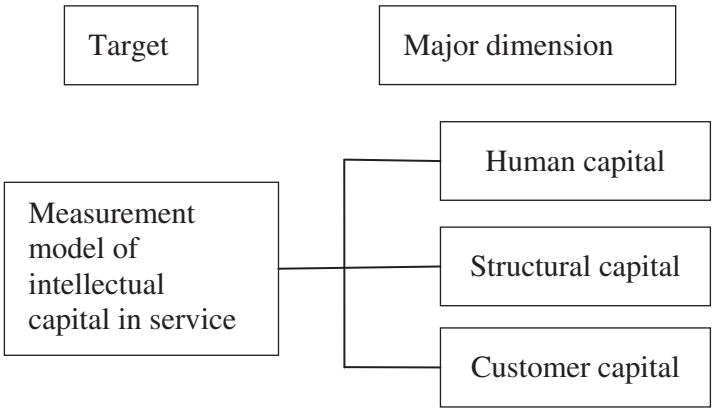


**Fig. 1. The conceptual hierarchical structure**

*2.1.2. The developmental process of the metric.* In this study, a first draft of the metric was formed after analyzing and summarizing the related literature on intellectual capital, completing the study framework, and preparing the headings. Scholars and experts in the industry completed an official questionnaire that required them to evaluate and confirm the dimensions and the headings.

**2.2. Analysis of the reliability and validity of the official questionnaire.** Official questionnaires included three measurement dimensions: "human capital", "structural capital", and "customer capital", as well as 45 headings.

*2.2.1. The sample structure.* For the official questionnaires, the sampling targets were five hundred large service enterprises and one hundred large firms in the financial industry in 2005. According to the industry's Executive Council Statistics, clustering was used for sample filtering of a number of enterprises. 15-20 questionnaires were sent to each enterprise, with a total of 250 questionnaires sent. 180 questionnaires were collected (72%), of which 153 questionnaires were valid (61%).

*2.2.2. Factor analysis.* The valid samples of the official questionnaire were used to select subject matter through exploratory factor analysis. Principal component analysis was used to remove subjects with low explanatory power. After the original data had been processed by factor analysis, subjects with commonality greater than 0.6 and factor loading greater than 0.5 were retained, after which factor analysis was further performed. In accordance with the above conditions for selection, the reserved subjects underwent factor analysis after iteration. The commonality of each question was greater than 0.6 and factor loading was larger than 0.5 or more, until no further selection was needed.

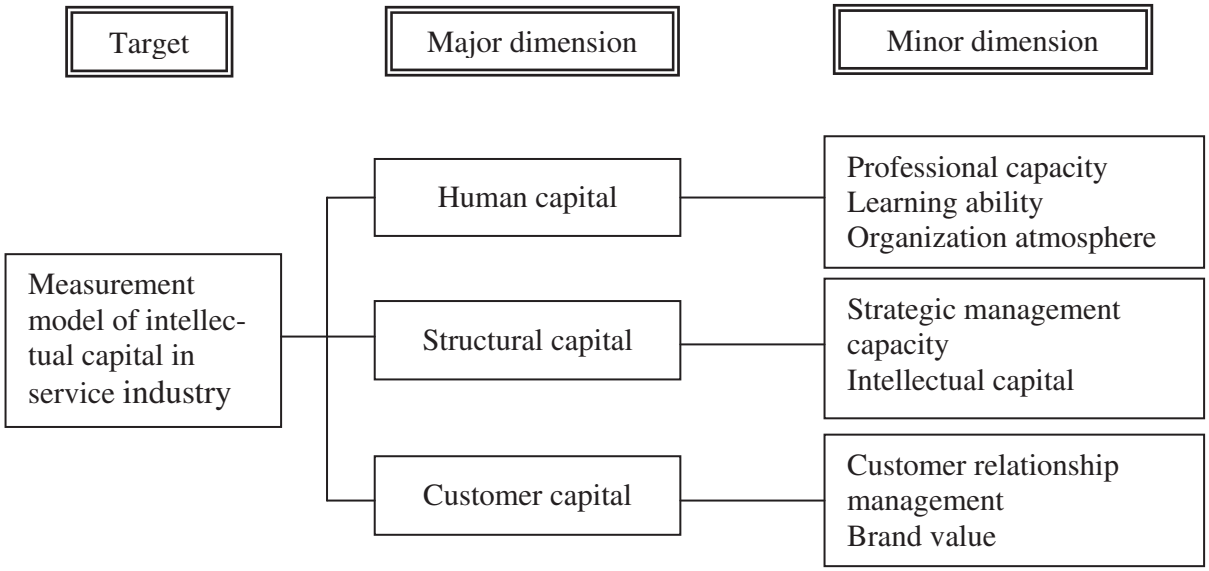


**Fig. 2. The empirical hierarchical structure**

Table 4. Factor analysis and reliability summary of intellectual capital in the Taiwanese service industry

| Research topic | Research dimension | Factor | Factor loading | Eigen value | Variance % | Total variance % | Item-to-total correlation | Cronbach's α |
|---|---|---|---|---|---|---|---|---|
| Intellectual capital | Human capital | Professional capacity | 0.815 | 2.322 | 17.863 | 70.309 | 0.7493 | 0.8539 |
| | | | 0.841 | | | | 0.7493 | |
| | | Learning ability | 0.810 | 3.096 | 23.815 | | 0.7175 | 0.8522 |
| | | | 0.641 | | | | 0.6733 | |
| | | | 0.574 | | | | 0.6319 | |
| | | | 0.759 | | | | 0.7725 | |
| | | Organizational climate | 0.608 | 3.722 | 28.631 | | 0.6927 | 0.8853 |
| | | | 0.634 | | | | 0.6527 | |
| | | | 0.536 | | | | 0.6504 | |
| | | | 0.753 | | | | 0.7590 | |
| | | | 0.719 | | | | 0.7775 | |
| | | | 0.678 | | | | 0.5147 | |
| | | | 0.775 | | | | 0.7414 | |
| | Structural capital | Intellectual properties | 0.601 | 5.328 | 35.517 | 73.85 | 0.7259 | 0.9293 |
| | | | 0.618 | | | | 0.7705 | |
| | | | 0.618 | | | | 0.7616 | |
| | | | 0.613 | | | | 0.7454 | |
| | | | 0.766 | | | | 0.7717 | |
| | | | 0.841 | | | | 0.7624 | |
| | | | 0.773 | | | | 0.7599 | |
| | | | 0.808 | | | | 0.8040 | |
| | | Strategic management capacity | 0.661 | 5.750 | 38.335 | | 0.7843 | 0.9510 |
| | | | 0.689 | | | | 0.8082 | |
| | | | 0.579 | | | | 0.7038 | |
| | | | 0.793 | | | | 0.8665 | |
| | | | 0.879 | | | | 0.8767 | |
| | | | 0.899 | | | | 0.8874 | |
| | | | 0.882 | | | | 0.9051 | |
| | Customer capital | Customer relationship management | 0.856 | 2.915 | 29.145 | 74.287 | 0.7260 | 0.8706 |
| | | | 0.890 | | | | 0.8137 | |
| | | | 0.736 | | | | 0.7255 | |
| | | Brand value | 0.689 | 4.514 | 45.142 | | 0.7891 | 0.9292 |
| | | | 0.763 | | | | 0.7439 | |
| | | | 0.826 | | | | 0.7391 | |
| | | | 0.715 | | | | 0.7427 | |
| | | | 0.791 | | | | 0.8184 | |
| | | | 0.836 | | | | 0.8146 | |
| | | | 0.768 | | | | 0.7795 | |

Table 5. Dimensions and indices of intellectual capital measurement table

| Major dimension | Minor dimension | Measuring indices | Index properties |
|---|---|---|---|
| Human capital | Professional capacity | 1. The employees of this company often work to provide suggestions and proposals.<br>2. The employees of this company will take the initiative to discuss the work with the manager. | Subjective index |
| | | 3. I have _____ work-related professional certificates (Please provide an approximate number). | Objective index |
| | Learning ability | 4. The work attitude of employees.<br>5. The learning ability of new employees is very strong.<br>6. Employees are very familiar with information technology.<br>7. Employees have a positive work attitude. | Subjective index |
| | | 8. The company spent an average of____ hours a year training me (Please provide an approximate number).<br>9. I receive _____ hours of job training per week (e.g., self-training, languages, computers) (Please provide an approximate number). | Objective index |

Table 5 (cont.). Dimensions and indices of intellectual capital measurement table

| Major dimension | Minor dimension | Measuring indices | Index properties |
|---|---|---|---|
| | Organization atmosphere | 10. The company focuses on the competence of its employees.<br>11. The employees often participate in the organization's activities.<br>12. The employees set high standards for product quality.<br>13. The employees are very confident in the company's management team.<br>14. The employees are quite satisfied with work.<br>15. The employees have higher salaries than their peers in the industry.<br>16. The company's managers make proper arrangements for staff working content. | Subjective index |
| Structural capital | Intellectual capital | 1. The company has an innovative culture.<br>2. The company focuses on the effective integration of information systems.<br>3. The company attaches importance to service satisfaction with information systems.<br>4. The company focuses seriously on incentives for employees.<br>5. The company effectively uses its developed patent.<br>6. The company focuses on the protection of the patent.<br>7. The company focuses on the quality management policy.<br>8. The company focuses on the management of its intellectual assets. | Subjective index |
| | | 9. The proportion of R & D expenses to total expenditures:_____% (Please provide an approximate number). | Objective index |
| | Strategic management capacity | 10. The company focuses on the speed of development and design of new products.<br>11. The company has the key technologies required for production.<br>12. The company focuses on a policy's implementation capacity.<br>13. The average time for product design and development in the company is faster than those of others in the industry.<br>14. The R & D investment in basic research and development is higher than those of others in the industry.<br>15. The R & D investment in product development is higher than those of others in the industry.<br>16. The R & D investment in application is higher than those of others in the industry. | Subjective index |
| | | 17. The staff resignation rate: _____% (Please provide an approximate number). | Objective index |
| Customer capital | Customer relationship management | 1. The company views the opinions of its customers very seriously.<br>2. The company views the complaints of its customers very seriously.<br>3. The company views the customers' suggestions very seriously. | Subjective index |
| | | 4. Product return is _____% of sales (Please provide an approximate number). | Objective index |
| | Brand value | 5. The company provides services to customers with an average speed faster than others in the industry.<br>6. The company focuses on customers, suppliers, and trust between partners.<br>7. The company focuses on domestic and international technology exchange within the industry.<br>8. Customers recognize the company brand.<br>9. The company takes the structure of its sales channels very seriously.<br>10. The company focuses on the control of new business opportunities.<br>11. The company can deliver customer service on time. | Subjective index |
| | | 12. The proportion of company advertising expenditure and expenditure on public relations is _____% of the total expenditure (Please provide an approximate number).<br>13. The company market share is:_____% (Please provide an approximate number). | Objective index |

**2.3. Fuzzy AHP method was used to analyze dimension weights.** In this study, the analysis results were validated using the FAHP method. The FAHP method was developed in 1971 by Thomas L. Saaty, a Professor at University of Pittsburgh, as a systematic decision-making method. Based on the established hierarchical structure with mutually influential relationships, this method allows effective decision-making when faced with complex issues or uncertainty and when seeking consistency from disagreements.

*2.3.1. Weight analysis of intellectual capital assessment indices in the service industry.* In the process of establishing an assessment index weight system for the intellectual capital measurement model, a fuzzy AHP method, which was based on the previously established assessment framework and information provided by 10 experts, was used to obtain the relative weights of the evaluation indices. The first level, "human capital", demonstrated how to convert the meaning of the language in the questionnaire into quantitative values and how to establish a fuzzy positive inverted matrix, calculate the weight, and analyze the results.

To achieve the purpose of this study, assessment and judgment should be conducted with all of the indices properly designated. However, because the expert's subjective judgment is imprecise, this study used semantic descriptions to allow the experts to easily and fully express their subjective assessment of value. The study used the triangular fuzzy number to represent the assessment value of each word, so that the fuzzy performance could be fully expressed in the decision-making process.

Table 6. An expert of code A inverted a fuzzy semantic conversion matrix

| Expert 1 | Professional capacity | Learning ability | Organizational atmosphere |
|---|---|---|---|
| Professional capacity | (1,1,1,) | (2,3,4) | (4,5,6) |
| Learning ability | (1/4,1/3,1/2) | (1,1,1,) | (1,2,3) |
| Organizational atmosphere | (1/6,1/5,1/4) | (1/3,1/2,1) | (1,1,1) |

Table 7. The weights of the minor dimensions and their individual rankings

| Assessment dimension | Minor dimension | Fuzzy weighted values | Defuzzified weight value | Normalized weights | Weight rating |
|---|---|---|---|---|---|
| Human capital | Professional capacity | (0.305, 0.512, 0.838) | 0.552 | 0.506 | 1 |
| | Learning ability | (0.175, 0.294, 0.486) | 0.318 | 0.292 | 2 |
| | Organizational atmosphere | (0.117, 0.194, 0.350) | 0.220 | 0.202 | 3 |
| Structural capital | Strategic management capacity | (0.374, 0.500, 0.716) | 0.530 | 0.513 | 1 |
| | Intellectual property | (0.358, 0.500, 0.650) | 0.503 | 0.487 | 2 |
| Customer capital | Customer relationship management | (0.457, 0.694, 0.996) | 0.716 | 0.681 | 1 |
| | Brand value | (0.223, 0.306, 0.475) | 0.335 | 0.319 | 2 |

*2.3.2. Level series.* Examples of the level series weight value of the "human capital" index fall under the "professional capacity" index. The minor dimension, minor dimension weight value, level series weight value, and the overall ranking of all the minor dimensions are presented in Table 7.

Table 8. The relative weights and overall ranking of all the minor dimensions

| Main dimension | Minor dimension | Minor dimension weight value | Level series weight value | Overall ranking |
|---|---|---|---|---|
| Human capital (0.409) | Professional capacity | 0.506 | 0.207 | 2 |
| | Learning ability | 0.292 | 0.119 | 4 |
| | Organizational atmosphere | 0.202 | 0.083 | 7 |
| Structural capital (0.236) | Strategic management capacity | 0.513 | 0.121 | 3 |
| | Intellectual property | 0.487 | 0.115 | 5 |
| Customer capital (0.355) | Customer relationships with management | 0.681 | 0.242 | 1 |
| | Brand value | 0.319 | 0.113 | 6 |

*2.3.3. The results of the relative weights.*

1. The main dimension analysis.

From Table 7, we can understand the fuzzy relative weight values of all the main dimensions in the level evaluation framework. After the defuzzification and rankings have been sorted, we can establish the order of the sizes of the main dimensions: "human capital" (0.409), "customer capital" (0.355), and "structural capital" (0.236). The analysis showed that human capital is most valued by experts, followed by customer capital; the two weights add up to 0.764. In the service industry, each service needs manpower for communication, so the screening and training of human capital is very important. The experts paid relatively less attention to structural capital, which suggests that the focus of the service industry is on customer service and customer satisfaction. Thus, the importance of structural capital is minimal for all of the conditions.

2. Evaluation index analysis.

- The standardization of weights and weight rankings for all of the evaluation indices.

From Table 6, we can establish the standardization of the evaluation index weights and weight rankings for each dimension. When using intellectual capital, this study can help the service industry more strongly emphasize the dimensions with more important evaluation indices. For example, in the human capital dimension, the weight of "professional capacity" is 0.506, which makes it the most valued minor dimension according to the experts. In the service industry, most employees are required to have professional knowledge and skills in customer service, so professional capacity is necessary and takes up a substantial proportion of human capital. The results of the study found that the weight of the "organizational climate" is the smallest (0.202), which suggests that the main dimension of the service industry is customer service. The experts appear to think that the other dimensions are relatively less important.

In the "structural capital" dimension, the weight value of "strategic management capacity" is 0.513, making it the most important factor in structural capital. Because the service industry pays substan-

tial attention to marketing strategy, a good marketing strategy can bring huge results for the company. Thus, strategic management capacity takes up a substantial proportion of structural capital.

In the "customer capital" dimension, the weight value of "customer relationships with management" is 0.681, which means that experts generally believe that the quality of customer relationships with management has a large impact on customer capital in the service industry. A slight error could lead to the loss of customer business in the service industry. Therefore, good quality on the part of customer service is subconsciously expected, and the related units must pay special attention to whether customer service and the reception staff are meeting the needs of customers. The second most important factor is brand value. In fact, the market in the service industry is monopolized by only a few companies. The brand is not everything, as the most important factor is whether a company can meet a customer's needs. Thus, brand value is relatively less important in comparison to customer relationships with management in the customer capital dimension.

- The weight rankings of all evaluation indices in the level series.

Table 7 shows that of the 7 evaluation indices, the first 5 evaluation indices most valued by the experts are the following: customer relationships with management (0.242), professional skills (0.207), strategic management capacity (0.121), learning ability (0.119), and intellectual capital (0.115). In these 5 evaluation indices, strategic management (0.121) and intellectual capital (0.115) are the evaluation indices belonging to the structural capital dimension (100%); professional capacity (0.207) and learning ability (0.119) belong to human capital (67%); and customer relationships with management (0.242) belongs to customer capital (50%).

With the above analysis, Table 6 and Table 7 can help analyze and assess the human capital, structural capital and customer capital of intellectual capital in the service industry. The relevant personnel in the service industry is also an important evaluation factor that receives higher value when good service is provided. After the calculation, consistent indices and consistent ratios were obtained from all the respondents to test the consistency of the paired comparison matrix. Correlation tests showed that the consistent ratio of all the returned questionnaires was less than 0.1, which indicates that the assessment value of all the respondents reached an acceptable standard and that the expert opinions are fully expressed by the research results.

Table 9. Table of overall test and ratio consistency

| | CI value | Pass or not | CR value | Pass or not |
|---|---|---|---|---|
| Human capital | -0.677 | Yes | -1.169 | Yes |
| Structural capital | 0.100 | Yes | 0.000 | Yes |
| Customer capital | 0.058 | Yes | 0.000 | Yes |

*2.3.4. Constructing the formula of the measurement of intellectual capital in the Taiwanese service industry.* After calculating the dimension weight and index weight of the intellectual capital in the Taiwanese service industry, 47 indices were normalized to give standard values (z value). The main purpose of standardization is to prevent all the indices from being affected by different units, as the *Z* value is always between 0 and 1. Obtaining the total sum of the standard values for each index requires acquisition of the standard values of all the dimensions. The sum of the standard values of all main dimensions multiplied by their weights gives the standard values of all of the system's dimensions; the sum of the standard values of all system dimensions multiplied by their weights gives the score for the level of intellectual capital in the service industry.

In this study, the AHP method was used to obtain the weights of various levels of dimensions and indices, which are combined with the simple additive weight method (SAW) to construct the measurement model for intellectual capital in the Taiwanese service industry. We standardized the variables and indices of all the levels in the model, multiplied them with their respective weights, and summed them. In other words, we used a linear combination approach to construct the measurement model and to calculate the score. The equations are as follows:

$$A_{ij} = \sum_{l=1}^{n} Z_{ijk} \ ,$$

where $Z_{ijk}$ is the standardized value of the *k*th index; $A_{ij}$ is the score of the *ij*th major dimension.

$$A = \sum_{k=1}^{m} W_{ij} \times A_{ij},$$

where $A_{ij}$ is the standardized value of the *i*th major dimension; $W_{ij}$ is the relative weight of the *i*th major dimension; $A_i$ is the score of the *i*th system dimension.

$$IC = \sum_{i=1}^{2} W_i \times A_i,$$

where $A_i$ is the standardized value of the $i$th system dimension; $W_i$ is the relative weight of the $i$th system dimension; $IC$ is the score of intellectual capital in the Taiwanese service industry.

This section aims to establish the measurement model for the intellectual capital in our nation's service industry by using rigorous research methods with continuous tests and revisions. The measurement model established in this study has integrated the opinions of many experts and scholars from the literature. Therefore, this model can echo the ideas of prior research and provide confirmation of previous scholars' analysis. This study utilized the opinions of many experts and scholars involved in establishing intellectual capital measurements in the service industry to determine what should be included as dimensions. In addition, the objective and subjective indicators were added to provide a rigorous method of calculation. This study puts forward many constructive improvements for the measurement of intellectual capital.

## Conclusions, implications and recommendations for management

**The main conclusions of Fuzzy AHP.** The results of this study suggest that weight value reflects the importance of the minor dimensions and that the importance of minor dimensions in the service industry's intellectual capital can be understood from the weight system. The results of the calculations indicate that among the three large dimensions of intellectual capital, the weight of "human capital" was the largest (0.409), followed by "customer capital" (0.355), and finally "structural capital" (0.236). The three most important minor dimensions according to the overall ranking are customer relationships with management (0.242), professional skills (0.207), and strategic management capacity (0.121). The above results provide mathematical values that can be used as references for the service industry in future assessments of intellectual capital.

This study applied fuzzy theory to traditional AHP and used the fuzzy AHP method to obtain the relative weights of all the indices. Doing so solved the subjectivity and uncertainty of the measurement model and increased the accuracy of the results.

**General conclusion.** For enterprises, the results from the fuzzy AHP measurement model confirm that the dimension of intellectual capital is relevant to the service industry, such that companies should focus more on the cultivation of human capital and recruit personnel with good, creative, and professional knowledge. Companies should use and allocate talent effectively to continuously accumulate human capital, such that human capital will become the core of the company's overall intellectual capital.

Due to investment in structural capital, which is a key to survival in a highly competitive business environment, companies need to invest in research and development to remain competitive and to create business value.

For precise structural development, intellectual capital has relevant value. However, measuring and reporting intellectual capital cannot be done objectively in most cases, so it is limited by the traditional methods used to valuate assets. Because the data concerning intellectual capital have not been accurately reported in financial statements, investors cannot truly understand the company's future profit potential. Thus, the establishment of measurement standards and an effective reporting system for intellectual capital is much needed, and precise structural development deserves further study.

**Theoretical implications.** Not many people have previously explored intellectual capital in the service industry. As a result, this study had to collect domestic and foreign theories as well as the literature on intellectual capital. We summarized all the possible intellectual capital assessment indices after consulting with experts, who provided the theoretical basis of the assessment model in this study. Compared to the study of intellectual capital from some scholars, this study focused on measuring the dimensions of intellectual capital as well as expanding on and clarifying its content, which resulted in further improvements and development. For example, the use of subjective and objective indices and fuzzy AHP to analyze and explore index weights brought greater accuracy to our measurements. Therefore, this study can support the establishment of an intellectual capital measurement model in the service industry. Future researchers can explore related variables using this model as the measuring tool.

**Practical implications.** While the service industry in Taiwan is facing globalization, the key factors determining how the service industry can undertake the most effective allocation of its resources to create the most business value are represented by the following: (1) excellent human resources, which are the source of energy in business development; (2) a perfect customer-management relationship, which is the foundation of all operational objectives.

Using the experience and knowledge of personnel to increase business competitiveness talent is an important asset of the business and is also the area where companies compete the most. To create an optimal learning environment, executives should be

personally involved and put together learning groups, and staff members should be involved in key decision-making processes to fulfill their personal potential and develop their future with the company.

1. The more human capital the company accumulates, the more significant human capital's impact will be on structural capital and customer capital. Therefore, companies should focus on personnel training and enhancing their human capital.
2. Knowledge is the source of all power. Good knowledge of management mechanisms is the key to victory or defeat in modern business.
3. Companies must establish cooperative relations and strengthen research and innovation to respond to market demand.

For customer capital, companies must provide valuable products or services to the customers to meet and increase customer satisfaction. Companies must establish confidence in dealing with the customers. Because reputation and brand are the most important elements of customer capital, the company's brand value can surpass its competitors' through rigorous quality control of products and services, which will gain the customer's trust and loyalty.

**Recommendations for future researchers.** This study reviewed the relevant literature and included the opinions of 10 experts, whose opinions were categorized into a total of three major dimensions and seven minor dimensions. However, the factors required to understand intellectual capital exceed those included in this study. We suggest that future researchers add interviews with experts and try to include all the relevant factors into their analysis before establishing their assessment framework.

The paper used factor analysis, reliability, validity analysis, and fuzzy AHP to establish an intellectual capital measurement model for the service industry. However, other methods can be used for the study of the minor dimensions. Future researchers are encouraged to list all of the advantages and disadvantages of the model, and compare the effects produced after adding the dimensions to find the best measurement model.

Future researchers can expand the number of respondents and focus on the consistency of the respondents' levels. The targets of this FAHP questionnaire included industry and academia, but there were only 10 valid questionnaires. The respondents should be experts in industry and academia. Because there are some differences in work duties, the work produced by, and perspectives of, the industry are different from those of academia. Bias might occur in these results when filling the questionnaires. Therefore, future researchers are encouraged to pay attention to the consistency of the responses when choosing the target respondents. Theoretically, executives at the same level in an industry will be consistent in evaluating that industry. In addition, if more questionnaires are sent and more respondents are included, the influence of biased results will be correspondingly reduced.

Future researchers are encouraged to continue collecting information on institutions and communities such as the manufacturing, construction, and other industries. Even government agencies, schools, and hospitals may expand the scope of the measurement model, which can enhance the contributions of the measurement model to intellectual capital research.

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