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"Innovation Cultural Management Under I4.0 Environment A PROMETHEE II and CODAS Analysis"

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Resumen

Este estudio presenta los múltiples factores a considerar para establecer los principios, objetivos y estrategias que influyen en la cultura organizacional en materia de gestión de la innovación con énfasis en la I4.0., donde se identifican 99 factores en base a revisión de literatura. Este estudio es significativo al presentar la determinación de un número reducido de factores, seleccionando los más significativos, mediante los métodos CODAS (Combinative Distance Assessment) y Organización de Clasificación de Preferencias para el Enriquecimiento de las Evaluaciones (PROMETHEE II) de manera comparativa. El análisis incluye adicionalmente métodos de ponderación de reducción de la ambigüedad, que considera la ponderación basada en los conocimientos adquiridos por los investigadores en la cultura organizacional de innovación y el juicio de expertos bajo la escala Saaty. El análisis comparativo determinó que las alternativas propuestas por el análisis CODAS modificado y PROMETHEE II, tienen un factor de coincidencia 43% entre los principales 30 factores seleccionados de 99, de las alternativas iniciales disponibles, proporcionando mayor confianza en la selección de factores en gestión de la innovación, así como la toma de decisiones en la asignación de recursos disponibles en las organizaciones para estos fines.

Abstract

This study presents the multiple factors to be considered to establish the principles, objectives and strategies that influence the organizational culture in terms of innovation management with emphasis on I4.0. This study is significant because it presents the determination reduced of the number of factors, where 99 factors are identified based on the literature review, selecting the most significant ones, by means of the methods CODAS (Combinative Distance Assessment) methods and Preference Classification Organization for the Enrichment of Evaluations (PROMETHEE II) in a comparative way. The analysis also includes weighting methods for the reduction of ambiguity, which considers the weighting based on the knowledge acquired by the researchers in the organizational culture of innovation, and the judgment of experts under the Saaty scale. The comparative analysis determined that the alternatives proposed by the modified CODAS analysis and PROMETHEE II have a factor agreement of 43% of the main 30 factors selected from 99, of the initial available alternatives, providing greater confidence in the selection of factors in innovation management, as well as the decision making in the allocation of available resources e in the organizations for these purposes

Keywords: Innovation, Organizational culture, CODAS, PROMETHEE II, MCMD, I4.0

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Introduction

The study presents in a comparative way the multi-criteria decision making analysis tools CODAS methods and PROMETHEE II for innovation management with emphasis on the I4.0; the analysis additionally includes ambiguity reduction weighting methods, which considers the weights based on knowledge acquired by researchers in the innovation organizational culture, and the judgment of experts under the Saaty scale. The alternatives presented in the modified CODAS and PROMETHEE II comparative analysis have a factor agreement of 43% from the top 30, selected from 99 available initial alternatives, providing greater confidence in the selection of factors in innovation management, as well as decision making in the allocation of available resources in organizations for these purposes.

Theorectical And Conceptual Framework

The organizational culture is fundamental for innovation (Naranjo-Valencia & Calderón-Hernández, 2015; Hoogan & Cote, 2014; Krásnicka, Głód, Wronka, 2018), for increasing the companies competitiveness (Piccarozzi, Aquilani, & Gatti, 2018), for this reason, and considering the six dimensions established by the OECD (2015): (i.e. research and development, product, commercialization, quality and finances as the main ones),; 99 alterntives are identified in literature review and categorized in technology, finances, process, knowledge, organization and management of intellectual property (Sansabas-Villalpando, Pérez-Olguín, Pérez-Domínguez, Rodríguez-Picón & Méndez-González, 2019), considering Industry 4. 0 (Zhong, Xu, Klotz, & Newman, 2017; Adamik & Nowicki, 2019; Müller, 2019; Birkel, Veile, Müller, Hartmann & Voigt 2019; Braccini & Margherita, 2019), the use of new technological tools derived from artificial intelligence, the Internet of things, large data, automation, robotization, digitalization, etc., as relevant information for comparative analysis

Multi-criteria decision analysis methods (MCDA) have been successfully applied in different fields and disciplines (Roodposhti, Rahimi, & Beglou,2014; Sałabun, Wątróbski, & Shekhovtsov, 2020; Dachowski, & Gałek, 2020. The PROMETHEE II method (Preference Ranking Organization Method for enrichment evaluation), based on the preference function that can be effectively used on finite set of classification and selection alternatives based on some mutually independent and contradictory criteria, using pairwise comparison of alternatives where deviations shown by the alternatives according to each criterion are considered (Brans, & Mareschal, 2005).

The steps used in the development of the PROMETHEE II method.

Step 1. Standardize the initial decision matrix

For benefit criterial:

$$R_{ij} = \frac{[x_{ij} - Min(x_{ij})]}{[Max(x_{ij}) - Min(x_{ij})]} \quad (1)$$

- For non benefit criterial:

$$R_{ij} = \frac{[Max(x_{ij}) - x_{ij}]}{[Max(x_{ij}) - Min(x_{ij})]} \quad (2)$$

Step 2. Calculate the evaluative differences of the alternative *ith* alternative with respect to other alternatives.

Step 3. Calcule the values of the preference function:

$$P_j(a,b) = \begin{cases} 0 & si\ R_{aj} \leq R_{bj} \\ (R_{aj} - R_{bj})\ siR_{aj} > R_{bj} \end{cases} \quad (3)$$

Step 4. Calculate the added preference function:

$$\pi(a,b) = \left[\sum_{j=1}^{n} w_j P_j(a,b)\right] / \sum_{j=1}^{n} w_j \quad (4)$$

Step 5. Determine the input and output flow of the hierarchies:

Input flow:

$$\varphi^{+} = \frac{1}{m-1} \sum_{b=1}^{m} \pi(a,b) \quad (\mathrm{a} \neq b) \quad (5)$$

Output flow:

$$\varphi^{-} = \frac{1}{m-1} \sum_{b=1}^{m} \pi(b,a) \ (\mathrm{a} \neq b) \quad (6)$$

Step 6. Calculate the net outranking for each alternative:

$$\varphi(a) = \varphi^{+}(\mathrm{a}) - \varphi^{-}(\mathrm{b}) \quad (7)$$

Step 7. With the obtained values of $\varphi(a)$ the alternatives are hierarchized.

Methodology

This study is based on the multi-criteria analysis of the 99 factors that influence the promotion of an organizational culture towards innovation with emphasis on Industry 4.0, the CODAS methodology is applied, see the process in Figure 1. Subsequently, the initial CODAS analysis was evaluated, selecting the factors and considering the highest value, that differs from the initial analysis, which was consider the lowest value for classification purposes, thus defining the modified CODAS; continuing with PROMETHEE II, in both methods include the assignment of linguistic terms (HFLTS), are included for the assignment of values within a qualitative context, (Rodriguez, 2012). The weighting used is obtained by AHP (Wind & Saaty, 1980), the knowledge acquired and the reduction of ambiguity. Cronbach's alpha analysis is carried out to determine the consistency of the values included. A modified comparison of CODES and FTOPSIS is performed to determine the level of agreement in the higher-ranking factors.

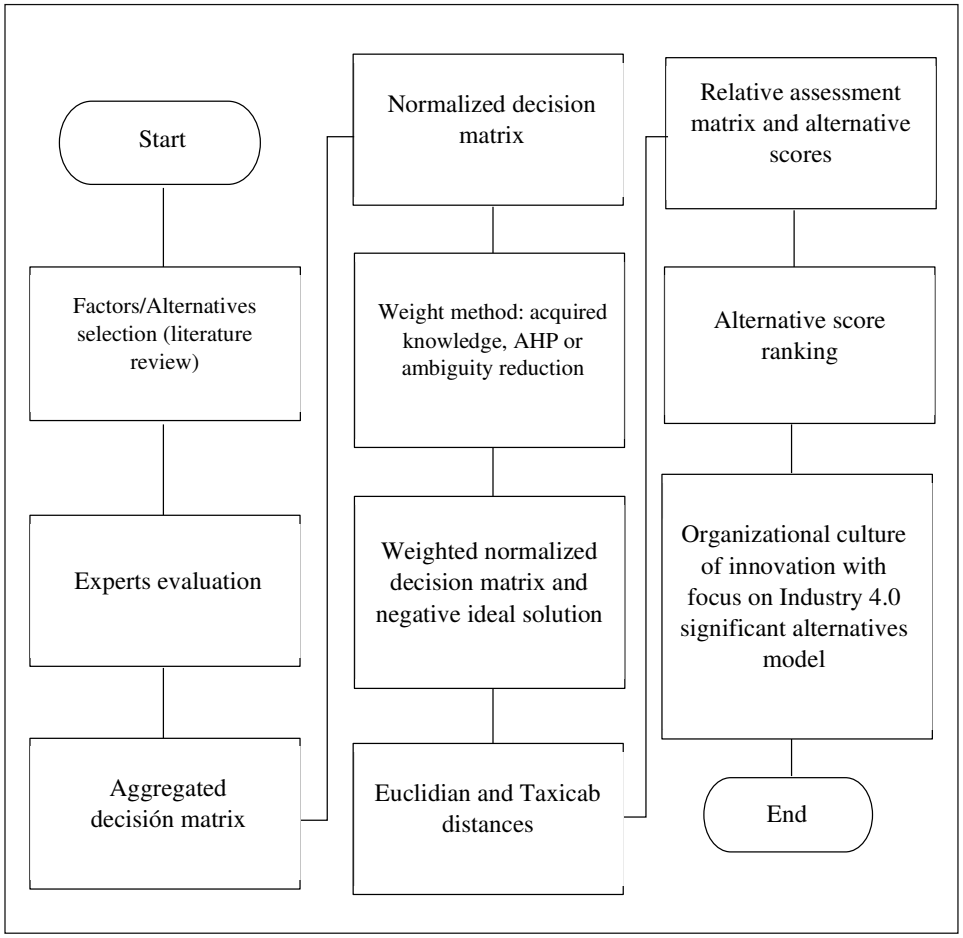

Fig. 1: CODAS methodology (Sansabas-Villalpando, Pérez-Olguín, Pérez-Domínguez, Rodríguez-Picón & Méndez-González, 2019).

Results

In the comparative analysis as a tool for decision making with the multicriteria methods of CODAS modified and PROMETHEE II, an agreement is found, in the selection of the factors of 43%, providing a reinforcement in the selection of organizational culture factors of innovation management, this applied allows to assignment of resources focus on relevant management. Table 1 presents the results obtained from the modified CODAS and Table 2 the results obtained from PROMETHEE II.

Tabla 1: Codas Modified ranking

CODAS MODIFIED					
				Assessment Weight	
ID	CODE	Ei	Ti	**Score**	**Ranking**
10	KM10	0.0931	5.9339	**-0.7353**	**28**
26	OM10	0.1005	6.6364	**-1.4214**	**1**
27	OM11	0.0992	6.3345	**-1.3078**	**12**
30	OM14	0.0970	6.4046	**-1.0992**	**16**
31	OM15	0.1005	6.6364	**-1.4214**	**2**
33	OM17	0.1005	6.6072	**-1.4175**	**4**
41	OM25	0.1004	6.5488	**-1.4120**	**6**
50	OM34	0.1004	6.5488	**-1.4120**	**7**
52	OM36	0.0994	6.2635	**-1.3301**	**11**
53	OM37	0.1005	6.6364	**-1.4214**	**3**
58	OM42	0.1005	6.6072	**-1.4175**	**5**
65	PRM3	0.0994	6.2927	**-1.3309**	**10**
85	TM1	0.0998	6.4559	**-1.3596**	**8**
81	IPM3	0.0962	6.0648	**-1.0266**	**17**
12	KM12	0.0933	5.7689	**-0.7622**	**26**
13	KM13	0.0938	6.0852	**-0.8018**	**23**
28	OM12	0.0970	6.2483	**-1.0993**	**15**
29	OM13	0.0930	5.8172	**-0.7308**	**29**
37	OM21	0.0936	5.3778	**-0.7990**	**24**
54	OM38	0.0946	5.6063	**-0.8860**	**22**
56	OM40	0.0990	6.0193	**-1.3007**	**13**
23	OM7	0.0933	5.7105	**-0.7600**	**27**
63	PRM1	0.0990	5.9901	**-1.2989**	**14**
66	PRM4	0.0957	5.9853	**-0.9829**	**21**
68	PRM6	0.0996	6.4094	**-1.3424**	**9**
69	PRM7	0.0960	6.1484	**-1.0094**	**18**
96	TM12	0.0958	6.1020	**-0.9965**	**20**
97	TM13	0.0958	6.0025	**-0.9989**	**19**
91	TM7	0.0930	5.8464	**-0.7306**	**30**
92	TM8	0.0938	6.0268	**-0.7980**	**25**

Conclusions

In the analysis carried out of the modified CODAS methodology and PROMETHEE II we found a 43% coincidence in the selection of the most significant factors; this allows us to conclude that the tool for decision making of factors the innovation in Industry 4.0 environment can be determined under any of the two methods as a tool that complements the selection of the allocation of resources by the decision-makers.

Table 2: PROMETHEE II, ranking

PROMETHEE II					
Ref	Code	ϕ+	ϕ-	ϕ(a)= ϕ+ (a)-ϕ-(b)	Rank
10	KM10	0.9393	0.0762	0.8632	1
26	OM10	0.1701	0.0402	0.1299	14
27	OM11	0.1452	0.0508	0.0943	24
30	OM14	0.1518	0.0534	0.0984	22
31	OM15	0.1701	0.0402	0.1299	15
33	OM17	0.1669	0.0405	0.1264	17
41	OM25	0.1701	0.0475	0.1225	19
50	OM34	0.1701	0.0453	0.1248	18
52	OM36	0.1468	0.0560	0.0908	27
53	OM37	0.1701	0.0424	0.1277	16
58	OM42	0.1701	0.0478	0.1223	20
65	PRM3	0.1468	0.0546	0.0922	26
85	TM1	0.1363	0.0572	0.0791	29
2	KM2	0.1912	0.0781	0.1131	21
5	KM5	0.2936	0.1246	0.1690	9
7	KM7	0.2054	0.0631	0.1423	13
32	OM16	0.4752	0.0168	0.4584	2
39	OM23	0.2234	0.0443	0.1791	6
40	OM24	0.2021	0.0514	0.1507	11
45	OM29	0.3000	0.0662	0.2338	5
19	OM3	0.2945	0.0323	0.2621	4
47	OM31	0.3418	0.0260	0.3159	3
48	OM32	0.1624	0.0740	0.0884	28
51	OM35	0.2637	0.1033	0.1604	10
20	OM4	0.1869	0.0917	0.0952	23
21	OM5	0.2190	0.0695	0.1495	12
24	OM8	0.2530	0.0750	0.1780	8
25	OM9	0.3461	0.1676	0.1785	7
72	PRM10	0.2177	0.1430	0.0746	30
88	TM4	0.1970	0.1039	0.0931	25
ϕ+ Positive input flow					
ϕ- Negative input flow					
ϕ(a) Hierarchy of alternatives					

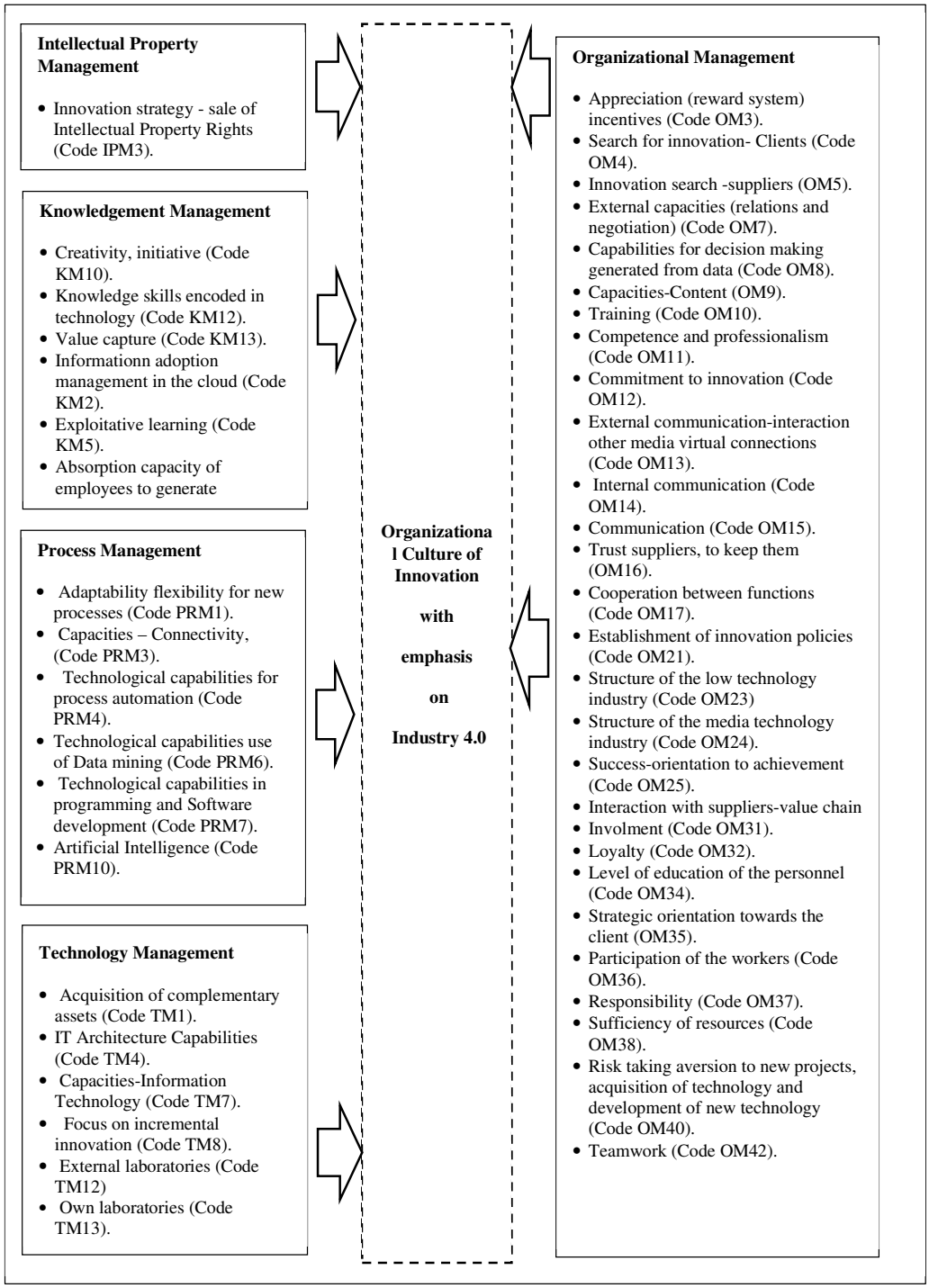

Figure 2: Model of organizational culture in innovation with emphasis on Industry 4.0. (CODAS-Modified and PROMETHEE II).

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