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THE SIGNIFICANCE OF R&D ACTIVITIES FOR MANAGING INTELLECTUAL CAPITAL OF ENTERPRISES

ABSTRACT

Enterprises are developing, increasing their profits, value and competitiveness based on successful synergies of human, structural and relational intellectual capital. In addition, R&D (Research and Development) has been acknowledged as a crucial contributor to the competitive advantage in today's competitive market. By performing R&D activities, companies create, develop and use intellectual resources (the knowledge of employees and managers, the knowledge contained in technology and processes), which are valorized on the market and converted into a certain value. R&D is the primary source of knowledge stored within individuals in the enterprise. The most generally used indicators of R&D outputs are patents and innovations, and very important components of structural intellectual capital. Both of these indicators are used to evaluate a company's technological strength and capabilities.

The purpose of this paper is to investigate the relationships and connections between investment in R&D, the components of the intellectual capital of enterprises and the efficiency of intangible assets as visible intellectual capital and the efficiency of the total intellectual capital. This paper aims to point out the importance of performing R&D activities for managing the intellectual capital of the enterprises. Correlation and regression analysis were used for that purpose. The results of the analysis show that R&D investments are positively correlated with visible and invisible intellectual capital, and the efficiency of intangible assets, while R&D investments have a positive influence on visible and invisible intellectual capital.

Keywords: *R&D activities, intellectual capital management, efficiency of intangible assets, efficiency of the total intellectual capital*

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1. INTRODUCTION

Having in mind the importance of research and development for the creation of intangible assets of the company, the paper analyzes the impact of R&D activities on the components of intellectual capital and intellectual capital management in the company. The paper explores the relationship between investment in R&D, visible and invisible intellectual capital of the company and the efficiency of the use of intellectual capital, on the example of companies from the high-tech sector in nine years period. Correlation and regression analysis will indicate the strength and direction of these interdependencies. Based on that, it will be concluded about the importance of allocating funds in the company for research and development in order for the company to maintain and further develop intangible assets that become a key resource for acquisition and preservation of competitive advantage.

2. Literature review

The development of research on the intellectual capital of enterprises can be observed through three phases. The initial focus was on raising awareness of the importance of intellectual capital for market success and business competitiveness. The second phase was based on the importance of developing intellectual resources and increasing investment in these resources in order to increase the value of the company's intellectual capital. In the third phase, the researchers sought to find non-financial and financial criteria for monitoring and measuring this valuable asset to provide a better information basis for decision-making (Tan et al., 2008). The ultimate goal of these indicators is the more successful management of the company's intellectual capital.

Intellectual capital management gained prominence in the eighties of the last century when the importance of intellectual capital for the success of business operations was emphasized (Harrison & Sullivan, 2000). In the last decade of the twentieth century, proactive intellectual capital management developed, when top management became increasingly involved in these activities and intellectual property (IP) dominated concerning physical and financial assets. Under the influence of such changes, IP managers appear in the company, as there were, for example, IT managers (Grindley & Teece, 1997).

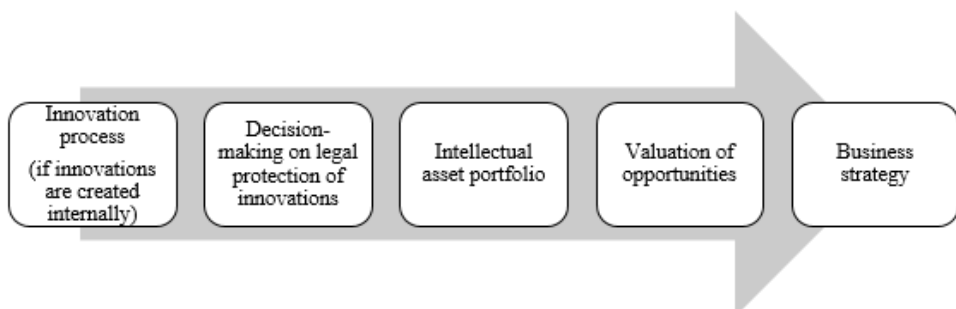
Edvinson (2000) highlights that intellectual capital consists of human competencies, abilities, skills, experience and other forms of knowledge that can contribute to the growth of the organization. Edvinsson and Malone (1997) point to the existence of three segments of intellectual capital - human, structural and capital based on relations with customers. Nick Bontis (1998) emphasizes that intellectual capital consists of human capital (human intellect), structural capital (organizational routine) and client capital (market relations).

Roos and Roos (1997) indicate that the concept of intellectual capital relies on three segments – human capital, organizational capital and capital contained in relationships with consumers and other stakeholders. Bollen et al. (2005) suggest that intellectual capital is based on three elements: 1) human capital, 2) structural capital and 3) relational capital. Human capital includes knowledge and competence of employees; structural capital is based on intellectual property, technology, processes, culture and internal relationships; relational capital consists of relations of the company with institutions, investors, partners, suppliers and customers (Stewart, 1995; Jurczak, 2008; Cricelli et al., 2013).

The structure of the intellectual capital of the company will be explained first, and then the key determinants of the management of intellectual capital.

Intellectual capital management is based on five key elements (Figure 1). The first segment of this system is the innovation process if the company itself develops new ideas that are the basis of innovation, within the R&D department or the creativity department. On the other hand, it starts from the second segment (decision-making on the legal protection of innovations) if the company comes to innovation externally, by buying on the market. Each company has certain methods for assessing the importance of innovation for the realization of the company's strategy. Based on these methods, the company will decide whether the innovation will be part of the intellectual asset portfolio. Such an assessment is necessary bearing in mind that legal protection implies certain costs, so it is necessary to perform a cost-benefit analysis. It is first necessary to conduct a qualitative evaluation, and then determine the quantitative contribution of a particular innovation. In addition, it is necessary to assess competitive conditions, that is, to consider the innovations and technology of competitors. Finally, the assessment of intellectual property from the aspect of the company's business strategy is also important. This means considering how each intellectual resource contributes to the achievement of the corporate strategy.

Figure 1: Intellectual capital management system



Source: Harrison and Sullivan, 2000

Intellectual capital management requires a long-term focus on intellectual capital and two perspectives – creating value and extracting value. It involves: 1) tightly managing the quality of the company's patents to eliminate non-profitable patents from portfolios, 2) research of insufficiently protected intellectual resources to develop commercialized innovations and 3) improving the efficiency of the process of creating commercialized innovations (Edvinsson & Sullivan, 1996).

Marques and his co-workers (2006), in their research on the impact of innovations (which is the result of investment in R&D activities) on intellectual capital management, came to the following conclusions: 1) R&D activities are crucial for creating knowledge assets (human capital); 2) R&D management has a significant positive influence on long-term relationships with suppliers, customers and other stakeholders (relational capital); 3) R&D competencies have a positive and strong relationship with structural intellectual capital. Ren and Song (2020) concluded in their analysis that there is a significant positive correlation between human and organizational capital and R&D investment, using the data of Chinese listed firms from 2007 to 2017. Additionally, Chang and Hsieh (2011) indicate, in their study conducted on 367 Taiwan semiconductor companies, that R&D expenditure and intellectual property rights have a significant positive association with the companies' intellectual capital performance. The R&D activities of the company create new opportunities for the company through the creation of new knowledge and the ability to assimilate and exploit external knowledge (Tsai & Wang, 2004). In this way, these activities improve the quality of the human capital of the company. Companies that invest more in R&D also have a larger number of product and process innovations (Stock et al., 2001), which indicates a favourable impact on the structural intellectual capital of companies.

On the one hand, the management of intellectual capital that is in line with the company's strategy contributes to the understanding of the value creation process in the company as well as uncertainties in the field of research and development. On the other hand, management of intellectual capital enables the company to evaluate the success of R&D activities, ie the efficiency and effectiveness of R&D investments (Dong-Young & Vinod, 2009).

Chen and co-authors (2010) concluded in their research of the impact of innovation capacity on the components of intellectual capital, that innovation capital - expressed in the intensity of R&D, has a strong positive impact on the sustainability of customer relationships, which is a key segment of the relational intellectual capital of the company. They also reported that R&D activities have a slightly positive impact on human capital.

There is also research that analyzes intellectual capital indicators that play a key role in maximizing the performance of R&D activities. According to Dong-Young and Vinod (2009), human capital plays a dominant role in the creation of superior R&D performance, while structural and ultimately relational capital has a significantly lower impact. Following this research, the following indicators influence R&D activities, with declining significance: 1) leadership, 2) commitment, 3) work attitude, 4) employee satisfaction, 5) patent per employee, 6) competence utilization, 7) standards contribution per person, 8) paper per employee, 9) education satisfaction, 10) working years, 11) training expenses per employee, 12) training hours per employee. Similarly, the analysis of other authors (Leitner, 2011) shows that if a company wants to improve its innovation capacity through investment in R&D, it is first necessary to invest in human capital, bearing in mind that R&D activities are key to improving the innovation capacity of the company (Chang, 2013).

2.1. R&D and human capital

Managing intellectual capital in R&D is a novel technique for assessing the efficiency and effectiveness of R&D efforts. R&D activities were described as input of innovative capability, while human capital was defined as absorptive capacity (Castellacci & Natera, 2013). R&D and human capital investments are intertwined and are both determinants of the knowledge-based economy.

Intellectual capital (IC) resources employed to generate innovativeness in products and services through investment in R&D and human capital (personnel investment and research & development) appear to be widely accepted as the fundamental drivers of sustainable competitive advantage and market value (Grant, 1996; Chen, Cheng & Hwang, 2005).

The development of new ideas, as well as the R&D of new technologies, is heavily influenced by human capital (Tullao, 2012). Human capital is the most important factor for technological progress. Some scholars claimed that firms' ability to learn is determined by their internal capabilities, which can be assessed by the number of researchers in their R&D department (Cohen & Levinthal, 1990)

Companies generate, develop, and utilize intellectual resources (knowledge of employees and managers, knowledge included in technology and processes) as a result of R&D operations, which are then commercialized and converted into a given value in the market. According to Hoffman et al. (1998), highly educated R&D human resources improve a company's innovation capability by facilitating the absorption, transformation, and invention of new technologies.

Satisfied and well-educated human capital plays an important role in driving innovation and performance in R&D and are likely to build organizational capital such as procedure, culture, and brand value (Elickson, 2002). Some researchers (Lynch & Black, 1995) stated that in the US, the ratio of highly skilled and educated employees is positively correlated with R&D activities. Based on the results of the empirical study, Ma et al. (2013) concluded that a “1% increase in R&D employee intensity input will contribute to 0.121% increase in innovation performance for emerging industries”.

2.2. R&D and structural capital

Following a review of the literature, some studies proposed a major revision to the intellectual capital scheme, which includes human capital, structural capital, social capital, and the addition of R&D derived from organizational capital (Edvinsson & Malone, 1997; Ross & Ross, 1997; Bounfour, 2002), as well as the underlying concept of intellectual property (Brooking, 1996; Sullivan, 2001). Structural capital is a combination of knowledge and intangible assets created from the organization’s operations, and it includes organizational processes, organizational design, organizational culture, procedures, technologies, information resources and intellectual property rights (Edvinsson & Malone, 2001).

Organizational design that blends internal and external R&D activities, provides not only benefits in terms of different information, but also challenges in terms of integrating such knowledge across organizational boundaries (Rosenkoph & Almeida, 2003). The management of R&D activities depends on the cultural environment and cultural patterns of an organization. A set of values, understandings, beliefs inside an organization is referred to as organizational culture. Within an organization, culture establishes suitable attitudes and approved ways of doing things. For a corporation to manage its R&D activities properly, it must strike a balance between uncertainties and processes on the one hand, and employee creativity and innovation on the other hand.

In order to commercialize innovation and develop its technological capability, which can boost the novelty and uniqueness of new products, a company must invest in R&D efforts (Zahra & Nielson, 2002). The most generally used measures of R&D outputs are patents and innovations and very important components of structural intellectual capital. Both of these are used to evaluate a company’s technological strength and capabilities. Laursen and Salter (2006) indicate that a company must frequently invest significantly in R&D to accomplish a radical innovation, which has a lower likelihood of success but higher performance.

Mairesse and Mohnen (2004) investigated the correlation between R&D and innovation outputs on the sample of 5500 French manufacturing companies for the period 1998-2000. The results of conducted research showed that R&D is positively correlated with all innovation indicators in the low-tech sectors more than in the high-tech sectors.

For the period 1981 to 2001, Prodan (2005) examined the association between R&D investments and patent applications in OECD countries. According to this empirical research, a positive link between R&D and patent applications exists. Some prior empirical studies analysed the relationship between R&D and patents (Bound et al., 1982; Hall et al., 1986) and concluded that there is a positive and significant association between R&D efforts and patents.

2.3. R&D and relational capital

In addition to human and structural capital, relational capital is one of the three basic components of intellectual capital. In today's dynamic and global environment, relational capital has become a means of gaining a competitive advantage. Relational capital has been observed from different perspectives and different conceptualizations and there is no one generally accepted definition. According to Brooking (1996) and Sveiby (1997), relational capital encompasses relations with customers, suppliers, competition, institutions and other agents, as well as reputation and corporate image.

In recent years has the significance of firm R&D cooperation between firms and customers has grown, which is reflected in the fact that these interactions have effects on R&D expenditures and the innovation effort of firms. In some studies, it has been found that customer participation reduced innovation investment (Henkel & Hippel, 2004; Jeppesen, 2005; Lettl et al., 2006), increasing innovation efficiency (Tether, 2002), reducing the trial and error process and the number of faulty prototypes (Lettle et al., 2006). Concerning R&D activities, the tighter collaboration and knowledge integration between firms and suppliers can assist in improving products and processes, making a decision and solving problems in the process of product development (Appleyard, 2003; Cousins et al., 2011).

Porter (1979) discovered that companies that place a greater emphasis on R&D activities create "entry barriers", which can help with reputation building. According to Chun (2006), R&D activities have a major positive impact on corporate reputation. Padgett and Moura-Leite (2012) highlighted that innovation acts as a moderator between R&D and business reputation.

3. Hypotheses and research methodology

Given the previous literature review, the following research hypotheses have been proposed:

H1. A positive correlation exists between R&D investments, the intangible assets and goodwill (Iag), the invisible intellectual capital (ΔIC), the efficiency of intangible assets (Eiag) and the efficiency of the total intellectual capital (EIC).

H2. R&D investments influence positively the company intellectual capital - visible (Iag) and invisible (ΔIC).

H3. R&D investments influence positively the efficiency of the use of company intellectual capital - visible and invisible (EIC).

Following the paper's aim, the research model is developed to measure the influence of R&D investments on intellectual capital categories. In this paper, secondary data for 15 high-tech companies from their annual financial reports were used. The analyzed period covers the period from 2012 to 2019. Except for investments in R&D and Iag which were derived from financial statements, other intellectual capital indicators were calculated separately by the authors. Therefore, ΔIC as the part of the intellectual capital of the enterprise that is not visible in the balance sheet of the enterprise is obtained as the difference between the market capitalization of the company and the net assets of the company. This part of the total intellectual capital of the enterprise together with intangible assets and goodwill constitutes precisely the total intellectual capital of the enterprise (Krstić, 2014). The efficiency of intangible assets (Eiag) and the efficiency of the use of company intellectual capital - visible and invisible (EIC) are calculated according to the methodology developed by Krstić and Bonić (2016).

According to Ren and Song (2020), all data was transformed and calculated as the logarithm of the original values. The descriptive statistics of the researched variables are presented in the following table.

Table 1: Descriptive statistics, 2012-2019

Variable	Meaning	N	Mean	SD	Min	Max
R&D	the logarithm of annual R&D investment	136	3,7398	,38177	2,80	4,56
Iag	the logarithm of the annual intangible assets and goodwill	123	4,2448	,43634	3,08	5,02
ΔIC	the logarithm of the annual invisible intellectual capital	120	4,9207	,53795	3,14	6,00
Eiag	the logarithm of the annual efficiency of intangible assets	123	,2433	,45436	-,44	1,24
EIC	the logarithm of the annual efficiency of the use of company intellectual capital	125	-,4876	,49760	-1,15	1,44

Source: Authors' calculation

In this research, all calculations were made by using the IBM SPSS program (version 23). Besides the data transformation technique and descriptive statistics, the test of the normality of data was conducted. In order to test the first hypothesis, correlation analysis was conducted, two-tail, and all significant coefficients were marked. For the second and third hypotheses testing, the simple linear regression analysis was applied. Moreover, the assumptions of the analysis were also tested and confirmed (multicollinearity and autocorrelation). For the obtained data, statistically significant results were considered if its p-value was equal to or smaller than 0.05.

The stated hypotheses were tested according to the following research models:

$$Iag = \alpha + \beta R\&D \text{ investment} + \varepsilon \quad (1)$$

$$\Delta IC = \alpha + \beta R\&D \text{ investment} + \varepsilon \quad (2)$$

$$EIC = \alpha + \beta R\&D \text{ investment} + \varepsilon \quad (3)$$

4. Results and discussion

The results of the conducted analysis and relevant conclusions will be presented below.

Firstly, the data of the correlations analysis will be presented for testing the first hypothesis, and, secondly, the linear regression analysis will be presented.

Table 2: Correlation analysis results

Variable	1	2	3	4	5
1. R&D	1				
2. Iag	.311**	1			
3. DeltaIC	.390**	.142	1		
4. Eiag	.258**	-.726**	.309**	1	
5. EIC	.101	-.067	-.703**	.216*	1

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Source: Authors' calculation

According to the previous table, a positive and statistically significant relationship between R&D investments and Iag is identified ($r = .311, p \leq .01$), R&D investments and ΔIC ($r = .390, p \leq .01$) and R&D investments and Eiag ($r = .258, p \leq .01$). This further means that the intangible assets and goodwill (Iag), the invisible intellectual capital (ΔIC) and the efficiency of intangible assets (Eiag) are positively correlated with R&D investments and if a company invests in R&D, it will increase positively its Iag, ΔIC and Eiag. Additionally, the size of correlation coefficients varies from small to medium practical effect, thus increasing the significance of the obtained results for the practice.

On the other hand, there was no significant correlation identified between investments in R&D and efficiency of the use of company intellectual capital (EIC). Therefore, the first hypothesis was for the most part confirmed.

After the correlation analysis was conducted, the linear regression analysis was applied. Table 3 gives an overview of the obtained data.

Table 3: Regression analysis's results

Independent variable	Dependent variable		
	Iag	Δ IC	EIC
R&D	.345***	.518***	4.058E-6
R square	.096	.152	.003
Adjusted R square	.089	.145	-0.05
Change R2	.096***	.152***	.003
F statistics	12.911***	21.167***	.363

***. Correlation is significant at the 0.001 level.

Source: Authors' calculation

The previous table presents the results of testing three proposed research models. The first model tests the influence of R&D investments on Iag is the visible component of the intellectual capital. The results indicate that R&D investments have a statistically significant and positive influence on Iag ($\beta = .345$, $p \leq .001$) and the model is statistically significant ($F = 12.911$, $p \leq .001$). According to the results, only 9.6% of the variance in Iag is explained by the change in R&D. The second model shows that the R&D investments have a statistically significant and positive influence on Δ IC ($\beta = .518$, $p \leq .001$). F statistics of the model is statistically significant ($F = 21.167$, $p \leq .001$). When it comes to the variance explained by the model, 15.2% change in Δ IC is caused by the change in the investments in the R&D. The last model is not statistically significant or the beta coefficient. Consequently, the second research hypothesis, which stated that there is a statistically significant and positive influence of R&D investments on visible and invisible intellectual capital, is confirmed. On the other hand, the influence of R&D investments on the efficiency of the use of company intellectual capital (EIC) is not identified and the third research hypothesis is rejected.

The study proved that R&D investments are positively correlated with both visible and invisible intellectual capital, and efficiency of intangible assets, while R&D investments have a positive influence on visible and invisible intellectual capital meaning that raise in R&D investments will generate visible and invisible intellectual capital for the company. The results of the analysis are somewhere in line with the previous researches on the same subject. Petković and Đorđević (2021) identified the positive influence of the R&D intensity indicator on Iag, but the negative influence of return on research capital impact on the intangible assets of the 11 French high-technology industries.

Additionally, Ren and Song (2020) stated that in their research conducted on the data of the Chinese companies', regression analysis presented a positive relationship between intellectual capital and investments in the R&D and applications of patents. In the research of Marques et al. (2006) investments in Schumpeterian competencies, as the radical progress of knowledge stock and generative learning, and in continuous improvement competencies, as incremental evolution of knowledge stock, loaded as significant predictors of the human, structural and relational capital change.

5. CONCLUSIONS

The study researched the relationship between R&D investments and intellectual capital (visible and invisible) and the efficiency of the use of company intellectual capital on the example of 15 companies for the period 2012-2019. In order to provide the empirical investigation of the impact of R&D investments on the intangible assets and goodwill, the invisible intellectual capital and the efficiency of the use of company intellectual capital, correlation and regression analyses have been utilized.

Based on the value of the coefficient of simple linear correlation, there is a strong linear correlation between R&D investments, intangible assets and goodwill and the invisible intellectual capital. Furthermore, the results have shown that there was no correlation between R&D investments and the efficiency of the use of company intellectual capital. Therefore, the obtained results partially confirmed our first hypothesis. The regression analysis findings confirmed that R&D investments have a statistically significant and positive impact on a company's intellectual capital (visible and invisible). Hence, these results confirm the second hypothesis. The analysis of the impact of R&D investments on the efficiency of the use of company intellectual capital shows that this is not recognized and the third hypothesis is rejected. The originality and value of this research are reflected in the identification of the results of the survey and creation of business policy and strategies with having this as a guideline. The conclusions of this research give directions for R&D policy makers in enterprises. In addition, this study promotes awareness of the importance of R&D investments and their implications for managing intellectual capital.

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ZNAČAJ AKTIVNOSTI ISTRAŽIVANJA I RAZVOJ ZA UPRAVLJANJE INTELKTUALNIM KAPITALOM PREDUZEĆA

SAŽETAK

Preduzeća se razvijaju, povećavajući svoj profit, vrednost i konkurentnost na osnovu sinergije ljudskog, strukturnog i relacionog intelektualnog kapitala. Osim toga, istraživanje i razvoj predstavljaju ključni pokretač konkurentske prednosti u savremenim uslovima poslovanja. Istraživačko -razvojnim aktivnostima preduzeća stvaraju, razvijaju i koriste intelektualne resurse (znanje zaposlenih i menadžera, znanje sadržano u tehnologiji i procesima), koji se valorizuju na tržištu i pretvaraju u određenu vrednost. Istraživanje i razvoj je primarni izvor znanja uskladištenog u pojedincima u preduzeću. Najčešće korišćeni pokazatelji rezultata aktivnosti istraživanja i razvoja su patenti i inovacije, što su važne komponente strukturnog intelektualnog kapitala i koriste se za procenu tehnološke snage i sposobnosti preduzeća.

Svrha ovog rada je istražiti odnose i veze između ulaganja u istraživanje i razvoj, komponenti intelektualnog kapitala preduzeća i efikasnosti nematerijalne imovine kao vidljivog intelektualnog kapitala i efikasnosti ukupnog intelektualnog kapitala. Ovaj rad ima za cilj da ukaže na značaj istraživačko-razvojnih aktivnosti za upravljanje intelektualnim kapitalom preduzeća. U tu svrhu korišćena je korelaciona i regresiona analiza. Rezultati analize pokazuju da su investicije u istraživanje i razvoj pozitivno povezane sa vidljivim i nevidljivim intelektualnim kapitalom, i efikasnošću nematerijalne imovine, dok ulaganja u istraživanje i razvoj imaju pozitivan uticaj na vidljivi i nevidljivi intelektualni kapital preduzeća.

Ključne riječi: *R&D aktivnosti, upravljanje intelektualnim kapitalom, efikasnost nematerijalne imovine, efikasnost ukupnog intelektualnog kapitala i*

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