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Psychometric properties of the scale: perception of the information and communication technologies for Knowledge Management

Propiedades psicométricas de la escala: percepción sobre las tecnologías de la información y comunicación para la gestión del conocimiento

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ABSTRACT

The objective of this research is to discuss the psychometric elements of reliability and validity on a measurement model that determines the perception on information and communication technologies for knowledge management in organizations. The scale is based on 6 questions and 2 structured factors in a Likert-type scale, with 5 answer options. It was applied to 337 small and medium companies with diverse specialties within the building field in the state of Campeche. The results of the exploratory and confirmatory factor analysis show an adequate fit and the reliability values are also satisfactory (χ^2 = 24.97, p = .002, SRMR = .01, AGFI = .93, TLI = .97, CFI =. 98, RMSEA .07 IC90 [.04-.11]; α = .88), thus confirming the empirical strength of the model. It is concluded that the scale is valid and reliable for use in the context studied.

Keywords
Management information systems; Technological capacity; Multivariate analysis

RESUMEN

El objetivo de este estudio es discutir los elementos psicométricos de fiabilidad y validez de un modelo de medida que determina la percepción sobre las tecnologías de la información y la comunicación para la gestión del conocimiento en las organizaciones. La escala tipo Likert, compuesta por seis reactivos y dos factores estructurados, con cinco opciones de respuesta, se aplicó a 337 empresas pequeñas y medianas de diversas especialidades del sector de la construcción en el estado de Campeche, México. Los resultados de los análisis factorial exploratorio y confirmatorio muestran un ajuste adecuado; asimismo, los valores de fiabilidad son satisfactorios (χ^2= 24.97, p= .002, SRMR= .01, AGFI= .93, TLI=.97, CFI= .98, RMSEA .07 IC90[.04-.11]; α= .88), con lo que se puede confirmar la solidez empírica del modelo. Se concluye que la escala es válida y confiable para su empleo en el contexto estudiado.

Palabras clave
Sistemas de información de gestión; capacidad tecnológica; análisis multivariante

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Introduction

Mexico's National Development Plan 2019-2024 (Federal Government of the United Mexican States, 2019), and the State Development Plan of Campeche 2019-2021 (Government of the State of Campeche, 2020), as guiding documents for economic policy, consider the construction industry as a priority. For Mexico, the share of this sector in the gross domestic product (GDP) was.

> 6.39% at the end of the fourth quarter of 2019, above the financial services sector (4.7%) and below transportation, post and storage (6.49%); likewise, its contribution to employment generation of 7.59% is recognized, higher than the contribution of the professional and financial services sector (7.03%) and lower than the social services sector (7.84%), according to data from the National Institute of Statistics and Geography (INEGI, by its acronym in Spanish, 2020). It is worth noting that as of June 2019, the state of Campeche was the entity with the highest share of public works with 96.1%, followed by Oaxaca with 75.8% and the State of Mexico with 69.3%, according to information from the Center for Construction Sector Studies (CEESCO, by its acronym in Spanish, 2020).

Based on the economic plans (federal and state), it is possible to establish as a priority that the construction sector be integrated by companies that identify the factors that affect their long-term planning, under a directed and proactive leadership, aware of the challenges of a constantly evolving economy. These organizations must have sufficient administrative, technical and financial elements to be part of the infrastructure development plans proposed in the guiding documents of the national economy –particularly for the southeast of the country– and to remain in the market in a sustainable manner.

This document shows the procedure developed to design and validate a scale that relates the requirements of information and communication technologies (ICT) for knowledge management in organizations (RTIC-GC), as well as market monitoring for products or services through these (SMTIC-GC).

The objective of the study included the development and verification of psychometric properties such as reliability and construct validity: information and communication technologies for knowledge management in organizations (ICT-GC) of the construction sector in the city of Campeche, Mexico. It is hypothesized that the model, proposed based on theory, meets the psychometric properties of reliability, content and construct validity.

Psychometry states that measurement methods and models should be valid in practical aspects and in terms of obtaining their measurements, so it is relevant to generate instruments that comply with the basic principles of this discipline, in any area of knowledge (Nunally, 1991). Thus, the contribution of this research focuses on providing a valid contextualized tool that supports the measurement processes in knowledge management.

The way in which organizations create knowledge through their operations is a factor that allows the development of long-term strategic planning and, to this end, ICTs contribute to this end. Studies have been carried out with instruments for obtaining information to establish the contribution of ICTs to the level of corporate governance; however, the means used must provide reliable data that contribute to the analysis of the problem and propose alternative solutions. Therefore, when considering the scope of the ICT and KM variables, it is necessary to delimit that the results obtained are relevant to the population and the context under study.

ICT in knowledge management

Nonaka and Takeuchi (1999) point out in the knowledge management spiral, the transfer of individual knowledge (tacit knowledge) to organizational knowledge (explicit knowledge), as a key element of the knowledge creation process. In this transition, technology plays an essential role to successfully carry out the function of sharing the knowledge generated (Hendriks, 1999).

To clarify the role of ICTs in companies, Macau (2004) formulated a research that considers the impact of ICTs according to their levels of management, implementation and development by each entity, which allowed him to conclude that technology favors the automation of processes and the development of the infrastructure necessary for information systems; it is also recognized as part of the production chains of goods and services, and as a fundamental element in the organization's activities.

Grande, Cañón and Cantón (2016), developed a theoretical research on the evolution of the conceptualization of ICT, as a result of the prominence they have had in social and business life, as precursors of the rapid transformation of knowledge. The authors analyzed studies formulated in the last 30 years that are the result of experiences at the social level, considering that knowledge about technology responds to a collective need of organizations and individuals. They also stressed that the most important aspect of ICT transformation is the diversity of use and development, which is reflected in competitive advantages, the management of which will depend on the management's ability to visualize the benefits of its implementation.

García (2013) proposes a classification of ICTs based on the theory of knowledge and considers them as useful tools in: 1) information search and retrieval, 2) information filtering and personalization, 3) storage, 4) analysis, 5) communication systems, 6) e-learning systems and e-commerce, and 7) business management systems. These technologies are also considered to produce positive effects on knowledge processes and knowledge generation.

Just as ICTs contribute to knowledge management, they also represent a disadvantage in emerging economies, as in the case of Mexico (Tello, 2007). In this regard, several authors have highlighted their role in the competitiveness of organizations (Subashini, Rita & Vivek, 2012; Suharyantoa, Gunawan, Normawatic & Rogayahd, 2015).

Technological capability in organizations at the national and organizational levels was analyzed by Lall (1992), based on how incentives, capabilities and institutions are related in countries such as South Korea, Taiwan, Hong Kong, Singapore, India, Brazil, Mexico and Thailand. It is generally accepted that innovation does not come from emerging economies, but from those that are identified as advanced, and that these, in turn, provide technology to developing countries.

This situation is replicated at the business level, where knowledge about technology is not shared and its transfer is difficult, since these are tacit, which makes it difficult to understand. This is reflected in an effort of acquisition and investment for its implementation by the companies. The differences between countries, in terms of technology, are not the sum of their exercise by companies, but the ability of the government to mediate their use and innovation (Lall, 1992).

Regarding technological competence and its relationship with performance, Domínguez and Brown (2004) used factor analysis as a tool to identify the elements that favor learning processes in Mexican manufacturing companies. The authors constructed performance indicators that confirm the positive association of performance with the technological capacity of the firm. In addition, Pérez and Pérez (2009) studied –in the same national and economic context– the relationship between competitiveness and technological capacity supported by foreign investment. In this research it was observed that the basis for accumulating this capacity is learning; therefore, establishing industrial policies that encourage this process contributes to better economic performance, as pointed out by Lall in 1992.

Reviewing instruments

Several authors have studied the contribution of ICTs to strengthen KM in organizations, small and medium-sized enterprises (SMEs), as well as the main factors that influence their adoption and diffusion, such as the economic environment and the particular characteristics of the company (Devia and Lora, 1998; Gargallo and Ramírez, 2007). Similarly, research has been conducted on companies that develop non-technological innovations and have external sources of knowledge (Del Carpio and Miralles, 2019).

The relationship between these variables was approached from various perspectives, such as organizational culture (López and Meroño, 2009), the generation of indicators that allow observing changes in KM in organizations (Artiles and Pumar, 2013; Inche and Álvarez,

2007), the determination of the degree of KM maturity by evaluating the use of ICT in companies (Durango, 2015), and innovation in the stages of acquisition, production, transmission and storage of knowledge in organizations (García 2014). In addition, studies have been conducted according to economic sectors, such as hotel (Gómez, Ortigueira & Romero, 2014), restaurant (Delgado, Vargas, Rodríguez & Montes, 2017), construction (Egbu & Botterill, 2002; Delgado, 2008), textile (García, 2014), commerce (Simón, Torres, García & Ravelo, 2015), and communications (Tong & Shaikh, 2010).

To establish the link between ICT and KM, studies have been developed that consider the relationship between different variables, such as organization and personnel, processes and technology (Durango, 2015), trends and challenges in information systems, process-oriented systems and systems for KM (Díaz, 2006). This has contributed to the formulation of theoretical (Andrade, 2003; Guerrero, 2014; Hamad, 2018; Hendriks, 1999, 2001; Pérez & Dressler, 2007; Soto & Cegarra, 2016) and empirical (Artiles & Pumar, 2013; Peñaloza, 2007; Simón, Torres, García & Ravelo, 2015; Tong & Shaikh, 2010) models.

Likewise, researchers have been busy designing instruments that measure the variables that are part of the problem under study and that, under various statistical tests, relate the elements that make up this article: ICTs and KM in organizations. An example of this is the research by García (2014), where the impact that ICTs can have on the stages of QA, innovation and learning with an economic approach was analyzed. These concepts were related by means of a theoretical model to be applied to an organization in the textile sector (Zara Group, which belongs to the Inditex company), where the ICT, QA and innovation variables were included. Their results indicate that the combined use of ICTs implies positive effects in the stages through which QA is initially combined and internalized and then socialized outside the company, which can be defined as a differentiation strategy with respect to its competitors in the economic sector in which it participates.

From the project management approach, ICT can have an impact on the success or failure of projects, due to causes such as the lack of collaborative work and the way in which each individual approaches his or her functions. As a result of the question: Is it possible to create knowledge from the use and appropriation of ICTs in the social management of projects, when there is a lack of communication among team members? González and Díaz (2013) studied the use of technological infrastructure, responsiveness according to business strategies, and flexibility of adaptation to changes by organizations as elements of project management, which aims at its success through the use of tools that will strengthen the relationships between those involved in the project, leading to a greater sense of belonging that will be reflected in the results achieved.

Briones, Bernal, Custodio and Santos (2018) studied the possibilities of cooperation of companies with suppliers, customers, competitors, companies from different sectors, private and public institutions, and the armed forces to infer the influence of cooperation and ICT as support in QA in 236 companies of the Spanish defense industry. Using the results of a

questionnaire, they contrasted the hypotheses posed through a multinomial logistic model, which allowed them to point out that the use of ICT as a support contributes to promoting collaborative relationships and managerial cooperation.

The median obtained was 4, on a 5-point scale. In its factor analysis, it was observed that the variance communalities are high, with values between 0.68 and 0.70 in the presence of a single factor (ICT as support for cooperation projects). The factor loadings of the items were between 0.82 and 0.84, with no significant differences. When debugging the factor analysis in two dimensions, the components extracted were: a) procedures to generate information and linkage with suppliers, and b) management of cooperation projects with customers; thus explaining 84.61% of the variance for both components (Briones, Bernal, Custodio & Santos, 2018). From the above, it is concluded that the scale is useful for the study of the combined use of knowledge and ICT in cooperation and business management.

The relationship between ICT potential and KM was studied by Pérez, Montes and Vázquez (2009), who considered 162 Spanish companies in the following sectors: gas and water, electric power, paper industry, graphic arts, electronics, transportation, commercial and private health services. These authors established the direct effect of ICTs on the production, transmission, codification and storage of knowledge in these organizations.

The instrument used considered three dimensions: 1) IT competencies, which includes eleven items on knowledge, operations and infrastructure; 2) KM, also with eleven items related to its generation, transfer, exchange, codification and storage processes; and 3) organizational structure, with four items used to evaluate the degree of centralization, complexity and vertical differentiation of organizations (Pérez, Montes and Vázquez, 2009).

Likewise, the content and structure of the psychometric scales were validated through personal interviews with academics and executive directors, and through a confirmatory factor analysis using EQS; the level of statistical confidence was established using Cronbach's alpha coefficient. All item loadings on the construct are significant (p<0.001), providing evidence of convergent and discriminant validity with correlation coefficients from 0.42 to 0.79.

The results of the tests made it possible to establish how fit the model was and confirm the dimensionality of the scale. The authors concluded that the competence of organizations with respect to ICTs has a determining influence on QA, favors their processes and the development of a good organizational structure (Pérez, Montes and Vázquez, 2009).

López and Meroño (2009) studied the impact of organizational culture on the decision to use ICTs for QA in various economic sectors. For this purpose, they administered a questionnaire with closed-ended questions to 300 Spanish SMEs with at least ten employees. To assess the validity and reliability of the instrument, they carried out different analyses in which they obtained high values of reliability (alpha greater than 0.7) and validity, with a correlation greater than 0.4, and a factor loading greater than 0.5, which

implies that the instrument they used was adequate and, therefore, allows identifying that the existing culture in the participating organizations does not significantly hinder the use of ICTs for QA as a strategy.

Rodríguez and Padilla (2019) evaluated culture and technology in the Chilean population by validating, through a factor analysis, the National Survey of Scientific and Technological Culture, in order to establish their perception regarding these topics. It was concluded that the dimensions studied are considered important for the country's progress, when there is adequate regulation on ethical grounds.

Similarly, Escuder (2019) studied the digital difference in Uruguay based on considering ICTs as elements to build the information society. Using factor analysis and the principal component analysis technique for the treatment of data according to departments or regions, it was established that in this country there are significant differences in access to ICTs in its geographic regions, which increases the digital segregation of its population.

Within the service sector, specifically in restaurants, a measurement instrument was developed and validated by Delgado *et al*. (2017) to evaluate the level of technological management in this economic activity on a probability sample of 132 organizations located in Playa del Carmen, Mexico. As a result of the statistical tests, three items derived from the exploratory analysis were obtained: technological strategy, research and development practices, and technological assimilation, which together explain 61.63% of the variance and a Cronbach's alpha of 0.90, which supports its level of reliability. The results obtained from the statistical adjustment of the instrument allow us to make a contribution with empirical evidence for similar studies in other contexts, with the reservations of the number of companies in the sample determined.

In the field of technology transfer, knowledge and learning for strategic partnerships in the hotel sector in Cuba, Gómez, Ortigueira and Romero (2014) formulated an instrument with a reliability of 0.804 (determined through Cronbach's alpha), whose dimensions are: a) the determinants of the establishment of the partnership, b) the results of the partnership, c) the interaction of the parties to the negotiation, and d) sustainability and strategic lines. Among the results of its application to the participating companies is the need to generate dynamic capabilities, as well as to create value through innovation processes and continuous learning of intangible assets.

The role of ICTs in the QA of private companies in the construction sector was studied by Egbu and Botterill (2002), who point out their importance and contribution based on their strengths and weaknesses, identified through a questionnaire and interviews for ethnographic data obtained in five medium and large organizations in the United Kingdom.

The interviews were analyzed using NVIVO software to identify relationships between variables and the questionnaires were analyzed using SPSS software to establish the

use of technology and thus rank the effectiveness of these tools in QA. The results indicate that conventional ICTs –such as telephone, Internet and e-mail– are used more frequently than the more innovative ones –such as videoconferencing or collaborative work software.

The researchers concluded that ICTs are not fully exploited in this economic activity, and there is a need for further implementation accompanied by corresponding training. The use of technology in these organizations is more frequent for the transmission of explicit knowledge, while traditional procedures for sharing and transferring tacit knowledge prevail, which derives from the absence of a formal strategy to maximize the benefits of ICTs for the organization.

To study the level of technological management in the construction sector in Mexico, Delgado (2008) considered the variables: use of technology (eleven items) and importance perceived by employees (ten items), which comprise a self-assessment questionnaire with dichotomous answers added with five-point numerical values on a Likert-type scale and through the case study of a civil engineering company. In a range between 1,300 and 2,400 employees on average, a sample of 40 employees comprising the middle and top management of the company was obtained.

Correlation of the values obtained from the answers allowed the author to point out that, for the case under study, there are coinciding opinions regarding the use of technology among the participating groups of collaborators; however, regarding the importance of technology management for employees, a weak correlation was observed; therefore, a greater dissemination of the concepts that make up this topic and its relevance among the company's stakeholders is required.

It is necessary to highlight the fact that the instruments should be designed or adapted in order to address the characteristics of the problem and the particularities of the population, since this allows making an effective contribution with the analysis of the results obtained, as identified by Mul, Mercado and Ojeda (2013), who proposed an instrument to learn about QA activities and the organizational factors that influence it –including ICTs– in companies in the southeast of Mexico, and whose design takes into account the characteristics of the leader and the economic context of the region, which served as a basis for the authors of this study.

From the literature review, instruments applied to companies with volumes of work, level of income, equipment and personnel superior to the participating organizations were identified. This is the case of the survey on Information and Communication Technologies (ENTIC), managed by the National Institute of Statistics and Geography in 2013 to contribute to decision-making in the design of public policies, and oriented to companies with more than ten people employed in various economic activities, whose dimensions of analysis are exclusively directed to issues of technological capacity, without addressing their contribution to business knowledge management.

Methodology

The research was of a quantitative type with a non-experimental, cross-sectional design. The purpose is to generate a measurement model of the construct. The objective of the study was the validation of the ICT-GC scale in small and medium organizations of the private sector in the southeast of Mexico.

Participants

A total of 337 managers of construction industry companies in the state of Campeche, located in southeastern Mexico, were invited to participate: 95% of the respondents were male, with a main age range between 45 and 52 years old (46.9%), mostly married (92.3%). Most of the population had higher education (93.8%), and a smaller percentage had a postgraduate degree (4.2%). Family companies (32.3%), partnerships (34.4%) and sole proprietorships (33.2%) were surveyed. Table 1 shows the distribution of the surveyed population by economic subsector.

Table 1. Distribution of the surveyed population by economic subsector and type of ownership of the organization

Economic subsector	Sole owner		Familiar		From various partners	
	Fr	%	Fr	%	Fr	%
Housing	43	38	14	13	51	44
Education	14	13	21	19	15	13
Water	3	3	8	7	-	-
Communication	44	39	52	48	35	30
Energy	-	-	9	8	12	10
Specialties	8	7	5	5	3	3
Total	112	100	109	100	116	100

Source: developed by the author with statistical data generated with SPSS version 25.0.

Procedure

Participants were asked to answer the questionnaire autonomously, on paper and pencil, with accompaniment from members of the research team during the months of May to August 2019.

Designing the instrument

The instrument is based on a dimension of the version developed by Mul, Mercado and Ojeda (2013), made based on previous literature (Alavi & Leidner, 1999; Camelo-Ordaz, García-Cruz & Sousa-Ginel, 2010; Holowetzki, 2002). The adaptation required a literature review for the correct wording of the context studied (Chauvel & Despres, 2002; Egbu & Botterill, 2002; Soto-Acosta, Colomo-Palacios & Popa, 2014; Subashini *et al*., 2012; Zhu & Kraemer, 2005).

Content validity was conducted qualitatively with a group of QA and ICT experts, who reviewed the items of the scale for this construct, according to the procedure described by Urrutia, Barrios, Gutiérrez and Mayorga (2015).

The instrument consisted of six items, which measure two factors: three items measure the ICT requirements that organizations have for QA (RTIC-QA), and three items for the second factor, which measures market monitoring through ICTs (SMTIC-QA). A Likert-type scale was structured with five response options: 1) Strongly disagree, 2) Disagree, 3) Neither agree nor disagree, 4) Agree, and 5) Strongly agree. Table 2 specifies the operational definitions of the construct.

Table 2. Table of specifications of the factors of the ICT-GC scale

Variable	Operational definition	Items
ICT requirements of organizations for QA (RTIC-QA)	Perception of the ICT support available to the organization that allows adequate knowledge management.	The organization updates the hardware/software constantly
		All employees have access to ICTs from their workplaces
		ICTs are indispensable in the organization's daily activities
Market monitoring through ICTs (SMTI-QA)	Perception of the use of ICTs to market products and/or services in the organization.	The organization makes use of ICT to conduct e-commerce
		Available ICTs are easily accessible to employees
		The organization uses ICT to monitor new products and/or services.

Source: developed by the author with data from Alavi & Leidner, 1999; Camelo-Ordaz *et al*., 2010; Chauvel & Despres, 2002; Egbu & Botterill, 2002; Holowetzki, 2002; Mul, Mercado & Ojeda, 2013; Soto- Acosta *et al*., 2014; Subashini *et al*., 2012; Zhu & Kraemer, 2005.

Data analysis

First off, a descriptive analysis of the data was carried out to verify the necessary assumptions of normality. The purpose of the study was to determine two of the psychometric qualities necessary in any measurement instrument: reliability and validity.

Reliability was calculated using Cronbach's alpha coefficient; however, as this coefficient does not consider correlated errors, it was decided to include the calculation of the McDonald omega coefficient, which, according to Ventura-León and Caycho-Rodríguez, (2017), works with factor loadings, which makes the calculations more stable and reflects a much more accurate level of reliability. The calculation of this coefficient was performed with the JASP 0.14.00 software.

Validity establishes the correspondence between the items and the construct that was defined to measure (Valdés-Cuervo, García-Vázquez, Torres-Acuña, Urías-Murrieta & Grijalva-Quiñonez, 2019). Thus, content validity was performed through the expert review technique (Urrutia-Egaña *et al*., 2015), and construct validity was established through exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).

Several authors point out that the CFA corrects the shortcomings of the exploratory perspective (Batista-Foguet, Coenders & Alonso, 2004; Ferrando & Anguiano-Carrasco, 2010; Lloret-Segura, Ferreres-Traver, Hernández-Baeza & Tomás-Marco, 2014), since the first technique only allows determining that the items fit the data, but does not establish equality of saturations or error variances. Lloret-Segura *et al*. (2014) rightly point out that the AFE technique is useful to build theory, but the AFC allows to have it corroborated.

Results

Descriptive analysis

In order to verify the necessary conditions for the AFA, a descriptive analysis was developed that included the values of the mean, standard deviation, skewness and kurtosis of the items (table 3).

Reliability

To ensure the homogeneity and internal consistency of the instrument, Cronbach's alpha values were calculated, and highly reliable values of α=0.84 were obtained for both factors (Milton, 2010). Since the calculation through this coefficient does not allow establishing the absence of correlated errors, the calculation of the McDonald omega coefficient was also included,

which reports a value of Ω = 0.84 for the ICT requirements factor that organizations have for knowledge management (RICT-GC) and Ω = 0.85 for market monitoring through ICT (SMICT-GC).

Table 3. Mean, standard deviation, skewness and kurtosis of the reagents of the ICT-GC scale

Items	M	DE	Asymmetry	Kurtosis
The organization updates the hardware/software constantly	3.32	0.74	-0.85	0.20
All employees have access to ICTs from their workplaces	3.09	0.7	-0.88	1.01
ICTs are indispensable in the organization's daily activities	3.12	0.72	-0.80	1.05
The organization makes use of ICT to conduct e-commerce	2.95	0.83	-0.46	-0.35
Available ICTs are easily accessible to employees	3.03	0.75	-0.71	0.63
The organization uses ICT to monitor new products and/or services	3.15	0.83	-0.81	0.12

Note: M: mean, SD: standard deviation.
Source: developed by the author with statistical data generated with SPSS version 25.0.

Validity of the internal structure

The assumptions for the multivariate analysis were tested through the Kaiser-Meyer-Olkin (KMO) tests, in which values above 0.60 were obtained, and Bartlett's sphericity tests with significance values below 0.00 (RTIC-GC: KMO= 0.64, *gl*= 3, χ^2= 532.31, *p*= 0.000; SMTIC-GC: KMO= 0.62, *gl*= 3, χ^2= 560.16, *p*= 0.000), indicating that it is possible to perform the AFE (Williams, Onsman, & Brown, 2010).

Exploratory factor analysis (EFA)

To provide evidence of the construct validity of the scale and to identify the number and composition of common factors needed to explain the common variance of the set of items analyzed, an EFA was performed using the maximum likelihood factor extraction method with direct oblimin rotation.

The results of the EFA show that the communalities of the items present values between 0.31 and 0.99, with factor loadings greater than 0.5, which meets the criteria for maintaining all

the items (Williams, Onsman and Brown, 2010). The total variances show a highly acceptable percentage of 66.72% (RICT-GC) and 69.11% (SMICT-GC) (see tables 4 and 5).

Table 4. Factor analysis of the ICT requirements factor of organizations for knowledge management (RTIC-GC)

Item	Factor	h^2
The organization updates the hardware/software constantly	0.56	0.31
All employees have access to ICTs from their workplaces	0.92	0.85
ICTs are indispensable in the organization's daily activities	0.92	0.85
% of total variance explained= 66.72%		

Note: N = 337, KMO = 0.64, χ^2= 532.31, *gl* = 3, $p < 0.000$, h^2 = Commonality. Extraction method: maximum likelihood analysis with direct oblimin rotation.
Source: developed by the author with statistical data generated with SPSS version 25.0

Table 5. Factor analysis of the market monitoring factor for products or services through ICT (SMTIC-GC)

Item	Factor	h^2
The organization makes use of ICT to carry out electronic commerce	61	0.37
Available ICTs are easily accessible to employees	0.83	0.70
The organization makes use of ICT to monitor new products and / or services	0.99	0.99
% of total variance explained= 69.11%		

Note: N = 337, KMO = .62, χ^2 = 560.16, *gl* = 3, p <.000, h^2 = Commonality. Extraction method: maximum likelihood analysis with direct oblimin rotation.
Source: developed by the author with statistical data generated with SPSS version 25.0

Confirmatory factor analysis (CFA)

Batista-Foguet, Coenders and Alonso (2004), and Fernandez (2015) make a severe criticism of construct validation methods solely through exploratory factor analysis. The authors propose establishing measurement models generated through confirmatory factor analysis as a necessary complement. These models allow contrasting validity by considering goodness of fit, where each item saturates only on the factor that comprises a valid indicator.

To validate the theoretical model, a CFA was performed to check the structure obtained previously and its theoretical inferences (Littlewood & Bernal, 2014). According to

Manzano and Zamora (2010), the main indicators of model fit were calculated. First, the indicators of the degree of goodness-of-fit are presented: the χ^2 test and the ratio of χ^2 over degrees of freedom. Then, the absolute fit indices are presented: the root mean square root of the residuals (SRMR), the adjusted goodness-of-fit index (AGFI) and the root mean squares error approximation index (RMSEA), which show acceptable values. Finally, the values of the main incremental fit indices are reported: the unnormalized fit index (TLI), and the comparative fit index (CFI), which also obtained satisfactory values (see table 6).

Table 6. Indicators of structural model adjustment of the ICT scale in knowledge management in organizations (ICT-CG)

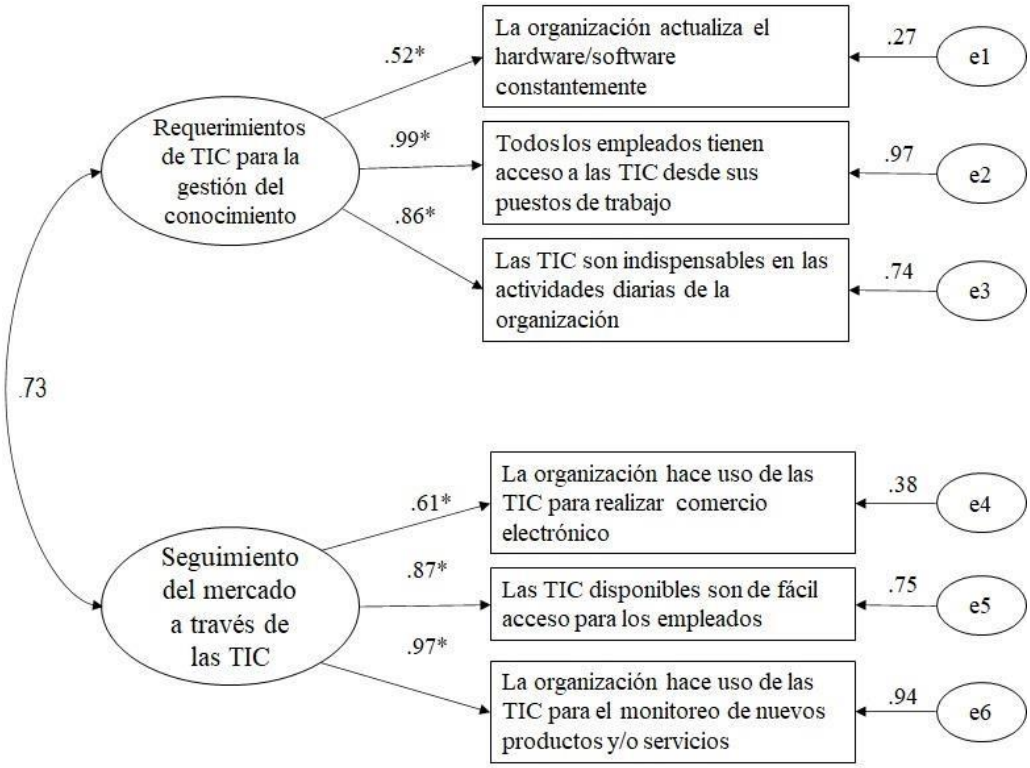
	Indicators of the degree of goodness of fit of the model			
Indicator	χ^2	*gl*	p	χ^2/df
Expected values			>0.001	1 a 3
Model	24.97	8	0.002	3.12

	Absolute adjustment indices			**Increment adjustment rates**	
Indicator	SRMR	RMSEA	AGFI	TLI	CFI
Expected values	<0.08	0.06 a 0.08	≥ 0.90	≥ 0.90	≥ 0.95
Model	0.01	0.07 IC 90[0.04-0.11]	0.93	0.97	0.98

Note: N = 337. Reference values taken from Arias (2008) and Manzano and Zamora (2010).
Source: developed by the author with statistical data generated with AMOS version 23.0

The measurement model shows significant factor loadings, above 0.60, in all the items of both factors; the covariance between the variables is positively significant (see figure 1).

Figure 1. Confirmatory factor analysis model of the ICT scale in knowledge management in organizations (ICT-CG)



* p <0.001
Note: fully standardized maximum likelihood parameter estimates.
Source: developed by the author with statistical data generated with AMOS, see 23.0.

Table 7 shows the estimated parameters of the model, the approximate standard error and the critical ratio. It can be seen that all critical proportion values are relatively large, which allowed all estimated parameters to show a significance level of p< 0.001; therefore, the null hypothesis that the parameter has a value of zero can be accepted (Lara, 2014; Littlewood & Bernal, 2014).

Table 7. Estimated parameters for the structural model of the ICT scale in knowledge management in organizations (ICT-CG)

Observed	Latent	Non-standardized coefficients	*S.E.*	*CR*	*p*
F1	The organization updates the hardware/software constantly	1.00			
F1	All employees have access to ICTs from their workplaces	1.94	.18	10.70	*
F1	ICTs are indispensable in the organization's daily activities	1.61	.15	10.39	*
F2	The organization makes use of ICT to carry out electronic commerce	1.000			
F2	Available ICTs are easily accessible to employees	1.27	.10	12.56	*
F2	The organization makes use of ICT to monitor new products and / or services	1.57	.12	13.57	*

* p <0.001
Source: developed by the author with statistical data generated with AMOS, see 23.0.

Discussion

The results of this work, and its contrast with previous studies, allow reinforcing the procedures used by Mul, Mercado and Ojeda (2013), when proposing an instrument to analyze the application of ICTs in QA in the context of companies in southeastern Mexico. Content validity was established through expert judgment, considered adequate by Urrutia *et al*. (2015) to evaluate the empirical evidence and theoretical bases of an instrument, a method that was also used by Briones *et al*. (2018) in their study to establish the influence of collaborative ICT in CG.

As established by Littlewood and Bernal (2014), the study made it possible to verify the validity of the measurement of the latent variables in relation to their indicators and the proposed theoretical model. The six items designated as indicators, or observed variables, make it possible to measure each of the factors that make up the model.

The models comply with presenting at least three observed variables (in this case, the items) for each factor, and the factor loadings are greater than 0.5, which is acceptable (Lara, 2014; Littlewood & Bernal, 2014; Manzano & Zamora, 2010). Batista-Foguet *et al*. (2004) point out that the confirmatory factor analysis model allows correcting deficiencies presented in the AFE and allows analyzing the covariance matrix, not only the correlation matrix, which was necessary for this model due to the values of some of the communalities obtained in the EFA.

Regarding the reliability of the data, both factors (ICT requirements that organizations have for QA, and market monitoring through ICT) present acceptable values of Cronbach's alpha coefficient and McDonald's omega, similar to those obtained in the processes developed by Gómez *et al*. (2014) to study technology and knowledge in the celebration of interorganizational alliances, as well as the results obtained by Delgado *et al*. (2017) and López and Meroño (2009), who analyzed the interference of culture in the use of ICT as a support for QA procedures and the level of technological management implemented in organizations. Based on the above, it can be affirmed that the model presents elements of reliability and validity as psychometric characteristics necessary for a measurement model.

The values obtained from the scales when applying the exploratory (Williams *et al*. 2010) and confirmatory factor analysis (Arias, 2008; Manzano and Zamora, 2010) are acceptable and satisfactory, according to the fit indicators established for each type of analysis. The use of both techniques allowed the development of the scale and the construct, just as Delgado *et al*. (2017) did when developing a measurement instrument for technology management in restaurants, and Escuder (2019) and Rodríguez and Padilla (2019), who applied these multivariate statistical procedures for the validation of the instruments used in their research related to the regionalization of the digital divide and the perception of science and technology in various Latin American countries, respectively.

Conclusions

This research discussed the psychometric elements of reliability and validity of a measurement model that determines the perception of ICT for QA in organizations of the construction sector in a southeastern entity of Mexico, in order to establish whether the instrument fulfilled the objective for which it was designed.

The results shown allow us to accept the working hypothesis that the proposed model complies with the psychometric properties of reliability and content and construct validity, evaluated through rigorous statistical processes (Littlewood & Bernal, 2014; Valdés-Cuervo *et al*. 2019; Ventura-León & Caycho-Rodríguez, 2017).

The reliability of both constructs, estimated by means of two different procedures (Cronbach's alpha and McDonald's omega coefficient), shows similar data and in both cases acceptable, in accordance with the reference parameters for these indicators (Milton, 2010; Ventura-León & Caycho-Rodríguez, 2017).

Regarding validity, the results of the exploratory factor analysis allowed establishing the dimensionality of the proposed theoretical constructs, and the confirmatory factor analysis; in turn, it allowed corroborating an adequate fit of the data to the measurement model, according to the reference indicators for this type of models (Batista-Foguet *et al*. 2004; Lloret-Segura *et al*. 2014).

Although the study does not make new contributions to the methodology of multivariate analysis techniques, it does achieve the objective of verifying the elements necessary in psychometrics to consider a model adequate. Several authors highlight the importance of performing confirmatory factor analysis (Batista-Foguet *et al*. 2004; Kano & Ihara, 1994; Mulaik & Millsap, 2009), since the validity estimated only through exploratory factor analysis may give rise to inconsistencies that lead to inappropriate conclusions.

The economic and social contribution of the construction sector, previous research by various authors and the results of this work highlight the need to validate the constructs of existing instruments related to the variables measured in a construction company, as well as to evaluate the role of ICT as a support in the processes of QA, since there is a gap with respect to these procedures in most of the research using this type of scales.

The proposed measurement model for ICT in QA developed in companies in the construction sector does not limit its application to different sectors or types of organizations. It is necessary to generate studies to corroborate the psychometric properties of the proposed scale in different contexts or with other actors relevant to economic development.

Limitations of the work carried out include the number of participating companies and the economic-sectorial and geographic scope of the state of Campeche. Future lines of research could focus on evaluating the leadership characteristics that influence the decision to invest in ICTs to strengthen QA procedures in organizations and, thus, contrast the results with other studies.

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