Effects of Structural, Relational and Human Capital on Entrepreneurship and Innovation in Colombian Micro and Small Software Companies

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Abstract

The research aims to determine the effects of human, structural, and relational capital on entrepreneurship and innovation in the software development industry in an emerging country, Colombia. The sample consisted of 310 surveys of software development in micro and small companies from Colombia. The data were analysed using a structural equation model. Among the results found is the positive influence of structural and relational capital on human capital and the positive influence of human, structural and relational capital on entrepreneurship and innovation capital in micro and small companies of software development in Colombia. The value of this research lies in the relationship of the main identified elements: human, structural, relational, entrepreneurship and innovation capital, reducing the gap between the theoretical model of Knowledge Spillover Theory of Entrepreneurship and empirical model of Intellectus.

Keywords: human capital; structural capital; relational capital; entrepreneurship and innovation capital; software development; knowledge spillover theory of entrepreneurship; micro and small companies; emerging economies.

Submitted: January 18, 2024 / Approved: July 19, 2024

1. Introduction

One of the Information and Communication Technology (ICT) industry's interests is associated with how the digitization processes of its activities are carried out, thus becoming a strategic purpose in adopting new information technologies (Andersson et al., 2021). In this way, digitalization can be considered a phenomenon that affects all economic activities and where it is necessary to be prepared to adopt new technologies. At the same time, develop capacities that allow firms to face the market dynamics.

On the other hand, software development firms, part of the ICT industry, face three characteristics of the digitization era that are important to analyse. The first is related to processing capacity, networks, and software. According to Andersson et al. (2021), the processing capacity is related to the conditions in which the equipment can perform in terms of efficiency. Second, networks are related to how people, firms, and teams connect and develop large amounts of information. Third, software programming with an essential element associated with resources and capabilities that are directed to specific market needs. In this way, these companies play an essential role in developing new businesses. However, they must also adapt to new dynamics that allow them to improve their productivity and generate profits for the firm in an innovative way.

This concern is also typical of firms located in European countries, which define entrepreneurship and innovation as two fundamental pillars of public policy (European Commission, 2022). However, this concern is not only for European countries or developed economies worldwide, developing countries also adopt these practices. This need to develop innovative practices that consider the relationship between resources-skills and capital work is due to the incredible complexity that currently characterizes the markets. According to Audretsch et al. (2020), most researchers and managers focus on understanding the relationship between capital and labour investments. This relation could allow the necessary skills and resources to face market changes successfully. Additionally, this effort goes hand in hand with collaboration processes with other companies and the use of spillovers nationally and internationally.

Much of the literature in the field of entrepreneurship and innovation has focused on: country studies (Iftikhar et al., 2022; Gimenez-Fernandez et al., 2022; Feyzbakhsh et al., 2022), Cross-country studies (Chung et al., 2022; Dheer & Treviño, 2022; Kirschning & Mrozewski, 2024), leadership (Hussain & Li, 2022; Rohlfer et al., 2022), digital innovation (Hevner & Gregor, 2020; Tang et al., 2022), intellectual property (Ali & Tang, 2022), technology (Woolley & MacGregor, 2022) and, strategy (Globocnik et al., 2022; Yeşilkaya, & Yıldız, 2022).

Within the gaps found in the literature, it is possible to highlight two gaps related to the field of knowledge into which this research is integrated. The first gap is related to the need to carry out studies that link knowledge management and entrepreneurship, focusing on the dynamics of specific industrial sectors (Audretsch et al., 2020), specifically in high knowledge-based sectors (Demartini & Beretta, 2022). The second gap to which this research is directed is related to research in the field of entrepreneurial organisations. Most of the interest is the need to identify the role of variables of knowledge management and its effect on entrepreneurship development activities (Audretsch et al., 2020; Salvador et al., 2022; Iftikhar et al., 2022) more specifically in small and medium enterprises (SME).

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In this framework, we aim to determine the effects of human, structural, and relational capital on entrepreneurship and innovation in Colombia's software development industry. To carry out this research purpose, this paper is structured as follows: The first section analyses the Knowledge Spillover Theory of Entrepreneurship (KSTE) perspective, highlighting how a firm's knowledge is leveraged to develop the capacity for entrepreneurial and innovative activities. The second section presents the study´s methodology, detailing the structural equation analysis model and the sample characteristics. he third section presents the main results of the study. Finally, the paper concludes with a discussion of the findings, conclusions, limitations, and potential directions for future research.

2. Theoretical framework and hypotheses

2.1 Knowledge Spillover Theory of Entrepreneurship

An essential element to highlight about the Knowledge Spillover Theory of Entrepreneurship (KSTE) is that it starts from the principle that entrepreneurial activities start from a knowledge platform that drives economic development (Iftikhar et al., 2022). A fundamental difference between this theory and other perspectives on entrepreneurship is that it allows considering aspects of the institutional context that determine the dynamics of a sector (Bruton et al., 2008).

A significant contribution of this theory is that it allows an understanding of how the entrepreneur makes investment decisions for the firms. Also, how the entrepreneur uses his knowledge to take advantage of the conditions in which he operates (West & Bogers, 2014). According to Iftikhar et al. (2022), the current context in which firms operate is characterized by a digital economy, considerable information, and knowledge exchange that influence productivity and innovation.

Demircioglu (2019) argue that knowledge management in the organisation has internal processes as its starting point. The starting point can feed on the spillover that develops in the contexts in which they operate. The creation process makes firms accumulate human capital and carry out entrepreneurial activities. On the other hand, the relational capital generated in the organisation considers the knowledge generated in collaboration with other industries that are not necessarily integrated into the firm (Mowery, 2009). The previous can be related to the Schumpeterian perspective, where innovation is generated as a disruptive effect on the dynamics of a sector by a firm.

For Iftikhar et al. (2022), one of the main challenges of firms lies in the management of internal knowledge of the company, the use of knowledge generated by collaboration, and the spillovers of the sector in which they are located. Similarly, Kirschning and Mrozewski (2024) highlight that the extent to which knowledge translates into entrepreneurial activity differs significantly across regions. Another critical element to highlight is the need to focus research on the dynamics of knowledge management. This need is related to the dynamic of different sectors such as health, high technology, education, and manufacturing. Furthermore, this need is based on the idea that it is necessary to identify the determinants of improvements in sector performance and the different relationships with institutional factors such as collaboration.

To improve their performance, firms have alternatives that allow them to manage the knowledge they possess from the different stakeholders and join forces with them to develop innovation activities. This condition is where the intellectual capital of the firm appears. This capital is defined as relationships between clients and associates, infrastructure, knowledge, and expertise the organisation possesses. Intellectual capital is a resource that the company possesses and can be transformed into profitability in the future. This profitability is seen because of adequate coordination between the ideas generated and the companies' inventions, designs, procedures, and software (Sullivan, 1999). Considering the approaches of Sánchez-Medina (2003), the firm's intellectual capital is made from three fundamental dimensions that explain its nature and dynamics: structural capital, relational capital, and human capital.

2.2 Research hypothesis

The structural capital dimension is defined as the knowledge that a firm has internalized and maintained in the organisation. This dimension is related to the structure, processes, and culture. According to the above, the firm's non-human intangibles should be included in this dimension. Furthermore, Hormiga et al. (2011) state that the procedures carried out by the firm, business models, and the flow of information, are also part of this type of capital. It is necessary to mention that although part of literature tends to find relational capital as part of structural capital, it is also considered independent. Regarding the relationship between structural and human capital, the literature suggests that processes, procedures, information management, and company culture determine the environment in which company employees create knowledge (Onuoha, 2021), therefore, a value generator (Hormiga et al., 2011).

On the other hand, it is essential to highlight that the relationship between structural and human capital still needs to be explored. For scholars, this relationship is meaningful because the structural capital becomes a foundation that supports the activities of the people within the firm (Ayu et al., 2019). The culture, philosophies, and processes being part of the structural capital create the tools for companies to develop appropriate work routines and organisational culture and clarity in the objectives to be achieved (Onuoha, 2021). However, the empirical evidence regarding the interaction between structural and human capital is mixed. While many studies show a positive relationship, others do not, suggesting a need for further research to understand these dynamics fully. For instance, research by Asiaei and Jusoh (2015) indicated no significant effect of structural capital on performance in certain industries, contrasting with other findings that support a positive relationship (Asiaei & Jusoh, 2015). This discrepancy points to the influence of industry-specific factors and the necessity for context-sensitive analysis.

Furthermore, according to Ramon-Jeronimo et al., (2019), this relationship between structural and human capital also suggests, from the Resource-based View Theory, that structural capital allows for building competitive advantage. Though, the degree to which structural capital influences performance through human capital can vary

significantly, underscoring the need for organizations to continuously enhance their structural capital to leverage their human resources effectively (Barney, 1991; Ayu et al., 2019). This condition considers human capital as a means for the development of competitive advantage through the improvement of performance. In this way, the following hypothesis is raised:

H1. (Hypothesis 1) Structural Capital directly and positively affects the firm's human capital.

For authors such as Onuoha (2021), structural capital positively affects the firm's results, based on the idea that structural capital becomes an operating platform that allows the firm to carry out its core activity and achieve its objectives efficiently. On the other hand, the results generated by structural capital allow the indicators to monitor the environment and the results of the processes, culture, innovation, and new entrepreneurial activities that improve the firm's results (Ayu et al., 2019; Salvador et al., 2022). An important aspect to highlight is that in the literature, structural capital can be improved from the company's human capital and is an essential source for the renewal of innovative strategies and processes. When knowledge becomes tacit, structural capital becomes an essential source for achieving objectives in innovation and entrepreneurial alternatives to improve the response to market dynamics.

However, not all empirical studies support these positive correlations. For example, some research highlights significant variations in the impact of structural capital in different contexts. According to the study Mention and Bontis (2013), did not find a significant mediating effect of structural capital on innovation in certain banking sectors, suggesting that the relationship may not be as straightforward as theorised. This condition considers a close study of the relationship between structural capital, innovation, and entrepreneurship activities (Onuoha, 2021; Salvador et al., 2022). In this way, the following hypothesis is raised:

H2. (Hypothesis 2) Structural capital directly and positively affects entrepreneurship and innovation capital.

According to De Castro et al., (2004) relational capital is a value creation process in the type of relationships a firm maintains with different stakeholders that operate in its closest environment. Other scholars argue that relational capital focuses on the network of relationships that are established by the organisation (Nahapiet & Ghoshal, 1998). Studies on relational capital indicate the importance of understanding its connection to critical aspects of a firm's performance and the methodological challenges in accurately assessing its value. Nahapiet and Ghoshal (1998) discuss the difficulties in quantifying the benefits derived from relational capital, highlighting the need for more robust and nuanced measurement tools. These relationships involve various agents surrounding the firm's activities and are related to processes, long-term outcomes, and the risks inherent in each relationship's dynamics.

For the specific case of human capital, this is conceived as the related process that the firm carries out with the social community of its closest environment. For scholars such as De Castro et al., (2004), the human aspect is critical for their performance, but how their level of involvement can be increased is even more critical. In this way, relational capital allows for maintaining relationships with a social environment that, through both social and financial results, enables attracting and maintaining talented personnel and achieving its objectives in terms of the market. However, an element that the literature highlights is the need for internal dynamics characterized by a managerial reputation that encourages attracting better-trained professionals where the firm's level of success can be improved. Studies in the field have shown a positive relationship between relational capital and human capital, both in financial benefits and value creation (Orlitzky et al., 2003). However, the strength and nature of this relationship varied across studies, suggesting that other contextual factors play a significant role (Orlitzky et al., 2003). In this way, the following hypothesis is raised:

H3. (Hypothesis 3) Relational capital directly and positively affects the firm's human capital.

Relational capital includes the firm's ability to generate value concerning the social structure to which they belong, which improves organisational performance (Zhao et al., 2020). In the improvement process, firms must obtain knowledge of the markets they serve through one of the networks made up of experts with a clear vision of the target market. In this way, firms reduce the uncertainty and risks associated with the penetration of new markets or those with high uncertainty (Zhao et al., 2020). According to Civera et al., (2020), entrepreneurial activity has its strength in the collaboration networks it is part of and from which it can obtain benefits. This way allows firms to stay within the scope of objectives according to the markets they serve. Nevertheless, the empirical evidence on the effectiveness of these networks is mixed. While some studies find that strong networks lead to better performance and innovation, others suggest that overly tight networks can limit a firm's exposure to new ideas and opportunities, potentially hindering innovation (Civera et al., 2020).

Relational capital and the capital of entrepreneurship and innovation include intangible resources provided by people who make up work teams. In this way, relational capital has as its fundamental premise the set of networks that a person possesses and allows them to provide the necessary knowledge to improve performance (Civera et al, 2020; Salvador et al., 2022). Furthermore, it is essential to point out that the relationship between relational capital and performance is still initial. The need to search for antecedents as consequences become essential in the field (Zhao et al., 2020). In this way, the following hypothesis is raised:

H4. (Hypothesis 4) Relational capital directly and positively affects the capital of entrepreneurship and innovation.

Human capital is defined as a source that generates innovation and value for the firm (Hormiga et al., 2011; Salvador et al., 2022). For other scholars, it is the capital that assists the firm members in generating value, which is made of two types of knowledge: tacit and explicit (Ordóñez de Pablos, 2002). Some studies suggest that this type

of capital falls not only on the company but also on the workers since it is lost when companies lose their employees due to difficulties in retaining them.

Despite the consensus on the importance of human capital, empirical evidence presents contradictions regarding its direct impact on firm innovation performance. Some studies indicate a strong positive correlation, while others suggest that the benefits of human capital are contingent upon various factors such as industry type and market conditions. For instance, Sun et al. (2020) emphasize the role of organizational behavior in mediating the effects of human capital on innovation and entrepreneurship performance, suggesting that the relationship is not straightforward and requires a nuanced understanding.

The learning generated by the firm's employees directly affects innovative performance. An important aspect to highlight here is that learning is fundamental in how firms are coordinated to generate talent (Dermol, 2019). However, the process of transforming individual human capital into organizational human capital is complex and varies across different contexts. Wang and Zatzick (2019) claim that the firm needs to transform the capital of individual human character into human organisational capital, as this will significantly influence performance. Human capital can maintain a competitive advantage through innovation, which is a fundamental part of successful performance (Kengatharan, 2019).

Giones et al, (2019) argue that the firm's human capital can generate a competitive advantage through its entrepreneurial experience. This entrepreneurial experience gives adequate conditions to the employees of the firms to impact creativity and innovation diversity. In addition, performance improvements have also been shown in the formation of work teams, especially in identifying business opportunities and further establishing the bases to face dynamic uncertainty in the market (Hogendoorn et al., 2019; Onuoha, 2021). In this way, investment in human capital can promote the discovery of business opportunities, especially in the firm's innovation. At a macro level, human capital promotes individual capital and the general one that influences the performance of directors, entrepreneurs, and managers of the firm (Guo & Chen, 2021). In this way, the following hypothesis is raised:

H5. (Hypothesis 5) Human capital directly and positively affects the firm's entrepreneurial and innovation capital.

3. Methodology

3.1 Sample and data collection

For this study, a census was conducted of the 782 software development companies in Colombia (Restrepo, 2022) obtaining a total of 310 consistent survey. This sample size represents approximately 40% of the total population, which is statistically significant and provides a robust basis for generalizing the findings (Cochran, 1997) . By surveying nearly half of the total companies, the study ensures that diverse perspectives and experiences are captured, enhancing the reliability and validity of the results. The minimum sample size was considered according to the PLS-SEM statistical method through the minimum power test in this case, it should be greater than 0.8. (Hair et al. 2017a). According to the ICT Ministry, the composition of the software industry in Colombia is as follows: 92% in micro and small companies, 7% in medium-sized companies, and 1% in big enterprises (CVN, 2022; Restrepo, 2022). The target population to which the survey was directed were senior officials of 782 companies dedicated to software development in the cities of Cali, Bogotá, Medellín, and Bucaramanga (Fedesoft et al., 2019).

The respondents were given independent questionnaires and were conducted through personal and telephonic interviews, between July 2019 and December 2020. The 310 consistent surveys obtained represent 92% of the population, which is composed of micro and small enterprises in the sector.

This study ensured informed consent by explaining the purpose, procedures, and voluntary nature of participation to all respondents. Confidentiality was maintained by anonymizing responses and securely storing data, with results presented in aggregate to protect participant identities.

3.2 Variables

For information gathering, a questionnaire was designed with 94 questions according to the constructs (Table 1) to evaluate the proposed hypotheses.

Table 1. Constructs

Construct	# Second-order construct	# Indicators (questions)
Human capital	3	16
Structural capital	8	30
Relational capital	11	34
Entrepreneurship and innovation capital	3	14

To guarantee the reliability and validity of the data, Cronbach's Alpha measurement was used, with results greater than or equal to 0.7 (Aldas & Uriel, 2017). Therefore, the first step consisted of carrying out a pilot test, which guaranteed the suitability of the survey with the fulfilment of these measurements. For this case, 30 surveys were carried out, and the researchers proposed the final version of the questionnaire.

3.3 Modelling and processing

We used PLS-SEM because of the likelihood estimation of structural models with latent variables based on partial least squares (Tenenhaus et al., 2005). The use of the PLS-SEM methodology requires a two-phase approach, the first is the analysis of the validity and reliability of the model, and the second is the verification of the hypotheses.

4. Results

4.1 Measurement model

4.1.1 Reliability

The analysis was carried out for this research with a standard significance level of α = 0.05, a moderate effect f = 0.25, and 34 predictors with the most complex construct. Using the G*Power 3 application (Faul et al., 2007), the power of the test obtained a value of 0.99, which represents a high reliability, and meets the requirement of values greater than 0.80 for the indicators proposed by Aldas & Uriel (2017) (see Table 2).

Table 2. Minimum power test.

Input:	Effect size f	= 0.25
	α err prob	= 0.05
	Total sample size	= 310
	Number of predictors	= 34
Output:	**Power (1-β err prob) = 0.9998506**	

4.1.2 Demographic data analysis

Once the power test with a value of 0.99 was obtained, the demographic data were analysed using the SPSS and Smart PLS software, respectively. The demographic information of the surveys is presented in Table 3, in which each response's frequency and relative frequency are indicated.

Table 3. Demographic data of the respondent

County of origin	**Frequency**	**Percentage**
Colombia	304	98%
Other	6	2%
Region of Colombia where the respondent works	**Frequency**	**Percentage**
Centre-East	243	78%
Caribbean	15	5%
Orinoco (East)	2	1%
Pacific	40	13%
Centre-South	0	0%
Eje Cafetero and Antioquia	10	3%
Products or services offered by the firm	**Frequency**	**Percentage**
Software development/factory	310	100%
Position in the firm	**Frequency**	**Percentage**
Executive	310	100%
Type of firm	**Frequency**	**Percentage**
Micro	243	78%
Small	67	22%
Experience in the sector	**Frequency**	**Percentage**
Form 11 – 15 years	205	66%
More than 15 years	105	34%

The information verifying the relevance of surveys is presented in Table 4, in which each response's frequency and relative frequency are indicated. The data were treated with the frequency function using the SPSS software. The data shows that 100% of the respondents know about the subject to be addressed in this research: agile methodologies, Scrum, and degrees of maturity of the company following international standards.

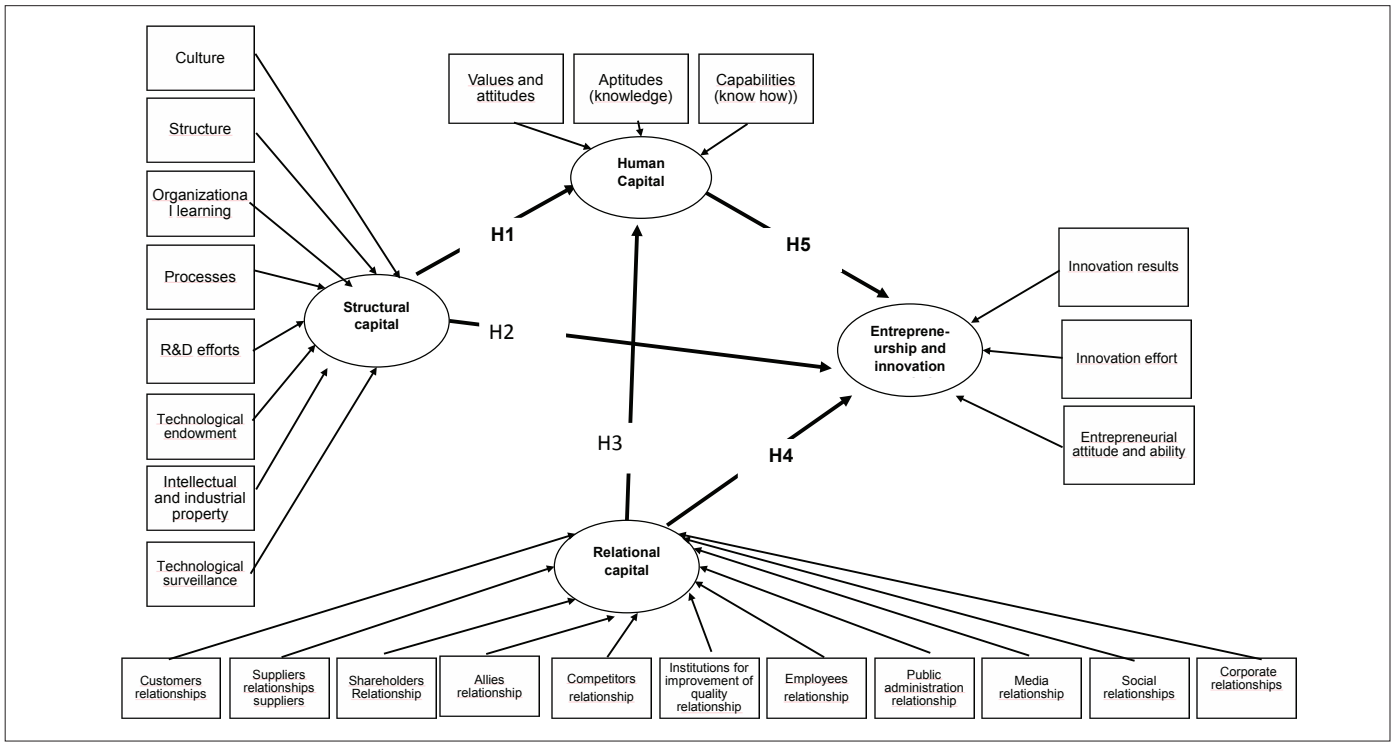
Table 4. Knowledge of the respondent

Self-appraisal	**Frequency**	**Percentage**
Expert	84	27%
Knowledgest	226	73%
Knowledge about agile methodologies	**Frequency**	**Percentage**
Yes	310	100%
Knowledge about performance indicators	**Frequency**	**Percentage**
Yes	310	100%
Knowledge about the degrees of maturity of the company	**Frequency**	**Percentage**
Yes	**310**	100%
Knowledge about agile manifest principles	**Frequency**	**Percentage**
Yes	**310**	100%
Knowledge about project planning	**Frequency**	**Percentage**
Yes	310	100%
Knowledge about project monitoring and control	**Frequency**	**Percentage**
Yes	310	100%
Knowledge about requirements management	**Frequency**	**Percentage**
Yes	310	100%
Knowledge about the product owner	**Frequency**	**Percentage**
Yes	310	100%

4.2 Structural model

In the Theoretical Model (see Figure 1), second-order indicators are presented, making the latent variables dependent, generating limitations because of phantom variables. This limitation was derived from the PLS-SEM algorithm since this tool does not admit 'phantom' latent variables, that is, latent variables that are not measured by at least one item (indicator).

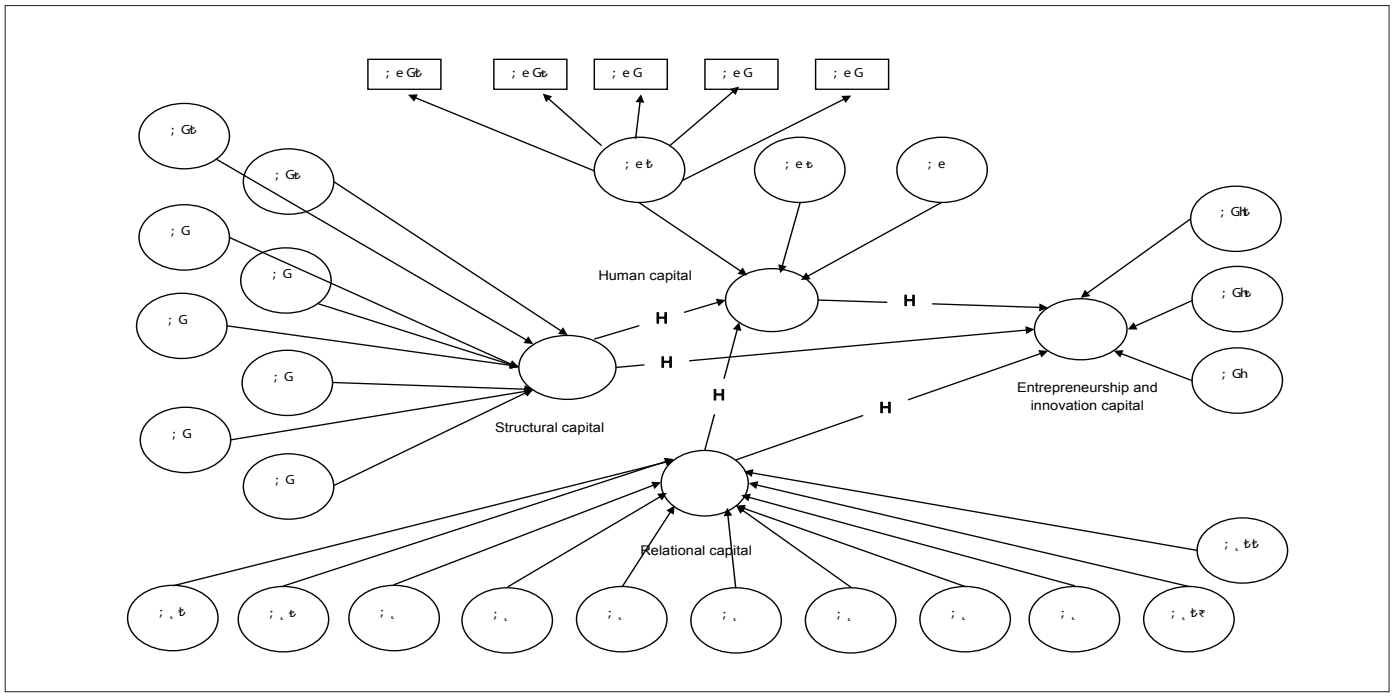
Figure 1. Theoretical Model



Source: Authors' own elaboration.

In Figure 2, the model is illustrated from the Smart PLS software (only the manifest variables of the latent variable CH1D are shown for visualization purposes). The model is type II "Reflective-Formative"; reflective in the manifest variables (indicators) and formative in the latent dependent variables (constructs) (Aldás, 2016).

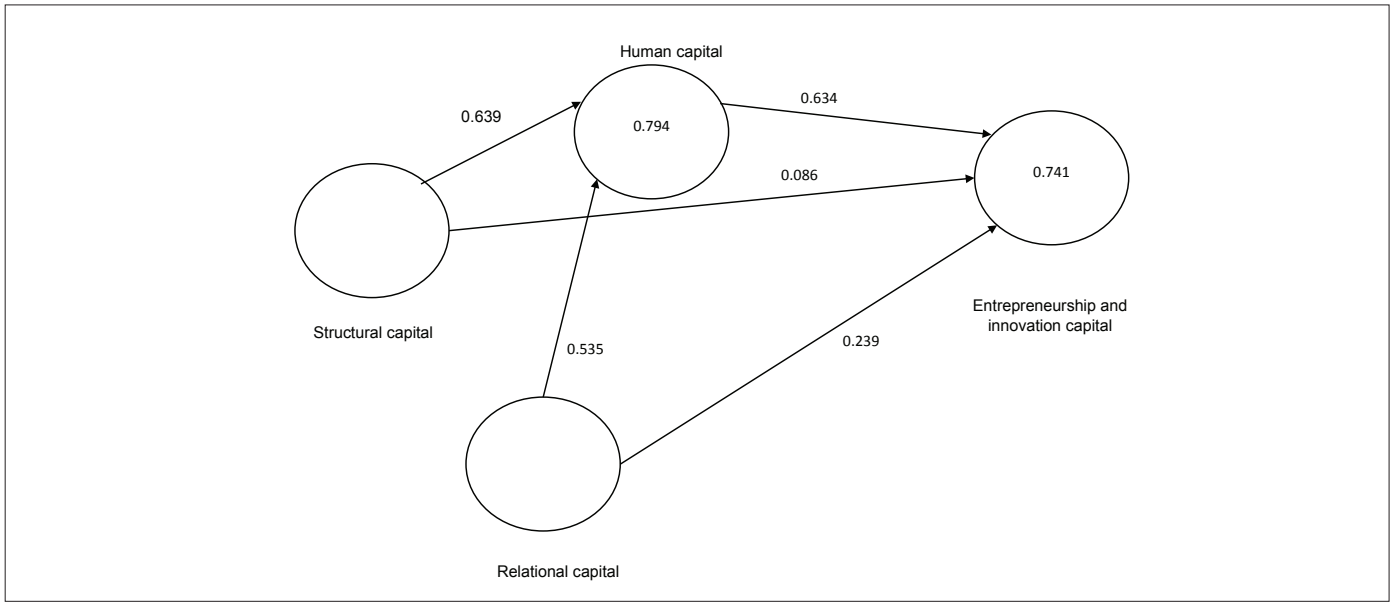
Figure 2. Initial model with Smart PLS.



Source: Authors' own elaboration.

To deal with the phantom variable, the two-stage approach is carried out (Hair et al., 2013; Hair et al., 2017b). The latent variable condition is removed for all first-order constructs, and the second-order constructs are eliminated (Kroonenberg & Lohmoller, 1990), allowing the new model to avoid the inconveniences generated by the phantom variables represented by the lack of items of the second-order constructs (Hair et al., 2017b; Wong, 2019), as can be seen in Figure 3. In this way, the model meets the minimum criteria to estimate the external component of the measuring instrument and the internal structural component.

Figure 3. Model from "the two-stage approach¨



Source: Authors' own elaboration.

Based on this new model, we find that we have a human capital R2 of 0.795 and entrepreneurial and innovation capital of 0.741, with no null significances (β=0.639, β=0.086, β=0.535, β=0.239, β= 0.634).

Given that in the proposed model, the latent variables are formative and their reliability and convergent validity cannot be assessed with Cronbach's α, composite reliability (CR), average variance extracted (AVE), and significant loadings, since these indicators are not applicable to formative constructs because the indicators do not need to be correlated with each other (Aldás Manzano, 2016; Bagozzi & Yi, 1988), we proceed to validate the measurement instrument based on the formative constructs. Therefore, according to Hair's (Hair, Sarstedt, Ringle, & Gudergan, 2017), the following must be validated: the diagnosis of multicollinearity and the analysis of the weight-loading relationship of the items,

Regarding evaluating potential problems of excessive multicollinearity, Table 5 shows that no variance inflation index (VIF) exceeds the critical value of 5 for the indicators of the educational construct (Hair et al., 2017a).

Table 5. VIF of the model.

	VIF		
CH1	1,032	**CR3**	1,115
CH2	1,022	**CR4**	1,095
CH3	1,052	**CR5**	1,057
CE1	1,036	**CR6**	1,039
CE2	1,065	**CR7**	1,02
CE3	1,018	**CR8**	1,028
CE4	1,041	**CR9**	1,039
CE5	1,046	**CR10**	1,082
CE6	1,033	**CR11**	1,028
CE7	1,026	**CEI1**	1,041
CE8	1,028	**CEI2**	1,068
CR1	1,069	**CEI3**	1,044
CR2	1,055		

To evaluate the significance of loads and weights, we bootstrapped, allowing the sign change option (Aldás, 2016), obtaining the following results (see Table 6).

Table 6. Significance of loads and weights.

	Loads	Weights
	Sample mean (M)	**Sample mean (M)**
CH1 -> Human Capital	0,692	0,601
CH2 ->Human Capital	0,627	0,542
CH3 -> Human Capital	0,573	0,389
CE1 -> Structural Capital	0,606	0,551
CE2 -> Structural Capital	0,404	0,351
CE3 -> Structural Capital	0,644	0,627
CE4 -> Structural Capital	0,123	0,006
CE5 -> Structural Capital	0,341	0,182
CE6 -> Structural Capital	0,115	0,026
CE7 -> Structural Capital	0,117	0,081
CE8 -> Structural Capital	0,111	0,018
CR1-> Relational Capital	0,66	0,531
CR2 -> Relational Capital	0,58	0,492
CR3 -> Relational Capital	0,559	0,451
CR4 -> Relational Capital	0,294	0,089
CR5-> Relational Capital	0,069	-0,001
CR6-> Relational Capital	-0,062	0,061
CR7-> Relational Capital	0,132	0,071
CR8-> Relational Capital	0,011	0,043
CR9-> Relational Capital	0,047	0,051
CR10-> Relational Capital	0,053	-0,016
CR11-> Relational Capital	0,191	0,097
CEI1-> Entrepreneurship and Innovation Capital	0,719	0,594
CEI2-> Entrepreneurship and Innovation Capital	0,61	0,41
CEI3-> Entrepreneurship and Innovation Capital	0,621	0,48

The multicollinearity values have presented a behaviour in the values associated with the indicators (VIF), which have been less than 5. This demonstrates the benefits of the external model and allows keeping all the formative items since the items were not highly correlated in the proposed model. In the same way, the values corresponding to the analysis of the load-weight relationship are maintained, because their load or their weight are positive (Aldás, 2016; Hair et al., 2014), demonstrating that the formative items have relative and absolute importance in the explanation of the construction of the construct.

To evaluate the explanatory power of the model, an analysis of the correlation coefficients of the dependent variables (R^2) and the predictive relevance of the proposed model (Q^2) was conducted, ensuring compliance with the minimum acceptable parameters (see Table 7). The obtained data reveal that the R^2 values are statistically significant and present relevant and moderate indicators for the dependent variables (Hair et al., 2017a). In this context, an R^2 of 0.794 was recorder for Human Capital and 0.741 for Entrepreneurship and Innovation Capital. It is important to note that the presence of multicollinearity is suggested when R^2 is equal to or greater than 0.80 (Aldás Manzano, 2016; Hair et al., 2017), which does not apply in this case.

Furthermore, the predictive relevance of the model, represented by Q^2, is used to assess the model's ability to predict the values of the dependent variables. A positive Q^2 value is a favorable indicator of the model's utility in terms of prediction (Aldás Manzano, 2016; Hair et al., 2017). In this study, a Q^2 of 0.767 was obtained for Human Capital and 0.623 for Entrepreneurship and Innovation Capital, suggesting that the observed relationship is not attributable to chance.

Additionally, the indicators employed are relevant and have a moderate impact, indicating that while the independent variables explain a sizable portion of the variability in the dependent variables, they do not account for everything, suggesting the existence of other factors that may also influence. Therefore, it can be inferred that the model explains 74.1% of the variance in Entrepreneurship and Innovation Capital and 79.4% in Human Capital. Similarly, the data obtained from Q^2 indicate that all the dependent variables of the model possess predictive relevance.

Table 7. Explanatory Power and Predictive Relevance

	R^2	Q^2
Human Capital	0,794	0,767
Entrepreneurship and Innovation Capital	0,741	0,623

The model of the analytical theoretical framework proposed in this research is empirically validated, demonstrating how the theoretical model has predicted the proposed relationships (Table 8). Structural Capital has a positive and significant impact on Human Capital (*B*=0639) validating H1. On the other hand, both Structural Capital and Relational Capital have a positive but low significance impact on Entrepreneurship and Innovation Capital (*B*=0.086 and *B*=0.239, respectively), however the H2 y H4 were validated. Relational Capital has a positive and significant impact on Human Capital (*B*=0.535), validating H3. Finally, Human Capital has a positive and significant impact on Entrepreneurship and Innovation Capital (*B*=0.634), validating H5.

Table 8. Test hypotheses

Hypothesis	**Relationship**	***Beta Standardized B***	***Valor t***
H1	Structural Capital -> Human Capital	0.639	22.224
H2	Structural Capital -> Entrepreneurship and Innovation Capital	0.086	1.208
H3	Relational Capital -> Human Capital	0.535	16.968
H4	Relational Capital -> Entrepreneurship and Innovation Capital	0.239	4.975
H5	Human Capital -> Entrepreneurship and Innovation Capital	0.634	8.050

Discussion

This research contributes to the theoretical objective of understanding the effects of human, structural, and relational capital on entrepreneurship and innovation in micro and small firms of the software development industry, which are the 92% of the software industry in Colombia.

The results demonstrate that Structural and relational capital have a positive impact on human capital. Although previous studies indicate a positive association between structural and relational capital with entrepreneurship and innovation Capital (Ayu et al., 2019; Civera et al., 2020; Sun et al., 2020; Onuoha, 2021; Salvador et al., 2022), we could find a low significance between those variables. However, we validate the positive impact of human capital on entrepreneurship and innovation capital.

The findings show that structural capital, including structure, processes, culture, organisational learning, technology endowment, intellectual and industrial property, and technology forecasting, present a direct and positive influence on human capital (*B=0.*639), defined as the generation of knowledge and value in the firm, validating H1. Even though the H2 and H4 were validated, it is concluded that the influence between structural capital (*B*=0.086) and relational capital (*B*=0.239) towards entrepreneurship and innovation capital is indirect through human capital.

On the other hand, this research shows that relational capital, understood as the value creation process between the firm and its stakeholders, directly and positively affects the firm's human capital (*B*=0.535), because these networks enable attracting and maintaining talented collaborators who create value for the firm in terms of the market, validating H3.

Lastly, this research confirms that human capital understood as values and attitudes, skills and abilities, directly and positively affect the firm's entrepreneurial and innovation capital (B=0.634), validating H5.

Conclusions

6.1 Theoretical implications

Our study contributes to the management and business literature by exploring the missing link between knowledge management and entrepreneurship and the dynamics of a specific sector. The study focuses on the ICT industry, which is characterized by rapid changes and has become of strategic importance for other industries because of their need to adopt new information technologies and digital transformation. While previous studies have focus on country studies (Iftikhar et al., 2022; Gimenez-Fernandez et al., 2022; Feyzbakhsh et al., 2022), Cross-country studies (Chung et al., 2022; Dheer & Treviño, 2022; Kirschning & Mrozewski, 2024), using one or two of the constructs (human, structural, relational, entrepreneurship and innovation capital), we tested a comprehensive model that includes the interrelation between the four constructs in a dynamic sector with rapid technological changes.

The second contribution of our study to the business and management literature is related to research in the field of entrepreneurial organisations, understanding the effects human, structural and relational capital in entrepreneurship and innovation activities of micro and small firms of software development, reducing the gap between the theoretical model of the KSTE (Aundretsch et al., 2020; Iftikhar et al., 2022) and empirical model Intellectus (CIC et al., 2011). Most of the interest is the need to identify the role of variables of knowledge management and its effect on entrepreneurship development activities (Audretsch et al., 2020; Salvador et al., 2022; Iftikhar et al., 2022).

Furthermore, our study has shown the direct and positive effect of human, structural, and relational capital on entrepreneurship and innovation capital in micro and small firms of the software development industry in Colombia, through the verification of the five hypotheses proposed in the proposed model.

By uniting theoretical models with empirical data, this research not only highlights the importance of these capitals in driving business performance and success, but also highlights the need for continued exploration and investment in these areas to sustain long-term economic development. The findings argue for specific initiatives that enhance collaboration, knowledge sharing and capacity development, thereby creating a fertile environment for entrepreneurship and innovation to thrive in emerging economies.

6.2 Managerial implications

Literature shows that the problem of micro and small enterprises has singularities specific to each region, each sector, and each type of company. Software is an intangible product, and the complexity of its development is rooted in the complexity of human consciousness and its relationships. In this sense, one of the main challenges of micro and small software development firms in Colombia is to guarantee good management of human, structural and relational capital. These will allow companies to identify the variables needed to manage knowledge and its effects on entrepreneurship and innovation activities.

The ICT industry can benefit from this research to the extent that entrepreneurs and managers in the sector could prioritize their actions to create entrepreneurship and innovation capital, through the adoption of processes, procedures, and activities, based on the studied constructs of human, structural, and relational capital. Therefore, these actions allow them to be more successful in their entrepreneurship and innovation activities, thereby strengthening the sector compared to similar companies in other countries, which is a valuable contribution to the competitiveness of the country given the importance this sector to the adoption of new technologies in other industries and their digital transformation.

However, the implications of this research extend beyond the software development industry in Colombia and offer valuable information for emerging economies worldwide. Understanding the dynamic interaction between different forms of capital can help policymakers and business leaders design strategies that leverage human, structural and relational capital to stimulate innovation and entrepreneurship in

various sectors. This holistic approach can help emerging economies build resilient and competitive markets, fostering sustainable economic growth through greater innovation capabilities. These strategic insights are crucial to addressing the complex challenges and opportunities presented by rapid technological advances and global market dynamics.

6.3 Limitations and future research

The study has some limitations that offer scope for future research. An aspect identified as a limitation has been that the research has only been carried out in micro and small companies in Colombia, leaving out medium and large organisations. Due to their degree of maturity, they can have different behavior (Gabriel & Ortiz, 2016). The generalization of their results is subject to the geographic context. Future research could explore medium and large organisations in the software industry to compare their behavior against the results of micro and small companies in the industry. It would also be important to investigate and compare these results with other emerging countries in Latin American.

The issues of operationalization of the elements of the model and its measurement through an instrument should be considered as possible limitations (Aldás, 2016; Bagozzi & Yi, 1988). Although the elements assumed in this study have been validated, it does not mean that they are the only ones existing and the absence of weighting in the descriptive analysis is assumed due to the lack of theoretical material that leads to an adequate weighting and the limitations in the statistical method PLS-SEM (Hair et al., 2017a). From the data, the analysis of the structural model is verified, however, analysing the significances (standardized betas), it can be observed that the highest are those that go towards human capital and from this to entrepreneurship and innovation capital, while those that are directed towards entrepreneurship and innovation capital are low except the one that comes from human capital, therefore, it will be needed further research including new variables (indicators) to understand the relationship between relational capital, cultural capital, and entrepreneurship and innovation capital.

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ISSN: 0718-2724. (http://jotmi.org)