Intellectual Capital Evaluation: A Project Management Perspective

Marcin Relich
Faculty of Economics and Management, University of Zielona Gora, Zielona Gora, Poland
m.relich@wez.uz.zgora.pl

Abstract: Intellectual capital has prevailed as a measure of core competency and competitive advantage which explains the gap between the market value and book value of a company. Given the fact that the nature of intellectual capital is abstract, intangible, and difficult to measure, a challenge has arisen for managers to evaluate intellectual capital performance effectively. Despite the fact that several methods have been proposed to assist managers in this area, there is still a scarcity of approaches that are able to combine accurate data from financial reports and subjective judgments by experts, and that are dedicated to measuring intellectual capital in the context of choosing a set of the most promising new products. This forms the motivation to propose a method for intellectual capital performance evaluation in the field of product development projects that is based on a fuzzy logic approach. Intellectual capital includes many intangible factors, and as a result, it is difficult to evaluate intellectual capital performance using only traditional crisp values. Therefore, an evaluation of intellectual capital is proposed according to linguistic variables used by experts. The proposed fuzzy logic approach applies fuzzy linguistic variables to express the level of qualitative evaluation of each intellectual capital dimension in the context of project management. The use of the proposed approach can support the decision-makers in the choice of a set of new products that are most promising, improving the planning and implementation of intellectual capital management, aiding companies in building their competitive advantages, and helping companies achieve sustainable development. The feasibility of the proposed approach is illustrated by the result of intellectual capital performance evaluation for a sample set of projects.

Keywords: Intellectual capital, measurement, new product development, linguistic variable, fuzzy numbers

1. Introduction

World economy is changing, with knowledge now being the primary value of a company. In this era of the knowledge economy, intellectual capital appears to be the most important competitive factor for any company. Over the last three decades there have been major changes in the global economy with the gradual decline of the industrial sector and substantial increases in the number of companies working in the service sector and using knowledge as their primary source of competitive advantage (Wall et al., 2004). The major driver behind the rise of the knowledge-based economy is the combination of three trends: globalization, the far-reaching deregulation in key economic sectors such as telecommunications, transportation, energy, and financial services, and the exponential growth of technological change, especially the emergence of new information and communication technologies (Andriessen, 2004).

The origins of the intellectual capital approach can be found in the quest to understand, mobilize, and measure the intangible or "invisible" aspects of companies. In today's knowledge-based economy, these are seen as the main drivers of value creation (Peppard, 2005). The market value of leading companies continues to be far higher than the value of their tangible assets and this has led to calls for intellectual capital, as opposed to intellectual property, to be included on balance sheets to give a more accurate impression of company value (Wall et al., 2004). The greatest challenge facing the accounting profession is understanding the huge difference between its balance sheet and market valuation. This gap represents the core value of company (Seetharaman et al., 2002).

Considering the research by method and purpose, there are two perspectives to studying intellectual capital – empirical tests based on financial accounting and practical development and adaption of intellectual capital reports (Han and Han, 2004). The first perspective focuses on decreasing value relevance of current financial reports or/and examination of IC related variables to substitute for current financial measures. In turn, the second approach concerns intellectual capital models and frameworks, as well as case studies for intellectual capital reporting.

The implication of intellectual capital (IC) is different from traditional capital in accounting terms. Therefore, it is a significant challenge for business managers to evaluate the performance of intellectual capital based on financial reports (Han and Han, 2004; Sveiby, 2005; Watson et al., 2005). In order to evaluate the performance of intellectual capital more appropriately, it should considered not only in terms of quantitative indexes but also qualitative dimensions or factors that are evaluated by experts (Tai and Chen, 2009). This paper investigates the intellectual capital performance evaluation in the context of project management and the use of fuzzy logic to assess the intellectual capital for diverse projects.

The rest of this paper is structured as follows: Section 2 presents the concept and evaluation of intellectual capital, including the dimension of human, structural, and customer capital, in the context of product development projects. In section 3, the proposed methodology for evaluating intellectual capital in a set of projects is illustrated. An example of the proposed methodology is presented in section 4. The final section summarises the paper and discusses the main findings.

2. Definition and components of intellectual capital

Intellectual capital plays an important role in improving financial performance and maintaining competitive advantage in a company. The value of a company includes its financial capital as well as its intellectual capital. Financial capital represents the company's book value and contains the value of its financial and physical assets (Joia, 2000). Intellectual capital can be summarised as the sum of intangible assets. It can create a competitive advantage for a company, efficiently organise the company's information, and create value (Lin et al., 2011). Stewart (1998) characterizes intellectual capital as ''intellectual material – knowledge, information, intellectual property, experience – that can be put to use to create wealth".

Scholars consider the content and composition of intellectual capital in various ways. Sveiby (1997) divided intellectual capital into employee competence, internal structure, and external structure. Edvinsson (1997) classified intellectual capital as structure capital, organization capital and customer capital. Subramaniam and Youndt (2005) consider intellectual capital from the following perspectives: human capital, organizational capital, and social capital. In turn, Maeques et al (2006) divide intellectual capital into three dimensions such as human capital, structural capital, and relational capital, based on the knowledge source and structure. Another classification identifies human capital, structural capital and customer capital (Stewart, 1998; Tai and Chen, 2009; Lin et al., 2011). This last classification is further considered in the paper.

Human capital comprises of all individual knowledge, both tacit knowledge (knowing how) and explicit knowledge (knowing what) (Tsui et al., 2014). Joshi et al (2013) claim that the value creation capability is highly influenced by human capital. Structural capital composes of company's routines, procedures, strategies, and policies that are in charge of company's daily operations whereas organizational capital is the collective and institutionalized knowledge and experience residing within and utilizing through databases, patents, manuals, structures, systems, and processes in a company. Relational capital refers to all knowledge acquired by companies because of their interaction with the external environment such as competitors, partners, government, and customers (Pandey and Dutta, 2013; Tsui et al., 2014).

The performance or value of intellectual capital can be evaluated with the use of countless methods. They can measure the intangible capital in accordance with tangible aspects of the subject resource based on discounted cash flow. Financial report methods can determine the value of intangible capital but they are inadequate and inappropriate as tools for business managers to recognize the performance of intellectual capital in a company. It is also essential to consider the multiple dimensions or factors that are assessed by experts in the evaluation processes of intellectual capital. Therefore, qualitative evaluation methods of intellectual capital have been proposed to tackle the existing problems of traditional financial report methods such as analytic hierarchy process, balanced score card and value-chain scoreboard (Eckstein, 2004; Han and Han, 2004; Tai and Chen, 2009).

Intellectual capital includes many intangible factors and items, and as a result, it is difficult to evaluate IC performance using only traditional crisp values. Therefore, the evaluation of intellectual capital according to data from financial and operational reports is proposed, incorporating expert judgements. The presented measurement model of intellectual capital is adapted to new product development. The phases of product development depend on the characteristics of the product, and the company in which it is designed. However, some common phases can be distinguished, such as concept initiation, program approval, prototype, pilot, and launch (Relich, 2014). These phases are usually performed in an R & D department but include processes concerning sales, logistics, production, and purchasing.

Business processes can be reflected in a company's information system, e.g. Enterprise Resource Planning (ERP) system that stores data about the previous transactions, including product development projects (Relich, 2013). An ERP database can be used to determining objective indices of intellectual capital. In this study, the dimensions of intellectual capital contain human capital, structural capital and customer capital. In turn, each dimension consists of four components that include the indicators. Moreover, the indicators have been divided into two groups: objective

indices and subjective judgements. An example of hierarchical structure for measuring intellectual capital is presented in Table 1.

Table 1: Indicators for evaluating IC in the context of product development projects

Dimension of intellectual capital	Item	Indicator	Type of indicator
Human capital	Employee knowledge	1. The learning ability of project team members. 2. Familiarity with information technology in R & D employees.	Subjective judgement
		3. Proportion of staff with a university degree. 4. Total training costs / total payroll expenses.	Objective index
	Satisfaction	1. Work attitude of R & D employees. 2. R & D employee confidence in the company's management team.	Subjective judgement
		3. Proportion of generally satisfied employees of R & D. 4. Work area per employee in R & D department. 5. Number of days absence / total working days. 6. The response rate in staff satisfaction survey.	Objective index
	Innovativeness	1. How often R & D employees work to provide suggestions and proposals for new products.	Subjective judgement
		2. Number of new products introduced during the last year / total products. 3. Percentage of existing parts used in new products. 4. Average number of distinct products per design platform.	Objective index
	Employee turnover rate	1. Number of employees leaving the company / total employees.	Objective index
		2. Fairness of employees' total number of seniority / total employees.	Subjective judgement
Structural capital	Corporate culture	1. Employees of R & D on average identified with the company's perspective.	Objective index
		2. Having values, faith and behaviour criterions, which are approved and shared by all the staff, is of considerable importance for company. 3. An innovative culture within the company.	Subjective judgement
	Information system	1. Proportion of updated knowledge documents on the company intranet.	Objective index
		2. The company focuses on the effective integration of information systems.	Subjective judgement
	Trademark	1. The company has a distinctive sign or indicator to distinguish its products or services from those of other entities. 2. The company effectively uses its developed patents. 3. The company focuses on the protection of patents.	Subjective judgement
	Operation process	1. Proportion of procedures or instruction described. 2. Standard operating procedure is of considerable importance for company. 3. The company focuses on the quality management policy. 4. The company focuses on the speed of development and design of new products. 5. The company has the key technologies required for production. 6. The average time for product design and development in the company is faster than those of others in the same industry sector. 7. The R & D investment in basic research and development is higher than those of others in the same industry sector. 8. The R & D investment in product development is higher than those of others in the same industry sector. 9. The R & D investment in product application is higher than those of others in the same industry sector.	Subjective judgement

Dimension of intellectual capital	Item	Indicator	Type of indicator
		10. Labour hours per product produced. 11. Proportion of R & D expenses within the total expenditure. 12. Time from design inception to production.	Objective index
Customer capital	Market share rate	1. The company's sales revenue from market / total sales revenue available in market.	Objective index
		2. Marketing initiatives are of considerable importance for the company. 3. Customers recognize the company brand. 4. The company focuses on the control of new business opportunities.	Subjective judgement
	Customer satisfaction	1. The company takes the complaints of its customers very seriously.	Subjective judgement
		2. Proportion of customers who are satisfied. 3. Warranty claims percentage. 4. Product return rate.	Objective index
	Customer relationship	1. The company considerably have close contact with customer during specification of requirements. 2. The company takes the opinions of its customers very seriously.	Subjective judgement
		3. Proportion of the company's advertising expenditure and expenditure on public relations, within the total expenditure	Objective index
	Customer loyalty	1. Longevity of the company / customer relationship. 2. The number of repeat customers buying the brand / total customers is of considerable importance for the company.	Objective index

The objective indices presented in Table 1 can be specified in a precise form from financial statements, production orders, etc. In turn, the subjective judgements depend on the employee's (expert's) knowledge and experiences and they are usually specified in the imprecise form, for example, as the following phrases: "strongly agree", "agree", "neither agree nor disagree", "disagree", "strongly disagree". An expert can choose one or more of these linguistic variables. In the second case, one of the methods which can be used for evaluating dimensions of intellectual capital is fuzzy logic.

3. Proposed methodology for evaluating intellectual capital

Intellectual capital and project environment is difficult to evaluate using only traditional crisp values. Therefore, the evaluation of IC ratings is proposed according to linguistic variables used by experts that can be specified in terms of fuzzy logic. The design of traditional questionnaires concerning intellectual capital usually include a checklist for answers, and allow the respondent to choose only one answer for each item. However, problems arise when the respondent has more than one answer. Asking the respondent to make only one decision for each item may result in the data becoming inaccurate. Hence, to improve the traditional survey, this research proposes the use of fuzzy logic. An improvement over the shortcomings of the original scale is that the respondent can make several answers for each item, and can give each answer as a percentage. If the respondents can express their judgement as a degree of membership corresponding to the linguistic variables, it becomes possible to give a real number between 0 and 1.

Fuzzy logic is based on the concept of fuzzy set membership, where the membership functions are used to calculate the degree of membership of a fuzzy IC indicator to different sets, expressed by linguistic terms, e.g. low, medium, and high (see Figure 1). The shape of a fuzzy number and the scale of a linguistic variable depends on the user's needs. In this study, a subjective judgement concerning level of indicator is assigned to the scale from 0 to 10. Compared to traditional binary sets (where variables may take on true or false values) fuzzy logic variables may have a value that ranges in degree between 0 and 1. Fuzzy logic has been extended to handle the concept of partial truth, where the value may range between completely true and completely false. The notion of truth can be considered as a means of representing and reasoning with partial knowledge (Sitek and Wikarek, 2013).

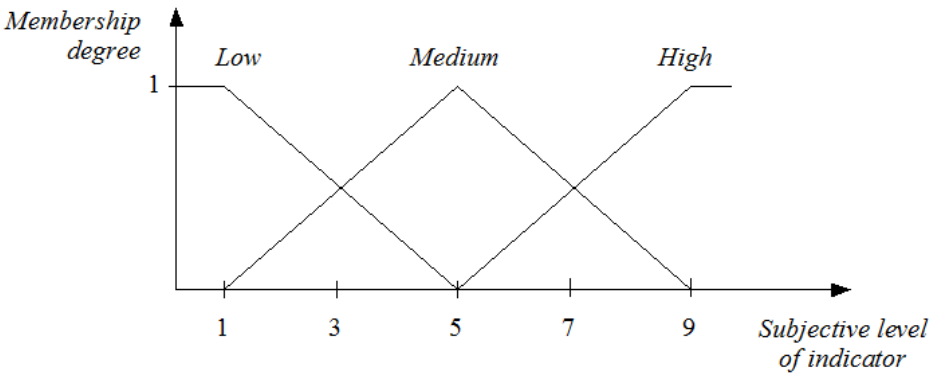

Figure 1: Membership function and linguistic terms

Taking into account the hierarchical structure of IC evaluation (see Table 1) and fuzzy numbers to describe the subjective judgements, a proposed approach consists of the following stages:

- Determine the rule base
- Determine subjective level of indicator by project team members (employees of R & D that develops new product)
- Defuzzify the values for item of IC dimension, e.g. *Employee's knowledge*, for each project
- Calculate the average of each IC dimension, e.g. *Human capital*, for each project
- Calculate the average of intellectual capital for each project

The rule base is determined from the experts, and its aggregation rules are in the form of IF … THEN rules. The aggregation rules reveal the value of an output variable (IC item) if values of input variables (indicators) are expressed by different linguistic terms. An example of decision matrix is depicted in Figure 2.

		Familiarity with information technology in R & D employees (FIT)		
		Low (L)	Medium (M)	High (H)
Learning ability of project team members (LA)	Low (L)	L	M	M
	Medium (M)	L	M	M
	High (H)	M	H	H

Figure 2: Decision matrix of aggregation rules

The above example concerns the impact of "Learning ability of project team members" and "Familiarity with information technology in R & D employees" on IC item "Employee knowledge". As an example, three of nine fuzzy rules for "Employee knowledge" are given below:
IF "LA" is *low* AND "FIT" is *low* THEN "Employee knowledge" is *low.*
IF "LA" is *low* AND "FIT" is *high* THEN "Employee knowledge" is *medium.*
IF "LA" is *high* AND "FIT" is *medium* THEN "Employee knowledge" is *high.*

The proposed approach enables the description of subjective judgements and objective indices taking into account the crisp and fuzzy numbers. For instance, the proportion of staff with a university degree may be described in the accurate form, whereas the learning ability of project team members may be described in the fuzzy form. As a result, the evaluation of intellectual capital for a new product seems to be more complete and suitable. The application of fuzzy numbers allows the linking of numeric information (gained from financial statements, production reports, etc.) with linguistic information (gained from project team members). The next section presents an example of the use of fuzzy numbers to evaluate the intellectual capital in the context of products that are in the development process.

4. Proposed methodology example

The proposed methodology has been applied to the evaluation of intellectual capital in four product development projects. Each project has different human and structural capital, whereas customer capital is the same for all

projects. Subjective level of indicator is from 0 to 10, where 0 depicts the lowest level of indicator and 10 – the highest level of indicator.

The determination of IC item has been calculated with the use of Fuzzy Logic Toolbox Matlab® software. After converting the linguistic variables (subjective statements) into triangular fuzzy numbers, the centroid of area method was performed for defuzzifying the triangular fuzzy numbers into corresponding non-fuzzy performance values. Figure 3 presents the employee's judgements concerning the indicators of human capital dimension. IC items (i.e. employee's knowledge, satisfaction, innovativeness, and employee turnover rate) are determined according to the assumed membership function and rule base. In turn, the score of human capital is calculated as the average of IC items.

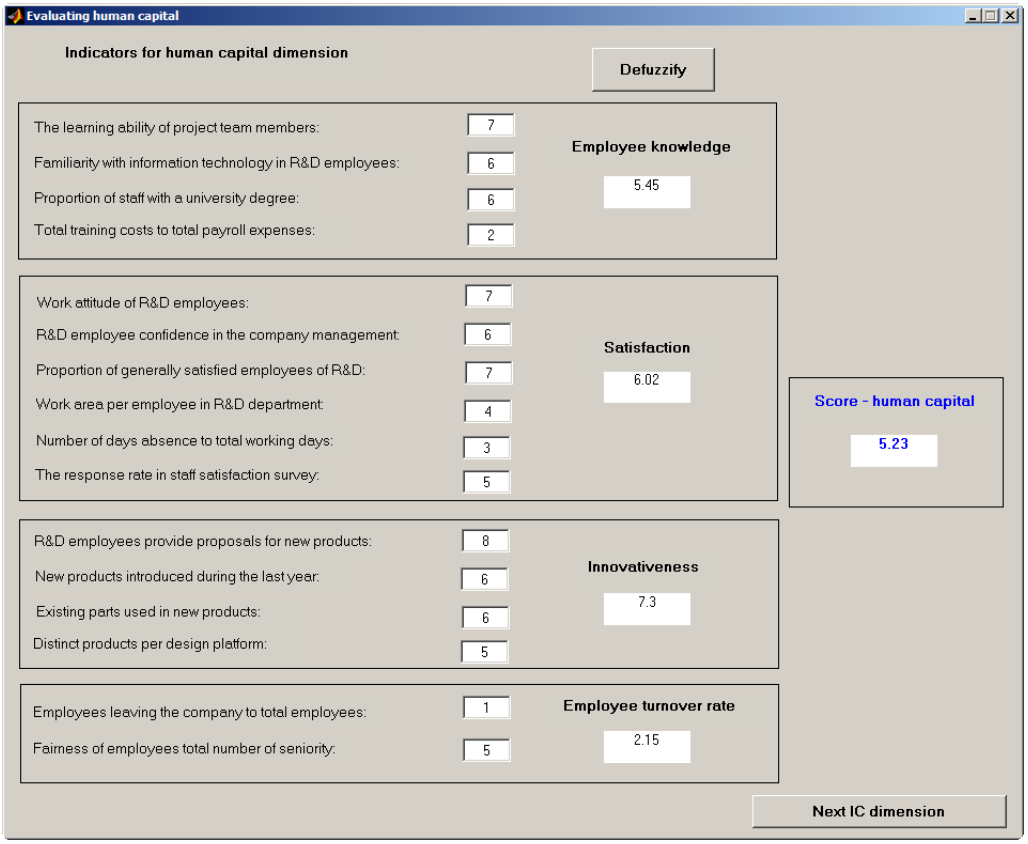

Figure 3: Evaluating human capital

The last stage of the proposed approach relates to the calculation of the intellectual capital for all projects. The comparison of IC level for four considered projects (product lines) is shown in Figure 4.

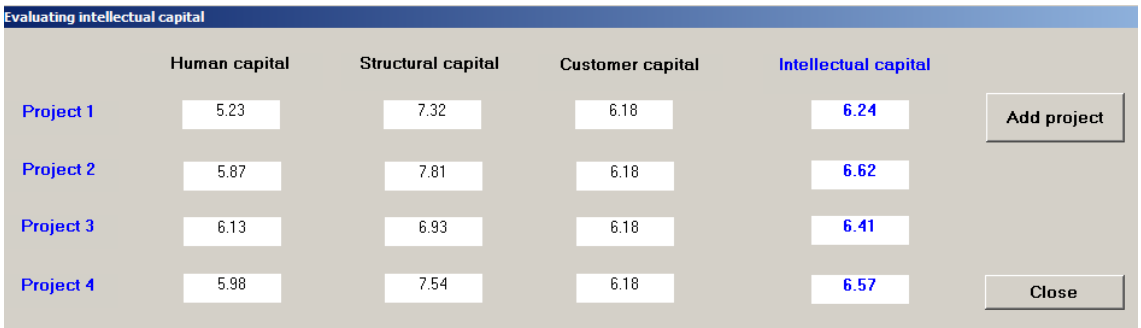

Figure 4: Evaluating intellectual capital

Projects 2 and 4 have the greatest IC value, whereas project 1 has the worst result. The comparison of scores for the intellectual capital can facilitate the decision-makers to select a set of the most promising projects and identify the projects that require more attention. Moreover, the obtained scores can reflect the attitudes of project team members and indicate which new products have the greatest chance for successful completion.

5. Conclusions

Nowadays, there is an increasing demand for the identification of a company's intellectual capital for decision support and providing important managerial insights in knowledge-intensive industries (Tsui et al., 2014). The present economy is full of turbulent changes, both social and technological, which create completely new conditions for a company's activity (Caganova et al., 2012; Cambal et al., 2012; Sujanova et al., 2012). Today's company has to choose an optimal set of new products and develop these products simultaneously in order to minimise cost and sustain competitiveness. The set of product development projects can be determined with the use of time-cost analysis as well as the level of intellectual capital that corresponds with a project.

The nature of intellectual capital is abstract and difficult to measure in a precise form. Intellectual capital indicators are usually vague and defined by subjective judgements rather than objective data (Relich, 2012). Also, project management includes fields (e.g. communication, leadership, culture within the project team) that can be described with the use of linguistic variables, and specified in the form of imprecise, fuzzy numbers (Relich, 2010; Relich and Jakabova, 2013; Samakova et al., 2013; Woolliscroft et al., 2013). The weight corresponding to a linguistic variable is different among employees, since personal preferences are subjective and fuzzy according to complicated, diverse, and indeterminate human behaviour. The use of fuzzy numbers provides a promising tool to quantify employees' knowledge in an explicit manner through the measurement of IC indicators that are typically vague and defined by subjective judgments rather than objective data.

The proposed approach enables the description of subjective judgements and objective indices taking into account both crisp and fuzzy numbers. The evaluation of intellectual capital uses the fuzzy logic methodology and is considered as a hierarchical structure. This approach allows managers to understand the performance of intellectual capital and its components in the context of new products. The presented approach can be a suitable tool for company to discover their core competitive advantage and plan future directions for business development. Furthermore, managers can handle and improve existing intellectual capital in accordance with the differing performance level of each dimension of intellectual capital, items and projects. The disadvantage of the presented approach lies in the capturing of knowledge from experts. This obstacle leads to an increase of interest for further research in the field of automatic knowledge discovery, for instance, with the use of statistical analysis or artificial intelligence techniques, such as case-based reasoning, neural networks, or hybrid fuzzy neural system.

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