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Exploring the effect of intellectual capital management on innovativeness in an R&D institute

Badanie wpływu zarządzania kapitałem intelektualnym na innowacyjność w instytucie badawczo-rozwojowym

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Abstract. The literature that empirically investigates the relationship between intellectual capital management and innovativeness in R&D institutions is scarce. In addition, no sources have been found to extend the analysis to include the technological orientation as a strategic approach to developing innovative capabilities. This study builds on the theoretical premises of the intellectual capital-based view of the firm and the dynamic capabilities view. This paper addresses a research gap, by setting out to study the impact of intellectual capital management on innovativeness in an R&D institute, while also considering the relationship with technological orientation. It is proposed that intellectual capital management, through its components human, structural and relational capital positively affect innovativeness in an R&D institute. Moreover, it is hypothesized that human capital and innovativeness positively affect innovativeness in an R&D institute. The research employs PLS-SEM analysis on data collected from a sample of (N = 61) employees of an R&D institute. Data has been acquired by means of a questionnaire measuring intellectual capital management through human, structural and relational capital components, as well as innovativeness and technological orientation. Findings confirm significant direct effects of structural and relational capital on innovativeness, as well as the positive direct effect of human capital and innovativeness on technological orientation. This research represents an original contribution to the academic literature, by bringing new evidence concerning the relationships between intellectual capital management, innovativeness and technological orientation in an R&D institute in Eastern Europe.
Keywords: Intellectual Capital Management, innovativeness, technological orientation, R&D sector

Abstrakt. Literatura badająca empirycznie związek pomiędzy zarządzaniem kapitałem intelektualnym a innowacyjnością w instytucjach B+R jest nieliczna. Ponadto nie znaleziono żadnych źródeł pozwalających rozszerzyć analizę o orientację technologiczną jako strategiczne podejście do rozwijania zdolności innowacyjnych. Niniejsze badanie opiera się na teoretycznych przesłankach spojrzenia na przedsiębiorstwo, opartych na kapitale intelektualnym oraz na dynamicznym spojrzeniu na możliwości. Artykuł dotyczy luki

badawczej, podejmuje próbę zbadania wpływu zarządzania kapitałem intelektualnym na innowacyjność w instytucie B+R, z uwzględnieniem związku z orientacją technologiczną. Proponuje się, aby zarządzanie kapitałem intelektualnym przez jego składowe, takie jak kapitał ludzki, strukturalny i relacyjny, pozytywnie wpływało na innowacyjność instytutu B+R. Ponadto stawia się hipotezę, że kapitał ludzki i innowacyjność pozytywnie wpływają na innowacyjność instytutu B+R. W badaniu wykorzystano analizę PLS-SEM na danych zebranych na próbie (*N* = 61) pracowników instytutu badawczo-rozwojowego. Dane pozyskano za pomocą kwestionariusza mierzącego zarządzanie kapitałem intelektualnym przez komponenty kapitału ludzkiego, strukturalnego i relacyjnego, oraz innowacyjność, a także orientację technologiczną. Wyniki potwierdzają znaczący bezpośredni wpływ kapitału strukturalnego i relacyjnego na innowacyjność, a także pozytywny bezpośredni wpływ kapitału ludzkiego oraz innowacyjności na orientację technologiczną. Badania te stanowią oryginalny wkład do literatury naukowej, dostarczając nowych dowodów dotyczących związków między zarządzaniem kapitałem intelektualnym, innowacyjnością i orientacją technologiczną w instytucie badawczo-rozwojowym w Europie Wschodniej.
Słowa kluczowe: zarządzanie kapitałem intelektualnym, innowacyjność, orientacja technologiczna, sektor B+R

Introduction

While intellectual capital (IC) research has been established as a field of study already decades ago, extant empirical studies measuring the effects of various IC components on an organization's performance and competitive advantage gains are far from exhausting the whole range of theoretical assumptions that have been put forward. Furthermore, the investigations into IC impact on organizations have yet to cover a diversity of industries and economic sectors, or national and regional peculiarities, as most of the research so far has focused on manufacturing and IT industry, on SMEs (Dinu, 2022), and on advanced economies (Andreeva, Garanina, 2016).

As stressed by Subramaniam and Youndt (2005), Buenechea-Elberdin, Saenz and Kianto (2018) nowadays business success depends on innovation and IC is a key factor in this respect. Developing innovative capabilities relies on successfully managing IC resources. Furthermore, innovation is reliant on technology, and this is truer than ever especially in the current context of accelerated digitalization. Information technology is present today in all of an organization's functional areas and facilitates various managerial processes, from strategic management to operational management, including IC management, knowledge management (KM) and communication with stakeholders. Toivonen, Smedlund and Järvenpää (2007) have stressed that many business software systems and IT organizational tools (i.e., for enterprise resource planning, supply chain management, customer relationship management and human resource management) are aimed to support the management of organizational knowledge.

Since only few studies exist that look into the management of IC in R&D institutions, the current paper is one of the first that addresses such a research gap, and seemingly the first of its kind empirically investigating the relationships between IC management, innovativeness and technological orientation, to the best of the author's knowledge. In addition, this research has been conducted in a R&D

institution from an emergent economy in Eastern Europe, which brings once again a novelty element to this research.

Literature review

Several theoretical approaches have considered the source of competitive advantage and firm performance in the post-industrial economy that relies substantially on intangible assets. Following the line of thought advocated by Barney (1991) in the resource-based view, which placed physical and intangible resources in the center of a company's vital valuables for achieving competitive position and growth, and the knowledge-based view (Grant, 1996), which placed the focus on knowledge as the fundament for value creation, Reed, Lubatkin and Srinivasan (2006) have advanced the Intellectual Capital-based view of the firm. In accordance with this latter approach, it is specifically the knowledge amassed in an organization's human capital, social relationships and organizational information technology systems and processes that drive the business success. These dimensions correspond generally to the three main components of IC widely agreed upon in the literature, which are human capital (HC), structural capital (SC) and relational capital (RC) (Bontis, 1998; Edvinsson, Malone, 1997; Petty, Guthrie, 2000; Andriessen, 2004; Nazari, Herremans, 2007). Some authors have proposed other classifications by renaming e.g., structural capital as organizational capital (Youndt, Subramaniam, Snell, 2004), or by introducing other categories e.g., customer capital (Edvinsson, 1997; Stewart, 1997; Mouritsen, Bukh, Larsen, Johansen, 2002), social capital (Nahapiet, Ghoshal, 1998), both encompassing relational capital, or renewal capital (Kianto, 2007).

HC is generally understood as comprising competences, skills, creativity (Edvinsson, Malone, 1997), education, know-how, innovativeness, entrepreneurial spirit (Petty, Guthrie, 2000), knowledge, abilities, behaviors (Martin de Castro, Delgado-Verde, López-Sáez, Navas-López, 2011). SC includes customer, innovation and process capital (Edvinsson, Malone, 1997), intellectual property, management philosophy, corporate culture, ICT infrastructure (Petty, Guthrie, 2000), technological and organizational capital (Martin de Castro, Delgado-Verde, López-Sáez, Navas-López, 2011). Finally, RC is seen as covering relationships and networks that include an organization's stakeholders, like customers and brands (Petty, Guthrie, 2000) or internal and external relations (Inkinen, 2015).

The foundation of IC is knowledge (Buenechea-Elberdin, Saenz, Kianto, 2018) and transforming it into valuable organizational resources that can be leveraged is the purpose of IC management (Edvinsson, Sullivan, 1996). According to Edvinsson (2013) through IC management an organization's knowledge capital can be identified, measured, disclosed and reported, with the aim of achieving competitive

advantage. Harnessing the value of knowledge is the ultimate goal of IC management (Santos-Rodrigues, Figueroa Dorrego, Fernandez-Jardon, 2011). Knowledge is generated by people and the human capital is converting it into structural capital through routines and codification, utilizing information systems. The relational capital is a source of external knowledge input.

Unlike the codified knowledge that is collected and stored inside the organization, tacit knowledge is transferred between people by means of information flows. The tacit knowledge is linked to HC and is the "source of innovation and strategic renewal" (Bontis, 1998, p. 65). One of the challenges of KM is harnessing the tacit knowledge and transforming it into explicit knowledge through codification. Such knowledge can be retrieved inside organizations in data bases, procedures, scientific formulae and others (Nonaka, Takeuchi, 1995), or blueprints, code, etc. (Edvinsson, Sullivan, 1996) and can be collected, compiled, stored, organized. Tacit knowledge on the other hand appears as individual insights (Nonaka, Takeuchi, 1995), lore, experience (Edvinsson, Sullivan, 1996), being shared at individual level (López--Nicólas, Meroño-Cerdán, 2011).

Knowledge-intensive organizations such as R&D institutions depend on enticing the most knowledgeable staff and preserving the best competences and skills among their human resources, and establishing successful external partnerships in order to ensure knowledge input. At the same time, effectively managing human, structural and relational resources is a prerequisite for positive organizational outcomes. More stable markets allow for efficient management of extant knowledge, while dynamic markets i.e., knowledge forward sectors, require continuous generation of adaptive knowledge (Eisenhardt, Martin, 2000).

Furthermore, according to the dynamic capabilities view (Teece, Pisano, Shuen, 1997), prosperous organizations have to look ahead and develop and adapt dynamically their capabilities, in line with their core competences, in order to successfully adjust to market changes and maintain competitive advantage. Dynamic capabilities are path dependent technological, organizational and managerial processes that enable organization to swiftly coordinate and (re)combine resources and competences (Teece, Pisano, Shuen, 1997). They are intangible resources such as knowledge embodied in R&D, intellectual property rights and complementary assets, that can be reconfigured with the aim of obtaining competitive advantage (European Commission, 2006).

Effective IC management has a positive impact on firm performance, by a joint effect of IC and knowledge management practices, sometimes mediated by dynamic capabilities and innovation capabilities, as shown by empirical research (Inkinen, 2015). IC by itself is not conducive to value creation in lack of suitable KM practices (Kianto, Ritala, Spender, Vanhala, 2014). Garcia-Perez, Ghio, Occhipinti and Verona (2020) argued that the stock of knowledge represented by IC require implementation of KM strategies in order to generate value. Youndt, Subramaniam and Snell (2004)

have found that investments in HR management, IT and R&D vary depending on a company's IC profile. Only high performing organizations develop high levels of human, social, and organizational capital, while most firms concentrate on one component. The authors have empirically proven that HRM and IT investments influence IC development more than R&D investments.

It has been suggested that knowledge generation and technological innovation result from joint management of knowledge, technologies and organizational resources (Heffner, Sharif, 2008), with intangible assets playing a central role in the knowledge economy enabled by advanced technology (Dumay, Garanina, 2013). An organization's technological level is affected by its R&D intensity (OECD, 2015). IT systems and advanced digital technology are enablers of knowledge collection, storage and processing, even though tacit knowledge can still elude codification. Additionally, IT offers tools for collaboration, communication and development of RC, whose impact on innovation has been frequently invoked in the academic literature (Toivonen, Smedlund, Jarvenpää, 2007).

Technology forward organizations have an inclination for significantly acquiring and utilizing technology, which has been described as technological orientation (TO) (Gatignon, Xuereb, 1997). This is one of the main strategic orientations within a company, the other two dimensions being customer and market orientations, and strategic orientations positively affect organizational performance (Masa'deh, Al-Henzab, Tarhini, Obeidat, 2018). TO is an indicator of innovation commitment, as innovation, especially in the current digital advancement relies on technology more than ever before. Furthermore, innovation incrementally or radically alters an extant technological trajectory (Gatignon, Tushman, Smith, Anderson, 2002).

Some researchers have attempted to prove empirically the relationship between TO and innovation, with mixed results. Al-Ansari, Altalib and Sardoh (2013) have found a significant relationship, while investigating small and medium sized enterprises (SMEs) in Dubai, but could not demonstrate a direct effect on business performance. Palazzi, Sgrò, Ciambotti and Bontis (2020) have researched the linkage between technological intensity and IC performance, and have argued that SMEs in the technology industry show several knowledge levels, hence IC management positively impacts performance. The authors suggested that more research should address this relationship. Another research limitation was found by Li, Song, Wang and Li (2019) regarding the technological innovation performance.

Innovation is defined by Eurostat Glossary (2012) as "a new or significantly improved product (good or service) introduced to the market, or the introduction within an enterprise of a new or significantly improved process". According to OECD (2015) innovation includes new organisational methods in business practices, workplace organisation or external relations. An organisation's inclination for innovation generation and adoption is described as innovativeness (Damanpour, 1991; Garcia,

Calantone, 2002). It is assumed that innovativeness is higher in bigger companies, due to availability of greater resources i.e., funding, talent acquisition, technological capabilities, R&D capabilities and technical knowledge, etc.

IC components affect an organization's innovative capabilities differently, based on how they are configured (Subramaniam, Youndt, 2005). These authors' empirical research showed that HC interacts with the social capital to impact radical innovation, while the latter affects incremental innovation also. Organizational capital has a significant effect on the incremental innovative capability. These findings have not been (entirely) confirmed by other researchers. HC was found to influence significantly innovativeness only in highly performing firms, however SC had no effect on its own, but only jointly with HC (Leitner, 2011). On the other hand, unexpectedly, R&D spending was not linked to innovativeness. Kipkirong Tarus and Kiptanui Sitienei (2015) have empirically established that HC and SC impact innovativeness in small firms. Social capital has a significant effect on innovation generation and adoption, and organizational capital affects innovation creation (Dost, Badir, Ali, Tariq, 2016). According to McDowell, Peake, Coder and Harris (2018) in small firms HC and SC have a direct effect on organizational performance, while innovativeness plays a mediator role between IC and performance. Positive links between IC and innovativeness have been confirmed by Gomezelj Omerzel and Smolčić Jurdana (2016) in the Serbian tourism industry, which further impact on growth, while Rehman, Bresciani, Ashfaq and Alam (2021) have found positive links among IC, knowledge management and innovativeness, which mediates also the relationship with competitive advantage.

Another line of research focused on the relationship between IC components and technical innovation (Subramaniam, Youndt, 2005; Martín de Castro, Delgado-Verde, López-Sáez, Navas-López, 2011; Dost, Badir, Ali, Tariq, 2016). Organizational learning significantly affects technical innovation, and is affected by organizational culture (Sanz-Valle, Naranjo-Valencia, Jimenez-Jimenez, Perez-Caballero, 2011). While comparing the relationships between IC and leadership across several industries and sectors in Poland, Kucharska (2021) has found that transformational leadership focused on innovativeness and knowledge management significantly impacts HC and RC evolution, through promoting tacit knowledge sharing. An organizational learning culture that stimulates knowledge codification leads to SC development in the IT industry. According to Delgado-Verde, Martín de Castro and Amores-Salvadó (2016) technological capital (which pertains to SC) enables radical innovation to some extent, nevertheless, HC and social capital have a significant positive effect on innovation.

Following the literature review, which supports the view that effective management of IC components has a positive impact on organization innovativeness, given the fact that technological orientation is a strategic orientation decided by the

organizational leadership, and taking into consideration the link between innovation and technology, the hypotheses below are proposed:

Hypothesis 1: HC management positively affects innovativeness in R&D institutions.

Hypothesis 2: SC management positively affects innovativeness in R&D institutions.

Hypothesis 3: RC management positively affects innovativeness in R&D institutions.

Hypothesis 4: HC management positively affects technological orientation in R&D institutions.

Hypothesis 5: Innovativeness positively affects technological orientation in R&D institutions.

The research model and the hypothesized relationships are represented in figure 1.

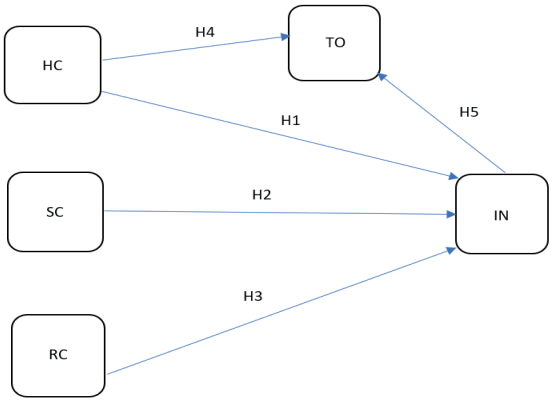

Fig. 1. Research model
Source: author's own elaboration

Methodology

Research instrument

With the aim to assess the relationships between the variables Intellectual Capital Management, Innovativeness and Technological Orientation a questionnaire has been drafted, based on the sources identified during the literature review, and the survey items have been clustered into five constructs and a section on demographics, which referred to the work position, experience with the R&D institution and the gender of

the respondents. The Intellectual Capital Management is made of the sub-constructs Human Capital (HC1-HC6), Structural Capital (SC1-SC6) and Relational Capital (RC1-RC6). Technological Orientation comprises three items (TO1-TO3) and Innovativeness eight items (IN1-IN8). Replies have been assessed with a five-point Likert scale, ranging from "Strongly agree" to "Strongly disagree". Items IN6 and IN7 have been reverse-coded. The items and constructs included in the questionnaire are summarized in table 1.

Table 1. Research instrument

Construct & source	Items
Human Capital (adapted from Bontis, 1998)	HC1 Competences & skills HC2 Work experience HC3 Regular training HC4 Technological upskilling HC5 Staff encouraged to contribute new ideas HC6 Staff encouraged to express opinions
Structural Capital (partially adapted from Petty, Guthrie, 2000; Cassol, Reis Gonçalo, Lima Ruas, 2016)	SC1 Flexible and efficient business processes SC2 Informal knowledge sharing between staff SC3 Digital technologies for knowledge codification SC4 Technological capability to capture relevant new knowledge SC5 Ability to adapt available technologies to the company's needs SC6 Ability to exploit new knowledge to sustain growth
Relational Capital	RC1 Organizational culture encourages trust and collaboration RC2 Staff feels valued and satisfied RC3 Organization engages with external stakeholders by employing technology RC4 Organization uses effectively digital technologies for internal communication RC5 Organization develops new knowledge and innovation by engaging with partners (academia, industry, governmental agencies, etc.) RC6 Organization builds and maintains a good reputation online
Technological Orientation (partially adapted from Cabello Medina, Carmona Lavado, Cuevas Rodríguez, Pérez-Luño, 2011; Gatignon, Xuereb, 1997)	TO1 Organization has a strategy based on up-to-date technology for new product/service development TO2 Organization's business model is based on technological innovation TO3 Organization stays up-to-date with the latest technological developments in its industry

Construct & source	Items
Innovativeness (adapted from Kipkirong Tarus, Kiptanui Sitienei, 2015; Cabello Medina, Carmona Lavado, Cuevas Rodríguez, Pérez-Luño, 2011)	IN1 Organization has produced incremental innovations in its sector IN2 Organization has produced radical innovations in its sector IN3 Organization continuously improves its work processes IN4 Organization tries out new professional ideas generated by staff for organizational development IN5 Organization uses input from partners to develop new products/services IN6 Organization considers innovation too risky IN7 Organization considers innovation too expensive IN8 Organization allocates sufficient funding for R&D

Source: author's own elaboration

Sample and data collection

The respondents pertain to a reputable Romanian scientific institution with several hundred employees involved in R&D on permanent bases. The questionnaire has been disseminated through an online form, to ensure easy access, free participation and anonymity, therefore non-probability methods, namely snowball sampling have been used to collect the data. 61 responses have been returned and used for the analysis. The descriptive statistics indicate that most of the respondents (34,4%) have a work experience between 5 and 10 years; 29,5% have a tenure of 10 to 15 years; 19,67% have over 20 years of experience, while 16,39% have been in office for less than 5 years. Out of the total number of replies 3 belong to senior managers, while the others came from operational staff and middle managers. The majority of the respondents (55,73%) were men.

Data analysis

For the data analysis the Smart PLS version 3 program has been utilized (Ringle, Wende, Becker, 2015). The evaluation started with the verification of the reliability and validity of the constructs, by checking the Cronbach's Alpha value, the Average Variance Extracted (AVE) and the Composite Reliability, which were all within the recommended limits, which are AVE > 0.5, Cronbach's Alpha and CR between 0.7-0.95 to avoid redundancy (Sarstedt, Hair, Pick et al., 2022). The values for each construct are presented in table 2.

Table 2. Construct reliability and convergent validity

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
HC	0.890	0.895	0.924	0.754
IN	0.898	0.901	0.925	0.712
RC	0.814	0.824	0.890	0.729
SC	0.845	0.846	0.896	0.682
TO	0.803	0.812	0.884	0.719

Source: author's data

In the next stept the discriminant validity of the constructs has been verified with the Fornell-Larcker criterion (Benitez, Henseler, Castillo, Schuberth, 2020) and the results of the test can be retrieved in table 3.

Table 3. Discriminant validity

	HC	IN	RC	SC	TO
HC	0.868				
IN	0.776	0.844			
RC	0.790	0.784	0.854		
SC	0.807	0.799	0.796	0.826	
TO	0.771	0.763	0.713	0.754	0.848

Source: author's data

The collinearity test shows for all the retained items VIF values under the recommended threshold of maximum 5 and actually, with a few exceptions the numbers are below 3, which greatly reduces the risk of collinearity. During the tests has been noticed that the items with the highest values (HC3 and HC4) significantly affect the discriminant validity and hence it has been decided to keep these items and not remove them. The results of this test are presented in table 4.

Table 4. Collinearity statistics

Item	VIF	Item	VIF
HC1	2.003	RC2	2.371
HC3	4.674	RC4	1.643
HC4	3.802	SC1	2.006
HC5	2.855	SC2	1.827
IN1	2.327	SC4	1.921
IN2	2.199	SC5	1.933

Item	VIF	Item	VIF
IN3	3.290	TO1	2.194
IN4	3.589	TO2	1.800
IN5	2.543	TO3	1.587

Source: author's data

Finally, in the last step of this stage, the factor loadings of the retained items have been checked and all values are above 0.769 as can be seen in figure 2 presenting the structural model evaluation.

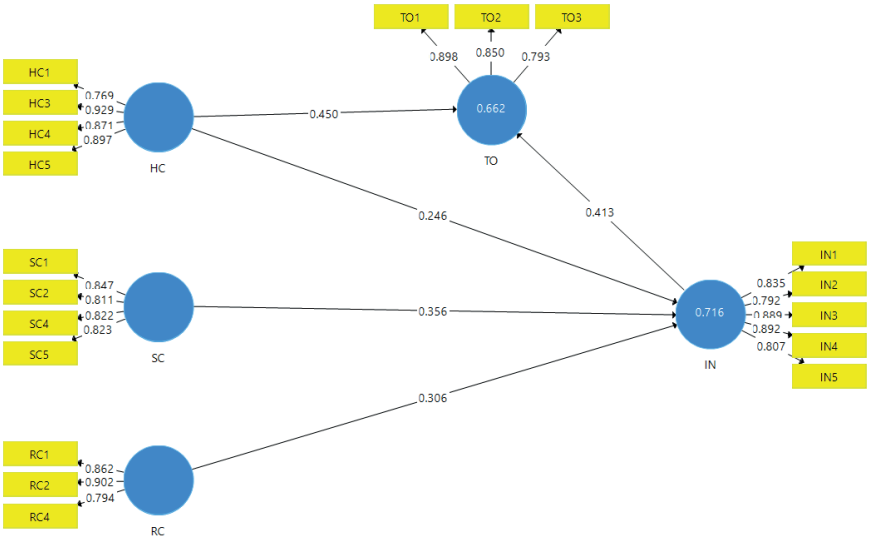

Fig. 2. Structural model assessment
Source: author's own elaboration

The second stage of the analysis was concerned with the structural equation modelling, following a bootstrapping statistical analysis on a 5.000 sample. The path coefficients analysis provided in table 5 indicates that all presumed effects except for the effect of HC on Innovativeness are significant. Additionally, it has been identified that Innovativeness mediates the relationship between RC and TO (see table 6).

Table 5. Path coefficients

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
HC -> IN	0.246	0.244	0.139	1.770	0.077
HC -> TO	0.450	0.448	0.120	3.761	0.000
IN -> TO	0.413	0.413	0.130	3.182	0.001
RC -> IN	0.306	0.311	0.121	2.521	0.012
SC -> IN	0.356	0.355	0.146	2.447	0.014

Source: author's data

Table 6. Specific indirect effects

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
HC -> IN -> TO	0.102	0.098	0.064	1.591	0.112
RC -> IN -> TO	0.127	0.127	0.064	1.989	0.047
SC -> IN -> TO	0.147	0.151	0.085	1.729	0.084

Source: author's data

The proposed structural model has a good model fit, with an SRMR value at 0.073 for the estimated model and 0.072 for the saturated model, which is under the threshold of 0.080 (Benitez, Henseler, Castillo, Schuberth, 2020). The R square adjusted value indicates that the model explains 70.1% of the variance in Innovativeness and 65.1% of the variance in Technological Orientation, as shown in table 7, while the effect size of the sample points to a small impact in what concerns the effect of HC, RC and SC on Innovativeness, at values of 0.062, 0.100 and 0.126 respectively, while the effect size is moderate for the HC and Innovativeness impact on Technological Orientation, with values of 0.239 and 0.202 respectively.

Table 7. The coefficients of determination (R square)

	R Square	R Square Adjusted
IN	0.716	0.701
TO	0.662	0.651

Source: author's data

Given the results of the PLS-SEM analysis, all the proposed hypotheses are validated, except for H1.

Discussion of the findings

The data analysis finalized with the structural equation modelling confirms that certain components of IC, i.e., SC and RC have a direct significant effect on Innovativeness in a R&D institution. Unexpectedly, HC does not. While this result did not confirm the initial assumption, a precedent has been identified by Leitner (2011), who established that only in highly innovative companies HC exerts a positive effect, while in the others a similar result could not be validated. A possible explanation for this finding could be linked to the low allocation of funding in the Romanian R&D sector, combined with the brain drain, which made it difficult for specialized institutions to attract and retain the staff with the highest creativity and innovative drive. Generally, it is assumed that organizations with greater resources enjoy greater innovativeness, as they invest more in talent acquisition, technological capabilities and R&D capabilities. Looking at the items of the HC construct that were included in the structural model, it can be assumed that most of the respondents that provided the answers to the questionnaire sense they could benefit from more training and access to the latest technologies in the field. Additionally, it could be that all staff does not feel encouraged to contribute more to the organizational development.

Notwithstanding this finding, SC and RC do have a significant positive effect on Innovativeness, which is in line with previous research (Kipkirong Tarus, Kiptanui Sitienei, 2015; Dost, Badir, Ali, Tariq, 2016; Subramaniam, Youndt, 2005) that indicated either that organizational capital supports incremental innovation, while HC leads the radical innovation, or that RC facilitates innovation adoption, while SC enables innovation generation. Based on the corresponding items that have been retained into the structural equation modelling, it appears that the R&D institution leverages its structural capital by encouraging the informal knowledge sharing and ensuring flexible and efficient work processes. In addition, the organization has technological infrastructure in place to capture and utilize the new knowledge acquired by the staff with the view to support organizational development. Furthermore, the organizational culture stimulates trust and collaboration, while the internal communication is facilitated by effective use of digital technologies. Combined with the informal sharing of knowledge, communication, trust and collaboration prove to be quintessential for the development of innovative capabilities in a R&D institution. Collaboration with external stakeholders is another source of knowledge input that contributes to higher innovativeness.

Though HC is not directly conducive to Innovativeness, the analysis shows the significant positive effect HC has on Technological Orientation, thus confirming previous research by Gatignon and Xuereb (1997). The link between innovation and technology is once again validated by the significant direct effect of Innovativeness on Technological Orientation. These findings were expected, considering the inherent reliance on technology of R&D institutions, whose purpose is scientific

and technological advancement and whose core competences are centered around technology.

Implications

From a theoretical perspective, this research adds to the scientific literature on the intellectual capital-based view, as well as to the literature on dynamic capabilities and innovation, by providing new evidence on the role of intellectual capital in organizational growth through the development of innovative capabilities. In addition, the paper contributes to the literature on strategic management, by bringing new proof on the importance of the strategic technological orientation on innovativeness.

From a managerial point of view, this research confirms that proper management of intellectual capital is paramount for leveraging all knowledge stocks inside the organization, while effectively managing knowledge, both from internal and external sources is the prerequisite for success. Continuous training and upskilling, an organizational culture of collaboration, partnerships with stakeholders that can enhance knowledge acquisition, as well as the effective use of up-to-date technological infrastructure are all important factors for organizational development that relies on appropriate management of intellectual resources.

Conclusions

This research has endeavoured to investigate from a new perspective the effects of intellectual capital management on innovativeness in R&D institutions, while introducing in a structural model the technological orientation dimension as a strategic organizational approach to developing innovation capabilities. The initial assumptions were that all intellectual capital components have a direct positive influence on innovativeness. However, the findings demonstrate that, while structural and relational capital significantly affect innovativeness in a R&D institution, human capital does not have a similar effect. Nevertheless, human capital has a significant impact on an organization's technological orientation, which has a reinforcing effect on the development of innovation capabilities. Furthermore, innovativeness significantly influences technological orientation in R&D institutions, whose core competences and business model are technology-related and technology-based respectively.

The results of the research are in line with the scarce investigations previously dedicated to the relationship between intellectual capital management and innovativeness in R&D institutions, while also adding to the extant knowledge in the field.

Limitations and future research

Several limitations can be identified in relation to this research. First of all, the coefficients of determination and the effect size are sample related and the sample size is limited by the voluntary participation of the respondents in this investigation. Moreover, the replies represent the respondents' subjective views, which can further affect the results and their replicability. In addition, the responses are reflective of the local R&D situation. Future research would ideally involve a larger sample and possibly include samples from more R&D institutions to allow comparability of results.

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