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Innovative Multicriteria Approach to Business Process Management Maturity in the Public Sector

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Findings: The AHP method allowed the analysis and weighting of capabilities. Fuzzy-TOPSIS has enabled the determination of maturity level effectively. As a result, Reference DIPAT and Real DIPAT obtained maturity level 3 (defined). Through comparative analysis, the critical factors for improvements in Real DIPAT were: strategic alignment, culture and people.

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GJMBR-A Classification: *JEL: M15*

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Innovative Multicriteria Approach to Business Process Management Maturity in the Public Sector

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Practical Implications: The model proved to be effective for descriptive, comparative and prescriptive purposes. In addition, the model can be used by managers from other areas to identify critical capabilities in process management and continuous performance improvement, resulting in the achievement of higher levels of maturity.

Originality/Value: Most BPMM models have a qualitative analysis of the maturity level. The proposed model presents a quantitative analysis, based on the MCDM, which brings great methodological rigor in the construction and application of the model.

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I. Introduction

Business Process Management (BPM) has been extensively addressed and refers to a combination of modeling, automation, execution, control, measurement, and optimization of activities applied to corporate objectives, encompassing systems, human resources, customers, and partners (Mahendrawathi et al., 2019). Therefore, BPM aims to assist organizations in the continuous improvement of their processes, describing how organizations operate, which directly impacts their performance (van Looy et al., 2013; Boer et al., 2015).

The measurement of processes in organizations is carried out through maturity models (MM). MM is an essential tool for improvement in organizations (van Looy et al., 2013) and an instrument capable of continuously evaluating and improving their processes (Tarhan et al., 2015). Additionally, process maturity refers to the assessment of its overall conditions, analyzed through different sets of multidimensional criteria. In this process, maturity levels range from an initial state to a more mature state (Froger et al., 2019). Generally, processes with a high level of maturity are associated with better performance, meaning that the output products and services have higher quality (Dijkman et al., 2015).

Despite its significance, the widespread adoption of maturity models in the BPM field has not materialized in organizations (Tarhan et al., 2016). Numerous maturity models proposed in the literature (Aragão et al., 2023; Chiroli et al., 2022; Mello et al., 2022; Soares et al., 2020) have been criticized in studies citing problems such as application complexity, limited flexibility, lack of empirical evidence presentation, and restricted prescriptive characteristics (Alshathry, 2016; Röglinger et al., 2012; Tarhan et al., 2015; Tarhan et al., 2016). Moreover, the measurement of maturity is often performed through qualitative methods, introducing limitations and high subjectivity to the models.

Röglinger et al. (2012) consider that the development of Business Process Management Maturity Models (BPMMM) should be based on integrating and consolidating an existing model, such as Tarhan et al. (2016), emphasizing the consolidation of BPMMM,

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focusing strongly on prescriptive properties, as the direction for future work.

Based on this, the objective of this study is to propose a BPMMM based on relevant models from scientific literature, with prescriptive characteristics and a multi-criteria decision-making approach (MCDM). The proposed model considers the capabilities of the Business Process Management Capability Framework (BPM-CF) model, including strategic alignment, governance, methods, information technology, people, and culture (Froger et al., 2019; Niehaves et al., 2013; Zwicker et al., 2010; Rosemann et al., 2006). After selecting these capabilities, we proceeded to analyze the factors within the BPM-CF and Process Execution Maturity Model (PEMM).

The relevance of this study is highlighted by its practical and managerial contribution to asset management, as well as its theoretical and methodological contribution to the scientific community. Due to the growing demand and expansion of asset control activities, the search for new tools and management strategies becomes crucial for public institutions. The application of a maturity model to measure the maturity of asset management processes aligns with these needs.

Through this research, it becomes possible to diagnose and evaluate the degree of maturity of processes and tools within the Property Divisions of public universities. This evaluation offers tangible improvement opportunities not only within these institutions but also within other public sector organizations sharing the same goal of enhancement.

The significance of this research also lies in its ability to assist researchers, experts, and public servants in understanding, evaluating, and selecting maturity models that best represent their organizational goals. This is achievable through the systematic literature review conducted, maximizing the results of its application. Furthermore, the proposal of a prescriptive maturity model, utilizing a multi-criteria approach and presenting ease of application, promises to be a valuable tool in facilitating the practical implementation of these models.

II. Literature Review

a) *Business Process Management Maturity Models (BPMMM)*

Maturity models are tools that assist in the measurement of general process conditions. Business process management capabilities are used to propose maturity models as measurement instruments (van Looy, 2019). Maturity levels are assessed by the desired phases, from an initial state to a more mature state (Froger et al., 2019), characterized as a set of criteria or standards, used by organizations, to evaluate the level of efficiency and compliance in the process management (Alshathry, 2016).

The main objective of maturity models is to describe the stages of the maturation path, including the characteristics of each stage and the logical relationship between them (Röglinger et al., 2012). As for practical application, the classic purposes of use are: descriptive, prescriptive, and comparative (BRUIN et al., 2005). The model with a descriptive goal is applied to assess the current state of the process. Although, the prescriptive model is applied to identify desirable maturity future levels and provide guidance on implementing these improvements base on improvement measures. The model with a comparative purpose allows internal or external benchmarking (Röglinger et al., 2012).

According to BPMMM analysis studies (Alshathry, 2016; Froger et al., 2019; Röglinger et al., 2012; Tarhan et al., 2015; Tarhan et al., 2016) and BPMMM selection study (Lima et al., 2017), the BPM-CF model (Rosemann and Bruin, 2005) is the most referenced in the literature, with extensive studies of its application. The PEMM model (Hammer, 2007) is the only one that can be applied to a single or a set of processes, and its simplicity in design allows for self-assessment, with no need for external specialists. Therefore, the proposed model of this study is based on the BPM-CF and PEMM models, considering that Röglinger et al. (2012) points out that the development of BPMMM must be based on the integration and consolidation of an existing model; as well as Tarhan et al. (2016), who states that the consolidation of existing BPMMM, with a strong emphasis on prescriptive ability, should be the direction for future studies.

b) *Capabilities and Maturity Levels*

The BMM-CF model, by Rosemann and Bruin (2005), comprises six assessment capacities: Strategic Alignment, Governance, Methods, Information Technology, People, and Culture. The PEMM model (Hammer, 2007) encompasses the so-called facilitators, who attribute to the process the potential to offer high performance, namely: Design, Executors, Responsible, Infrastructure, and Metrics. This model also addresses the so-called capacities, which guarantee the process needs to change and support, which are: Leadership, Culture, Knowledge, and Governance.

The BPM-CF model, regarding the maturity levels, covers five levels: initial, repetitive, defined, managed, and optimized. The PEMM model covers four levels: P1 (reliable, predictable, and stable), P2 (superior results), P3 (ideal performance), and P4 (best in class).

III. Methodology

a) *Selection of the Maturity Model*

The maturity model proposed in this study is based on the BPM-CF and PEMM models, because in addition to being relevant models in the literature, according to Froger et al. (2019), the performance of the processes depends not only on their individual characteristics but also on business skills, such as culture and knowledge. In this context, the BPM-CF and PEMM models are the only ones that evaluate these capacities among the models presented in reviews studies of BPMMM analysis (Alshathry, 2016; Froger et al., 2019; Röglinger et al., 2012; Tarhan et al., 2015; Tarhan et al., 2016).

The capacities and evaluative factors of the proposed model are based on the BPM-CF model. In addition, some evaluative factors are based on the PEMM model because its comprehensiveness in a certain item and/or language more appropriate to the user. The capacities and factors assessed, as well as the model questions, are described in Appendix 1.

The maturity levels are based on the BPM-CF model (Rosemann and Bruin (2005) since it is the most cited in the literature (Tarhan et al. 2016) and the main model used concerning the proposal of the new model. Table I presents the levels and descriptions of the proposed maturity model, based on the BPM-CF model.

Table I: Maturity Levels

MaturityLevel	Description
Level 1 – Initial	It does not have process management initiatives or has uncoordinated and unstructured initiatives.
Level 2 – Repetitive	It is progressing beyond the first process management initiatives and is looking for management improvements.
Level 3 – Defined	It has growing quests to build and develop the capacity for process management and expand individuals who analyze the organization from a process perspective.
Level 4 – Managed	It has a management process firmly implanted in the composition of improvement strategies.
Level 5 – Optimized	It has a management process firmly implanted in strategic and operational management.

b) Model Maturity Level Evaluation

After defining the model maturity levels, the next step is to define the ways for the proposed model to deliver the final result, presenting the maturity level of the sectors surveyed. To achieve this goal, we decided to use a quatitative model to mesure the maturity level, in order make it easier for users. For this, figure 1 illustrates the followed procedures.

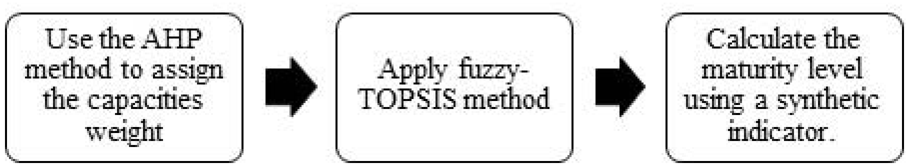

Figure 1: Calculation for the Maturity Level

The evaluation model proposed here is based on the MDCM methodology of Aragão (2020) and Zola et al. (2019).

i. *AHP Method*

The AHP is a MCDM based proposed by Saaty (1994), where the decision-maker can express his preferences (Serrano et al., 2011). It can be applied to rank the alternatives or to weigh the criteria, being the second option the most used one (Zola et al., 2019). In this study, the AHP method is used to weigh the criteria. In the AHP weighting process, an individual or a group of decision-makers do pairwise comparisons of each of the criteria, using the Saaty scale (Saaty, 1980) as a reference, as shown in Table II.

Table II: Saaty Scale

Number	Linguistic Variable	Meaning
1	Equalpreference	The two criteria contribute identically to the objective.
3	Moderatepreference	One criterion is a little more preferable than the other.
5	Strong preference	One criterion is clearly preferable to the other.
7	Verystrongpreference	One criterion is predominant for the objective.
9	Extreme preference	Without any doubt, one of the criteria is absolutely predominant for the objective.
2,4,6,8 Reciprocal Valuesofprevious	Intermediatevalues	When looking for a compromise condition between the two definitions.

From the comparison matrix, the priority vector is calculated using the eigenvector method. With the eigenvector *w* of the matrix A, $AW = \lambda_{maxW}$, considering that λ_{maxW} is the maximum eigenvector of the *A* matrix, it is possible to estimate the priority of the criteria (Saaty, 1994). It is also necessary to calculate the consistency rate (*CR*) that aims to capture whether decision-makers were consistent in their opinions, through the equation:

$$CR = \frac{CI}{RI} \quad (1)$$

where CI is the consistency index and RI is the random index. CI and RI values depend on the number of criteria (*n*). The CI is calculated by using the formula:

$$CI = \frac{\lambda - n}{n-1} \quad (2)$$

where λ is the average value of the consistency vector. For comparisons to be consistent, the *CR* value must be less than 0.1 (Saaty, 1994).

In order to calculate the weighting of a series of criteria weights base on more than one decision-maker, the method of entropy of Zeleny (1976) is used. The entropy method is considered a measure of the uncertainty of the information, where the first step consists of normalized the decision matrix through the equations:

$$x_{ij} = \frac{a_{ij}}{max\{a_{ij}\}} \quad (3)$$

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (4)$$

where r_{ij} represents the normalized performance of the alternative i $(i = 1, \dots, m)$ in relation to the criterion j $(j = 1, \dots, n)$. After the normalization process, the following equations are used:

$$E_j = -k \sum_{i=1}^{m} r_{ij} \, In(r_{ij}) \quad (5)$$

$$k = 1/In(m) \quad (6)$$

$$D_j = 1 - E_j \quad (7)$$

$$\lambda_i = \frac{D_j}{\sum_{j=1}^{n} Dj} \quad (8)$$

where E_j means the entropy of the set of alternatives for the criterion j; D_j means the degree of diversification of the information provided by the results of the criterion j; and λ_i is the weight of the criterion j.

ii. *Fuzzy-TOPSIS Method*

After defining the capacity weights, the Aragão methodology (2020) is used to generate a synthetic indicator that makes it possible to measure the maturity level of the model.

Aragão's (2020) proposes the use of the so-called "evaluation alternatives", being the basis to compose a synthetic indicator, which determines the level of final maturity. The evaluation alternatives are: (i) the Utopian alternative (A^+), with the data considered ideal for the highest level of maturity; (ii) the Reference alternative (A_r), with the data obtained from a maturity reference to the user (sector, processes, department, etc.) for possible comparison with the data from where the model will be applied (sector, process, department, etc.); and the Real Alternative (*A*), which is the data where the model will be applied (sector, process, department, etc.); and the alternative Limit (A_0) which has the minimum values among the main references. From these definitions, the evaluation alternatives of this study are composed by the variables: Utopian DIPAT (A^+); Reference DIPAT (A_r) and Real DIPAT (*A*). The alternative Limit (A_0) was not used in this study, as we chose to use only the values of the Utopian alternative (A^+) to calculate the priorities for applying improvements.

Aragão (2020) used the TOPSIS method to generate a synthetic indicator. In this study, the method was changed to Fuzzy-TOPSIS, since the proposed maturity model has only qualitative variables. The Fuzzy methodology allows the transformation of qualitative variables into numerical variables. The Fuzzy-TOPSIS method was created by Chen (2000) and consists of a version of the TOPSIS method to be used when the decision-maker needs to use linguistic values based on a scale. The Fuzzy-TOPSIS method was created by Chen (2000) and consists of a version of the TOPSIS method to be used when the decision-maker needs to use linguistic values based on a scale. The methodology allows the decision-maker to identify the best alternatives concerning its approximation with the positive ideal solution (PIS) and greater distance from the negative ideal solution (NIS).

Here, the maturity model is applied to the evaluation alternatives Reference DIPAT (A_r), Real DIPAT (*A*), and Utopian DIPAT (A^+). The Utopian DIPAT is the ideal DIPAT, that is, the best possible alternative.

Subsequently, the decision matrix must be filled by the decision-maker, who chooses a linguist variable for each criterion. This linguistic variable is used to represents the importance of the criteria and the classifications of the alternatives regarding the qualitative criteria. All linguistic variable option is expressed by positive trapezoidal fuzzy numbers, where the weight of the importance of each criterion is attributed directly or indirectly using the paired comparison (CHEN; LIN; HUANG, 2006; COOK, 1992), as expressed in Table III (Chen, 2000).

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Tabela III: Linguistic Variables

Linguistic Variables	*Fuzzy* Numbers $(a_{ij}, b_{ij}, c_{ij}, d_{ij})$
Verylow(VL)	(0,0,1,2)
low(L)	(1,2,2,3)
Mediumlow(ML)	(2,3,4,5)
Medium(M)	(4,5,5,6)
Medium high (MH)	(5,6,7,8)
high (H)	(7,8,8,9)
Very high (VH)	(8,9,10,10)

Therefore, the decision matrix is building by transforming linguistic variables into *fuzzy* trapezoidal numbers, using Table III as a reference. When there is more than one decision-maker, everyone should build their decision matrix, and a simple arithmetic average should be applied to obtain a single fuzzy result for each criterion, base on Tan et al. (2010) methodology.

Subsequently, the next step consists of determining the maximum numerical variable (d_j^*) of the evaluation alternatives for each factor through the equation:

$$d_j^* = \max_i d_{ij} \qquad (9)$$

The numerical decision matrix is normalized to obtain the matrix with fuzzy data through the equation:

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{d_j^*}, \frac{b_{ij}}{d_j^*}, \frac{c_{ij}}{d_j^*}, \frac{d_{ij}}{d_j^*}\right) \qquad (10)$$

The normalization method mentioned above is designed to preserve the property in which the elements $\tilde{r}_{ij}$, ∀i,jare standardized (normalized) trapezoidal fuzzy numbers(Chen *et al.*, 2006).Then, considering the different importance of each criterion evaluated, the normalized*fuzzy* matrix should be weighted using the equations:

$$\tilde{R} = [\tilde{r}_{ij}]_{mxn} \qquad (11)$$

$$\tilde{v}_{ij} = \tilde{r}_{ij}(.)\tilde{w}_j \qquad (12)$$

In the sequence, the next step in the TOPSIS method consists of calculating the positive ideal solution (A*) and negative ideal (A⁻) for each criterion. In this study, the positive ideal solution is the maximum weight, considering that the ideal scenario is to reach the highest score of each criterion; and the negative ideal solution is 0 since the un-ideal scenario is the minimum score.

Then it is necessary to calculate the distance between each alternative from the positive ideal solution (d_i^*) and the negative ideal solution (d_i^-), through the equations:

$$d_i^* = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^*) \qquad (13)$$

$$d_i^- = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^-) \qquad (14)$$

where $d_v(.,.)$ is the distance measured between the two fuzzy numbers (Chen *et al.*, 2006).

With the values of the distances of each alternative, the proximity coefficient (CC_i) can be calculated. The CC_iThe CCI determines the classification order of all alternatives, representing the distances from A^* and A^- simultaneously, bringing relative proximity to the positive ideal *fuzzy* solution. It is calculated by the equation:

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-} \qquad (15)$$

It is observed that $CC_I = 1$ if $A_I = A^*$ and $CC_i = 0$ if $A_i = A^-$. In other words, $CC_I = 1$ when the alternative is closer to A^* and further away from A^-. Thus, once the set of alternatives is classified, it is possible to select the best among a set of viable alternatives (Chen *et al.*, 2006).

Base on this result, the maturity level can be calculated using the synthetic indicator proposed by Aragão (2020), through the equation:

$$I_{maturity} = \frac{A_n}{A_+} \qquad (16)$$

where A_n is the CC_i valueof the alternative to be evaluated (Reference DIPAT and Real DIPAT), and A^+ is the CC_i of the Utopian alternative.

From the synthetic indicator, it is possible to determine the maturity level (Table II). Table IV shows the values of each maturity level base on the methodology proposed by Aragão (2020).

Table IV: Maturity Level Values

Level	Values	Qualitative Evaluation
5	> 0,90	Optimized
4	0,90 - 0,75	Managed
3	0,75 – 0,50	Defined
2	0,50 – 0,25	Repetitive
1	< 0,25	Initial

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Finally, to identify which capabilities should be treated with priority by Real DIPAT (*A*), the proximity index is calculated using the equation:

$$I_{proximity} = A_R^* - A_A^* \quad (17)$$

where A_R^* represents the value of the ideal solution from Reference DIPAT (A_r) and A_A^* represents the ideal solution of Real DIPAT (*A*).

The maturity index determines how close to Real DIPAT it is to Reference DIPAT concerning its process management capabilities. Base on this, the methodology proposes improvements to the process to reach a higher maturity level, which makes the model prescriptive.

c) Model Prescription

To determine the model prescription, it is analyzed the characteristics of each capacity and factors of the BPM-CF model, presented by Rosemann et al. (2006), the PEMM model described by Hammer (2007), and the characteristics of the maturity levels, according to Rosemann et al. (2006). For more details on the prescriptiveness of the proposed model, one can see Appendix 2 (prescriptions for reaching levels 2 and 3) and section 5.2 (prescription for reaching levels 4 and 5).

IV. Application

a) Determining the Weight of the Criteria

To assign weights to the model's capacities, questionnaires were sent by email for peer comparison to apply the AHP method to the heads of the 12 campus divisions of a federal public university, with a total of 11 questionnaires answered. After returning the questionnaires, the results were transferred to a matrix, based on the Saaty scale, and the property vector of each decision maker was calculated. Then, the consistencies of the results were verified through equation (2), which resulted in the inconsistency of one of the questionnaires of a decision maker, since the value of the consistency rate was greater than 0, as shown in Table V. This decision-maker's questionnaire was disregarded for the calculation of weights.

Table V: Consistency of AHP Results

Decisors	Consistency Rate	Result
Decisionmaker 1	0,02980	Consistent
Decisionmaker 2	0,06825	Consistent
Decisionmaker 3	0,08296	Consistent
Decisionmaker 4	0,09780	Consistent
Decisionmaker 5	0,05995	Consistent
Decisionmaker 6	0,07847	Consistent
Decisionmaker 7	0,08344	Consistent
Decisionmaker 8	0,08183	Consistent
Decisionmaker 9	0,09472	Consistent
Decisionmaker 10	0	Consistent
Decisionmaker 11	0,50702	inconsistent

This was followed by the application of the entropy method by filling in the decision matrix with the priority vectors of each decision maker, resulting in Table VI.

Table VI: AHP Decisionmatrix

	StrategicAlignment	Governance	Methods	IT	People	Culture
Decisionmaker1	0,153618968	0,17818011	0,1946722	0,1946722	0,22785679	0,05099973
Decisionmaker2	0,081897082	0,49901384	0,06111282	0,11213032	0,12292297	0,12292297
Decisionmaker3	0,22024	0,23683	0,18233	0,04453	0,23229	0,08378
Decisionmaker4	0,040505325	0,28220836	0,13075129	0,16244427	0,35509583	0,02899493
Decisionmaker5	0,184814832	0,21711734	0,1569437	0,24941985	0,10291097	0,0887933
Decisionmaker6	0,154532553	0,26187292	0,04423887	0,28042254	0,10630691	0,15262621
Decisionmaker7	0,062808121	0,05382998	0,20030112	0,21747771	0,4096101	0,05597297
Decisionmaker8	0,093849867	0,10615536	0,33528473	0,27381347	0,12011584	0,07078074
Decisionmaker9	0,397100587	0,16655904	0,15180675	0,1086708	0,103581	0,07228183
Decisionmaker10	0,192307692	0,19230769	0,19230769	0,19230769	0,19230769	0,03846154

Subsequently, the decision matrix was normalized using equations (3) and (4), obtaining the results shown in Table VII.

Table VII: Normalization of the AHP Decision Matrix

	Strategic Alignment	Governance	Methods	IT	People	Culture
Decisionmaker 1	0,097	0,081	0,118	0,106	0,115	0,067
Decisionmaker 2	0,052	0,227	0,037	0,061	0,062	0,161
Decisionmaker 3	0,139	0,108	0,111	0,024	0,118	0,109
Decisionmaker 4	0,026	0,129	0,079	0,088	0,180	0,038
Decisionmaker 5	0,117	0,099	0,095	0,136	0,052	0,116
Decisionmaker 6	0,098	0,119	0,027	0,153	0,054	0,199
Decisionmaker 7	0,040	0,025	0,121	0,118	0,208	0,073
Decisionmaker 8	0,059	0,048	0,203	0,149	0,061	0,092
Decisionmaker 9	0,251	0,076	0,092	0,059	0,052	0,094
Decisionmaker 10	0,122	0,088	0,117	0,105	0,097	0,050

Then, entropy was calculated using equations (5), (6), (7) and (8). Table VIII presentstheresults.

Table VIII: Capacity Weight

	Strategic Alignment	Governance	Methods	IT	People	Culture
E_j	1,186	1,213	1,222	1,234	1,213	1,226
D_j	-0,186	-0,213	-0,222	-0,234	-0,213	-0,226
λ_i (weight)	**0,144**	**0,165**	**0,171**	**0,181**	**0,164**	**0,174**

According to the decision makers, the most important capacities for assessing maturity in process management in the sectors that perform their functions (DIPAT) are, respectively: information technology, culture, methods, governance, people and strategic alignment. From the weights of capacities, the weights of the respective factors were assigned with a simple arithmetic mean, as shown in Table IX

Table IX: Capacity Weights and Factors

Capabilities Andfactors	Weights
StrategicAlignment	**0,144**
Factors1,2,3 e 4	0,036
Governance	**0,165**
Fator 5,6,7 e 8	0,041
Methods	**0,171**
Factors9,10,11,12 e 13	0,034
IT	**0,181**
Factors14,15,16 e 17	0,045
People	**0,164**
Factors18,19,20,21 e 22	0,033
Culture	**0,174**
Factors23,24,25,26 e 27	0,035

b) Application of the Maturity Model

First, the model's qualitative variables (factors) were converted to linguistic variables, based on Table III. The linguistic variables used in the model are described in Table X.

Table X: Linguistic Variables of the Proposed BPMMM

Linguistic Variables	Code	*FUZZY* Number			
Veryrare	VR	0	0	1	2
Rare	R	1	2	2	3
Mediumrare	MR	2	3	4	5
Medium	M	4	5	5	6
Frequentmedium	FM	5	6	7	8
Frequent	F	7	8	8	9
Veryfrequent	VF	8	9	10	10

Subsequently, the proposed model was applied in the Reference DIPAT A_r, for a public official who performs his/her function in the property sector, through e-mail; and at Real DIPAT A,to five civil servants who perform their functions in the property sector, via email. All participants answered the model.

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The linguistic variables were obtained and the result was transferred to the decision matrix represented by Table XI. For Utopian DIPAT A^{+}, os values correspond to the best alternatives for each factor, considering that A^{+} would be an ideal DIPAT (maximum level of maturity).

Table XI: Decision Matrix of Linguistic Variables

Factors	A^{+}	A_r	A (D1)	A (D2)	A (D3)	A (D4)	A (D5)
Factor 1	VF	MR	R	FM	MR	FM	M
Factor 2	VF	M	M	M	FM	M	VR
Factor3	VF	FM	M	M	FM	M	M
Factor4	VF	VF	M	M	MR	FM	F
Factor5	VF	R	MR	M	MR	MR	F
Factor6	VF	F	F	FM	F	FM	VF
Factor7	VF	FM	M	M	FM	FM	VF
Factor8	VF	FM	M	MR	FM	M	F
Factor9	VF	M	M	MR	FM	F	F
Factor10	VF	F	F	FM	VF	FM	VF
Factor11	VF	FM	F	FM	F	MR	FM
Factor12	VF	VR	R	F	M	FM	F
Factor13	VF	M	R	FM	R	MR	F
Factor14	VF	M	F	FM	F	F	VF
Factor15	VF	M	M	F	FM	FM	FM
Factor16	VF	M	MR	F	FM	F	M
Factor17	VF	MR	MR	F	FM	FM	VF
Factor18	VF	F	F	F	FM	F	FM
Factor19	VF	F	FM	M	R	VF	VF
Factor20	VF	F	FM	M	F	F	F
Factor21	VF	F	FM	M	F	F	F
Factor22	VF	F	F	F	F	F	F
Factor23	VF	F	F	FM	R	R	F
Factor24	VF	FM	F	VF	MR	MR	F
Factor25	VF	FM	F	F	MR	M	M
Factor26	VF	FM	F	FM	VF	F	F
Factor27	VF	F	F	F	MR	F	FM

The next step consisted of transforming linguistic variables into trapezoidal *fuzzy* numbers, taking Table III as a reference. With the *fuzzy* decision matrix completed, the methodology of Tan *et al*. (2010) to obtain the arithmetic mean of the data of the decision makers (D1, D2, D3, D4 and D5). Then, equation (9) was applied to determine the maximum numerical variable of the evaluation alternatives in each factor, and then equation (10) was applied to normalize it. Then, the matrix was normalized and weighted using equations (11) and (12), resulting in Table XII.

Table XII: Standardized and Weighted Fuzzy Decision Matrix

Factors	Weights	A^{+}	A_r	A
Factor 1	0,036	(0,029; 0,032; 0,036; 0,036)	(0; 0,011; 0,014; 0,018)	(0; 0,016; 0,018; 0,022)
Factor 2	0,036	(0,029; 0,032; 0,036; 0,036)	(0,014; 0,018; 0,018; 0,022)	(0,012; 0,015; 0,017; 0,02)
Factor 3	0,036	(0,029; 0,032; 0,036; 0,036)	(0,018; 0,022; 0,025; 0,029)	(0,015; 0,019; 0,019; 0,023)
Factor 4	0,036	(0,029; 0,032; 0,036; 0,036)	(0,029; 0,032; 0,036; 0,036)	(0,016; 0,019; 0,021; 0,024)
Factor 5	0,041	(0,033; 0,037; 0,041; 0,041)	(0,004; 0,008; 0,008; 0,012)	(0,014; 0,018; 0,021; 0,025)
Factor 6	0,041	(0,033; 0,037; 0,041; 0,041)	(0,029; 0,033; 0,033; 0,037)	(0,026; 0,031; 0,033; 0,036)
Factor 7	0,041	(0,033; 0,037; 0,041; 0,041)	(0,021; 0,025; 0,029; 0,033)	(0,021; 0,026; 0,028; 0,031)
Factor 8	0,041	(0,033; 0,037; 0,041; 0,041)	(0,021; 0,025; 0,029; 0,033)	(0,018; 0,022; 0,024; 0,28)
Factor 9	0,034	(0,027; 0,031; 0,034; 0,034)	(0,014; 0,017; 0,017; 0,021)	(0,017; 0,021; 0,022; 0,025)
Factor 10	0,034	(0,027; 0,031; 0,034; 0,034)	(0,024; 0,027; 0,027; 0,031)	(0,023; 0,026; 0,029; 0,031)
Factor 11	0,034	(0,027; 0,031; 0,034; 0,034)	(0,017; 0,021; 0,024; 0,027)	(0,018; 0,021; 0,023; 0,027)
Factor 12	0,034	(0,027; 0,031; 0,034; 0,034)	(0; 0; 0,003; 0,007)	(0,016; 0,02; 0,021; 0,024)
Factor 13	0,034	(0,027; 0,031; 0,034; 0,034)	(0,014; 0,017; 0,017; 0,021)	(0,011; 0,014; 0,016; 0,019)
Factor 14	0,045	(0,036; 0,041; 0,045; 0,045)	(0,018; 0,023; 0,023; 0,027)	(0,031; 0,035; 0,037; 0,041)
Factor 15	0,045	(0,036; 0,041; 0,045; 0,045)	(0,018; 0,023; 0,023; 0,027)	(0,024; 0,028; 0,031; 0,035)
Factor 16	0,045	(0,036; 0,041; 0,045; 0,045)	(0,018; 0,023; 0,023; 0,027)	(0,023; 0,027; 0,029; 0,034)
Factor 17	0,045	(0,036; 0,041; 0,045; 0,045)	(0,009; 0,014; 0,018; 0,023)	(0,024; 0,029; 0,033; 0,036)
Factor 18	0,033	(0,036; 0,030; 0,033; 0,033)	(0,023; 0,026; 0,026; 0,03)	(0,02; 0,024; 0,025; 0,028)
Factor 19	0,033	(0,036; 0,030; 0,033; 0,033)	(0,023; 0,026; 0,026; 0,03)	(0,017; 0,02; 0,022; 0,024)

Factor 20	0,033	(0,036; 0,030; 0,033; 0,033)	(0,023; 0,026; 0,026; 0,03)	(0,02; 0,023; 0,024; 0,027)
Factor 21	0,033	(0,036; 0,030; 0,033; 0,033)	(0,023; 0,026; 0,026; 0,03)	(0,02; 0,023; 0,024; 0,027)
Factor 22	0,033	(0,036; 0,030; 0,033; 0,033)	(0,023; 0,026; 0,026; 0,03)	(0,023; 0,026; 0,026; 0,03)
Factor 23	0,035	(0,028; 0,031; 0,035; 0,035)	(0,024; 0,028; 0,028; 0,031)	(0,015; 0,018; 0,019; 0,022)
Factor 24	0,035	(0,028; 0,031; 0,035; 0,035)	(0,017; 0,021; 0,024; 0,028)	(0,018; 0,022; 0,024; 0,027)
Factor 25	0,035	(0,028; 0,031; 0,035; 0,035)	(0,017; 0,021; 0,024; 0,028)	(0,017; 0,02; 0,021; 0,024)
Factor 26	0,035	(0,028; 0,031; 0,035; 0,035)	(0,017; 0,021; 0,024; 0,028)	(0,024; 0,027; 0,029; 0,031)
Factor 27	0,035	(0,028; 0,031; 0,035; 0,035)	(0,024; 0,028; 0,028; 0,031)	(0,02; 0,023; 0,024; 0,028)

Therefore, the ideal and anti-ideal distance was calculated using equations (13) and (14). For the ideal solution, we considered the factor weights and, for the anti-ideal solution, weight 0 was considered.

In the final step, the proximity coeficiente CC_i was calculated using equation (15). From the proximity coefficient, the maturity level of each evaluation alternative was also calculated using equation (16), as shown in Table XIII.

Table XIII: Proximity Coefficient and Maturity Level

Evaluation Alternatives	d^*	d^-	CC_i	Maturity Index
Utopian DIPAT A^+	0,141	1,723	0,924	1
Reference DIPAT A_r	0,677	1,154	0,630	0,68
Real DIPAT A	0,627	1,199	0,657	0,71

V. Analysis of Results

a) *Analysis of the Maturity Level*

Based on Table IV, Real DIPAT A presented a maturity level 3. Therefore, it presents a "defined" maturity, with actions in search of building and developing the capacity of process management and expanding the individuals who analyze the organization of a company. process perspective.

Generally, the sector with a level 3 maturity has the combination of the following characteristics (Rosemann *et al*., 2006): (i) use of elaborate tools (for example, process redesign, workflow management and risk management based on in processes); (ii) combination of different process management methods and tools; (iii) wider use of technology for delivery and communication about processes (for example, process designs available to users via the intranet); and (iv) comprehensive and formal training.

Reference DIPAT A_r also presented maturity level 3 and Utopian DIPAT A^+ presented maturity level 5 (optimized), as this alternative serves as the basis for calculating the maturity index. Figure 2 shows the graph on the maturity level of each analyzed DIPAT.

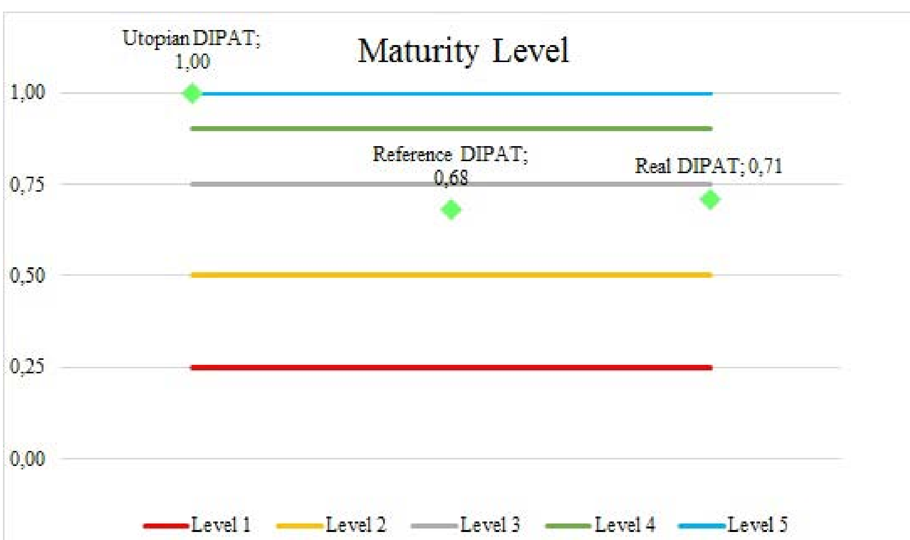

Figure 2: Maturity Level

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b) Improvement Prescriptions

For the proposed maturity model to be considered prescriptive, it is necessary to drive improvements so that the researched sector is able to reach higher maturity levels.

For this purpose, equation (17) was used to identify which capacities should be prioritized for the improvement of the Real DIPAT, in comparison with the Reference DIPAT. For the interpretation of the proximity index, it is considered: (i) for capacities with values equal to 0, the Reference DIPAT and Real DIPAT have the same performances; (ii) for capacities with values > 0, Real DIPAT outperforms Reference DIPAT; and (iii) for capacities with values <0, Real DIPAT has lower performances than Reference DIPAT.

With the application of the proximity index, the results of Table XIV were obtained.

Table XIV: Proximity Index

	Strategic Alignment	Governance	Methods	IT	People	Culture
Reference DIPAT	0,098	0,121	0,148	0,169	0,055	0,086
Real DIPAT	0,126	0,110	0,112	0,097	0,063	0,105
Proximity index	-0,028	0,011	0,036	0,072	-0,008	-0,019

After the results, it was possible to observe that the strategic alignment, culture and people capacities showed lower performances in the Real DIPAT compared to the Reference DIPAT, with indexes of -0.028, -0.019 and -0.008, respectively. In contrast, the governance, methods and information technology capabilities performed better at Real DIPAT compared to Reference DIPAT, with rates of 0.011, 0.036 and 0.072, respectively.

The Figure 3 illustrates the proximity indexes and the performance of the assessed capacities of Real DIPAT compared to Reference DIPAT.

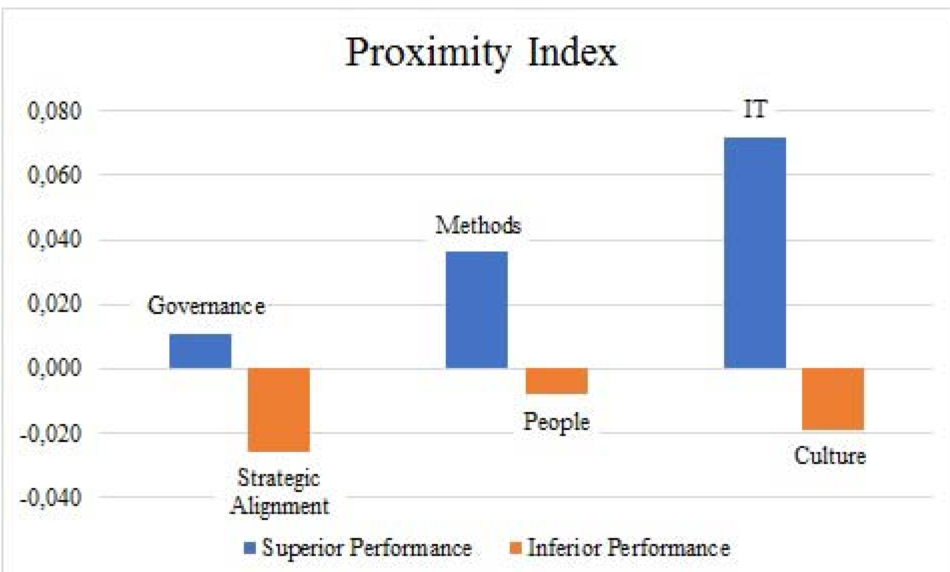

Figure 3: Proximity Index

The results of the proximity indexes made it possible to create an order of priority for the application of improvements, making it possible to continuously improve performance and increase the level of maturity in DIPAT Real's process management. Following are the descriptions of continuous improvement in process management for Real DIPAT, so that it progressively raises its maturity level.

To reach maturity level 4 (managed), the requirements for each capacity follow the order of priority:

- *Strategic Alignment*: measure all processes and monitor their performance, even if in isolation; discuss plans for process improvement in conjunction with other sectors; model processes taking into account executors and other stakeholders and; support improvement plans for process management.
- *Culture*: management must be prepared for major multidimensional changes; stakeholders in the processes must accept the changes and initiate an increasing adaptation to them; management must seek actions for process management, seeking to exaggerate its benefits; all stakeholders in the processes must contribute to the smooth running of the processes; the leadership must seek more

actions in the management of the processes, adopting a holistic (global) view of the institution.

- *People*: The sector must have skilled employees in the execution and management of its processes; provide training courses to civil servants for new knowledge and skills relevant to the processes, when possible; work as a team in the execution and in the process improvement projects, in order to achieve the desired results; the employees and the management must be responsible for the results of the processes, and the management must also propose improvements to achieve the desired results and; the head of the sector must delegate control and authority to the executors of the processes.
- *Governance*: Discuss some strategies that can contribute to the improvement of processes; formalize the role of each server in the process, with the attribution of autonomy to act; model processes at the sectoral level and extend to other stakeholders and; exercise formal control over all processes in the sector.
- *Methods*: Design the processes so that they fit with other processes of the institution; document the processes in an electronic and standardized manner; implement and execute the documented processes in a standardized manner; control and measure critical processes and; establish methods to be used in the improvement of processes.
- *Information Technology*: Using an integrated IT system, designed with the processes and adhering to industry standards to support the processes; make equipment and software available that provide specific reports to support the processes; control and measure industry processes with independent IT systems and; apply process improvement and innovation projects supported by an independent IT system.

To reach level 5 of maturity (optimized), the requirements for each capacity follow the order of priority:

- *Strategic Alignment:* Measure all processes, monitor their performance and align them between the sector's operational and strategic team; make process improvement plans part of the sector's strategic cycle; model processes based on the expectations of all stakeholders and; carry out the integration between management and executors, so that the improvement plans are defined together.
- *Culture*: Management must recognize that changes are inevitable for the improvement of processes, provide their support and adopt them whenever necessary; management must recognize the importance and benefits of processes, so that their management actions must be process-oriented; all parts of the processes must be interested in its good progress, proposing improvements and contributing to them and; the leadership must act oriented by the processes and have a holistic (global) view of the institution.
- *People*: The sector must have servers skilled in the execution and management of large-scale processes; provide training to servers to maintain knowledge and skills relevant to the processes, making them skilled in their execution and management; work as a team with other sectors / departments in order to achieve the desired results of the processes; employees and management must be responsible for the results of the processes, proposing improvements to achieve increasingly better results and; leadership must delegate authority to process executors through leadership based on vision and influence, rather than command and control.
- *Governance*: Discuss strategies and action plans to improve the critical processes in the sector; each servant must exercise his responsibility and assume roles, have autonomy to act, while the head.

c) *Practical Implications*

From the results, the AHP method was considered efficient for the analysis and weighting of capacity weights. The *fuzzy*-TOPSIS method was able to generate a synthetic indicator for the measurement of the maturity level from the data of the alternatives Utopian DIPAT, Reference DIPAT and Real DIPAT.

The scientific literature (BRUIN *et al*., 2005) points out that a maturity model can be applied for descriptive, prescriptive and comparative purposes. The results obtained in the application of the BPMMM proposed in this study, shows that there is a possibility of application for the three purposes, since it enabled the assessment of the current state of maturity of the process management (descriptive); enabled the identification of desirable levels of future maturity, providing guidance for the implementation of improvements (prescriptive); and allowed a comparative analysis between two sectors of different campuses of a federal public university (comparative). In addition, the model can be used in practice as a guide for advances in the performance of processes by any sector and/or institution, public and private; because its generic structure allows its use for the measurement of any process or set of processes.

The quantitative evaluation of the model to obtain the result of the maturity level and prescription of improvements also contributes to its periodic application in practice; as it allows for agile and reliable results, as it is an evaluation with methodological rigor, and allows anyone to apply it, eliminating the need for application by professionals in the process area.

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Its prescription in order of priority allows managers to analyze which capacities are in a critical state of performance, making it possible to take better targeted actions, according to the reality of each organization.

VI. Conclusions

This study offers a maturity model in BPM, whose main objective is to fill the gaps found in the literature: proposal of maturity models based on the consolidation of existing models, scarcity of BPMMM with prescriptive properties, over-complexity in the application and low flexibility existing models.

The objective of the study was accomplished, the model was structured based on two models of maturity in BPM consolidated from the literature: BPM-CF and PEMM. The model was built to propose continuous improvement actions that enable the achievement of higher levels of maturity gradually, showing a high prescriptive property. In addition, its quantitative assessment, using the methodology of Zola (2019) and Aragão (2020), allowed agility in the results and low complexity in the application, which makes the model applicable by any interested party, without the need of specialists in the area of processes or evaluators external. The proposal for quantitative evaluation gave methodological rigor to the model, minimizing possible subjectivities that could be qualitative models.

The use of the AHP method allowed decision-makers to analyze and consider the importance of each process management capacity, according to the reality of the assessed equity sector. Thus, assigning weights to the model's capabilities becomes a strong point; because each process has its peculiarities; that is, it is possible that each capacity has a different weight for the management of certain processes, as was the case with DIPAT, determining that the most important capacities for its processes, respectively: information technology, culture, methods, governance, people and strategic alignment.

As a result of its application, Real DIPAT presented a maturity level 3 (defined), characterized by actions in search of building and developing the capacity for process management and expansion of individuals who analyze the organization in a process perspective. In addition to the diagnosis of the level of maturity provided to the sector, the model also provided prescriptions for improving the performance of its process management.

The application of the Reference DIPAT maturity model was the basis for the comparison with the maturity of the management of Real DIPAT's processes. This enabled the comparative analysis of critical improvement factors and their prescription in order of priority.

In view of this comparison, the critical improvement capacities, when compared with Reference DIPAT, in order of priority, were: strategic alignment, culture and people. The information technology, methods and governance capabilities performed better at Real DIPAT when compared to Reference DIPAT.

The proposed BPMMM proved to be efficient for measuring the maturity of the processes of the property divisions in the two federal public universities. In addition, the model was able to be applied to assess the current state of maturity of process management (descriptive purpose); for the identification of desirable levels of future maturity, providing guidelines for the implementation of improvements (prescriptive purpose); and for the comparative analysis between two sectors of different campuses (comparative purpose).

Finally, this research contemplates both practical and managerial aspects, as well as theoretical and methodological aspects of process management; considering the construction of a prescriptive maturity model in process management with a multicriteria approach and proposal of prescriptions for continuous performance improvement. The model contributes to the analysis of the performance of processes, allowing their continuous improvement; it can be used in different processes, set of processes, sector and institutions, public or private, due to its flexibility.

As a suggestion for future research involving the theme, the effective application of the model's prescriptions and measurement of results in the impact of the maturity level would be an important complement to the study. In addition, it is also suggested to apply the model in other sectors or institutions, both public and private, to test its effectiveness when applied in processes other than those in the property sector.

References Références Referencias

1. AlShathry, O., (2016), Business process management: a maturity assessment of Saudi Arabian organizations, *Business Process Management Journal,* Vol. 22, No. 3, pp. 507-521. Doi: 10.1108/BPMJ-07-2015-0101.
2. Aragão, F. V., Chiroli, D. M. D. G., Zola, F. C., Aragão, E. V., Marinho, L. H. N., Correa, A. L. C., & Colmenero, J. C. (2023). SmartCitiesMaturity Model-A Multicriteria Approach. Sustainability, 15 (8), 6695.
3. Moizer, P. (2003), "Como a pesquisa acadêmica publicada pode informar as decisões políticas: o caso de rotação obrigatória de nomeações de auditoria", documento de trabalho, Leeds University Business School, University of Leeds, Leeds, 28 de março.
4. Aragão, F.V. (2020), Maturity model for smart cities: a multicriteria approach, thesis (PhD in Production

Engineering), Federal Technological University of Paraná, Ponta Grossa.
5. Bruin, T., Rosemann, M., Freeze, R. and Kaulkarni, U., (2005), Understanding the main phases of developing a maturity assessment model. In Bunker, D., Campbell, B., and Underwood, J. (Eds.) *Australasian Conference on Information Systems (ACIS).* Australasian Chapter of the Association for Information Systems, pp. 8-19. Available at: https://eprints.qut.edu.au/25152/.
6. Chiroli, D. M. D. G., Solek, É. A., Oliveira, R. S., Barboza, B. M., Campos, R. P. D., Kovaleski, J. L., ... & Trojan, F. (2022). Using multi-criteria analysis for smart city assessment. Cidades. Comunidades e Territórios, (44).
7. Chen, C. T. (2000), Extensions of the TOPSIS for group decision making under fuzzy environment, *Fuzzy Sets and Systems*, Vol. 114, No. 1, pp. 1-9. DOI: 10.1016/S0165-0114(97)00377.
8. Chen, C. T., Lin, C. T. and Huang, S. F. (2006), A fuzzy approach for supplier evaluation and selection in supply chain management, *International Journal of Production Economics*, Vol. 102, No. 2, pp. 289–301. DOI: 10.1016/j.ijpe.2005.03.009.
9. Cook, R.L. (1992), Expert systems in purchasing: applications and development. *International Journal of Purchasing and Materials Management*, Vol. 28, No.4, pp. 20-27. Doi: 10.1111/j.1745-493X.1992.tb00577.x.
10. De Boer, F., Müller, C., and ten Caten, C. (2015). Assessment model for organizational business process maturity with a focus on BPM governance practices, *Business Process Management Journal*, Vol. 21, No. 4, pp. 908-927. Doi: 10.1108/BPMJ-11-2014-0109.
11. Dijkman, R., Lammers, S. and de Jong, A., (2015), Properties that influence business process management maturity and its effect on organizational performance. *Information Systems Frontiers*, Vol. 18 No. 4, pp. 717-734. Doi: 10.1007/s10796-015-9554-5.
12. Froger, M., Bénaben, F., Truptil, S. and Boissel-Dallier, N. (2019), A non-linear business process management maturity framework to apprehend future challenges. *International Journal of Information Management,* Vol.49, pp. 290-300. doi: 10.1016/j.ijinfomgt.2019.05.013
13. Hammer, M., (2007), The process audit. *Harvard Business,* Vol. 4, pp. 111-123. Available at: http://modir3-3.ir/article-english/article330.pdf (accessed 6 february 2020).
14. Lima, E., Viegas, R. and Costa, A., (2017), A multicriteria method based approach to the BPMM selection problem. *2017 IEEE International Conference on Systems, Man, and Cybernetics,* pp. 3334-3339. Doi: 10.1109/SMC.2017.8123144.
15. Mahendrawathi, E. R., Hanggara, B. T. B. T. and Astuti, H. M. H. M., (2019), Model for BPM implementation assessment: evidence from companies in Indonesia, *Business Process Management Journal*, Vol. 25 No. 5, pp. 825-859, 2019. Doi: 10.1108/BPMJ-08-2016-0160.
16. Mello, V. G. D., Kovaleski, J. L., Zola, F. C., Lima Junior, F. R., Aragão, F. V., & Chiroli, D. M. D. G. (2022). Proposal of a Fuzzy-QFD model for startup selection. Technology Analysis & Strategic Management, 1-16.
17. Röglinger, M., Pöppelbuß, J. and Becker, J., (2012), Maturity models in business process management, *Business Process Management Journal,* Vol.18, No. 2, pp. 328-346. Doi: 10.1108/14637151211225225.
18. Rosemann, M. and Bruin, T., (2005), Towards a business process managment maturity. *ECIS 2005 Proceedings of the Thirteenth European Conference on Information Systems*. Germany, Regensburg. Available at: thttp://citeseerx.ist.psu.edu/ viewdoc/download?doi=10.1.1.425.681&rep=rep1&type=pdf.
19. Saaty, T. L. (1980), *the analytic hierarchy process*, McGraw-Hill, New York.
20. Saaty, T. L. (1994), *Fundamentals of decision making*, RWS Publications, Pittsburgh.
21. Serrano, M. D., Peral, F.J.B., Casas, F. M. G. and Lozano, M. G. (2011) , Una revisión crítica para la construcción de indicadores sintéticos,*Revista de Métodos Cuantitativos para la Economia y la Empresa*, Vol. 11, pp. 41-70. Available at: https://www.econstor.eu/bitstream/10419/59089/1/684025426.pdf.
22. Soares, A. M., Kovaleski, J. L., Gaia, S., & Chiroli, D. M. D. G. (2020). Building sustainable development through technology transfer offices: An approach based on levels of maturity. Sustainability, 12 (5), 1795.
23. Tan, Y., Shen, L., Langston, C. and Liu, Y. (2010), Construction Project selection usign fuzzy TOPSIS approach, *Journal of Modeling in Management*, Vol. 5, No. 3, pp. 302-315. Doi: 10.1108/17465661011092669
24. Tarhan, A., Turetken, O. and Ilisulu, F.(2015), Business process maturity assessment: state of the art and key characteristics, *Proceedings - 41st Euromicro Conference on Software Engineering and Advanced Applications*, pp. 430-437. Doi: 10.1109/SEAA.2015.50.
25. Tarhan, A., Turetken, O. and Reijers, H. (2016), Business process maturity models: a systematic literature review, *Information and Software Technology*, Vol. 75, pp. 122-134. Doi: 10.1016/j.infsof.2016.01.010
26. van Looy, A., de Backer, M., Poels, G. and Snoeck, M. (2013), Choosing the right business process

maturity model, *Information and Management*, Vol. 50 No. 7, pp. 466-488. Doi:10.1016/j.im.2013.06.002.
27. van Looy, A. (2019), Capabilities for managing business processes: a measurement instrument, *Business Process Management Journal,* Vol.26, No. 1, pp. 287–311. doi:10.1108/BPMJ-06-2018-0157.
28. Zeleny, M. (1976). The attribute-dynamic attitude model (Adam), *Management Science*, Vol. 23, No. 1, pp. 1-107. DOI: 10.1287/mnsc.23.1.12.
29. Zola, F. C., Colmenero, J. C., Aragão, F.V., Rodrigues, T. and B. A. Jr. (2019), Multicriterial model for selecting a charcoal kiln, *Energy*, Vol. 190, article 116370. Doi: 10.1016/j.energy.2019.116377.

Appendix 1: Questions of the Proposed Model

STRATEGIC ALIGNMENT
Results Indicators/Metrics
The processes are measured to monitor their performance and are aligned between the sector's operational and strategic team.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)
Process Improvement Plans
The process improvement plans are part of a strategic sector cycle.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)
Interested Parts
The processes are modeled after the expectations of all interested parties.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)
Communication Between the Parties to the Process
The management is integrated with the sector and the improvement plans are defined together with the process executors.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)
GOVERNANCE
Decision-Making
Strategies and action plans are discussed for critical sector processes.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)
Responsibilities and Duties
People have responsibilities in assuming roles, they have autonomy to act and the leadership shares responsibility in the performance of processes.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)
Process Model
The sector's processes are modeled, extended to other interested parties and used for the development of strategies.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)
Process Management Control
The sector's processes are formally controlled and continuously reviewed.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)
METHODS
Purpose of the Processes
The processes are designed to fit with other processes in order to optimize performance across sectors and/or departments.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)
Process Design

The processes are documented in an electronic and standardized way, providing support to their performance, management and analysis for possible reconfiguration.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM)
( ) Frequent (F) ( ) Very frequent (VF)

Implementation and Execution of Processes

The process documentation is implemented and executed with standardization and on an ongoing basis.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM)
( ) Frequent (F) ( ) Very frequent (VF)

Control and Measurement of Processes

Processes are controlled and measured using methods established in the sector.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM)
( ) Frequent (F) ( ) Very frequent (VF)

Process Improvement and Innovation

Innovation techniques are established to improve the critical processes in the sector.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM)
( ) Frequent (F) ( ) Very frequent (VF)

INFORMATION TECHNOLOGY

Information Systems for Process Management

Existence of a standardized IT system that follows the standards of the sector's processes, assists in the communication between the interested parties, sectors, departments and other institutions, supporting the processes.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM)
( ) Frequent (F) ( ) Very frequent (VF)

Infrastructure for the Execution of Processes

The processes are executed with the support of all necessary IT resources, such as: reports, specific equipment, software, among other technological resources.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM)
( ) Frequent (F) ( ) Very frequent (VF)

Control and Measurement of Processes

Processes are measured and controlled by integrated IT systems.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM)
( ) Frequent (F) ( ) Very frequent (VF)

Innovation and Technological Improvement

Process improvement projects are carried out through the support of integrated IT systems.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM)
( ) Frequent (F) ( ) Very frequent (VF)

PEOPLE

Skills and Expertise

The sector has servers that have skills in managing and executing processes on a large scale.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM)
( ) Frequent (F) ( ) Very frequent (VF)

Training

The sector provides training to servers to maintain the knowledge and skills relevant to the processes, in order to make them skilled in execution and management.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM)
( ) Frequent (F) ( ) Very frequent (VF)

Team Work

The achievement of the desired results of the processes is obtained from teamwork, extending to other sectors.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM)
( ) Frequent (F) ( ) Very frequent (VF)

Leadership Conduct

The servers (not just the boss) feel responsible for the results of the sector's processes and propose improvements to achieve increasingly better results.
( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM)
( ) Frequent (F) ( ) Very frequent (VF)

Leadership Style The leadership delegates authority to the executors of the processes through leadership based on vision and influence, instead of command and control. ( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)
CULTURE
Posture Towards Changes The management recognizes that changes are inevitable for the improvement of processes, provides support and adopts them whenever necessary. ( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)
Adaptation to Changes Stakeholders accept and adapt to changes in industry processes. ( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)
Beliefs and Values Related to Processes The management recognizes the importance and benefits of the processes, so that its management actions are process-oriented. ( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)
Attitudes and Behaviors The servers involved and affected by the sector's processes are concerned with the way the processes are executed, propose improvements and are willing to contribute to the smooth running of the processes. ( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)
Leaders' Commitment to Processes The leadership acts oriented by the processes and has a holistic (global) view of the institution. ( ) Very rare (VR) ( ) Rare (R) () Medium rare (MR) ( ) Medium (M) ( ) Frequent medium (FM) ( ) Frequent (F) ( ) Very frequent (VF)

Appendix 2: Requirements for Levels 2 and 3

CAPACITY	LEVEL	PRESCRIPTION
Strategic alignment	2	▪ Start measuring some processes; ▪ Discussion of improvement plans among the sector's operational servers; ▪ Model the processes from the perspective of the executor; ▪ Some server or group of servers initiate the support of improvement plans for the management of the sector's processes.
	3	▪ Measure all processes and monitor their performance, even if in isolation; ▪ Discuss process improvement plans in conjunction with other sectors; ▪ Model the processes taking into account the executors and other interested parties; ▪ The sector supports improvement plans for the management of processes.
Governance	2	▪ Carry out structured decision making; ▪ Possibility for employees to identify themselves with certain processes and informally assume responsibility for the improvement initiative; ▪ Model the processes; ▪ Exercise informal process controls.
	3	▪ Discuss the critical processes in the sector; ▪ Identify the areas and servers that act in the processes and indicate them to assume the responsibilities that they are responsible for; ▪ Model processes at the sectoral level; ▪ Exercise formal control over some of the sector's processes.

Methods	2	▪ Use an existing (inherited) model of processes for the sector; ▪ Build or use a process design that is functional and identifies the connections between other sectors / departments / institutions; ▪ Document the processes for implementation and execution, even without standardization; ▪ Control and measure some processes; ▪ Improve processes systematically, even without the establishment of a specific method.
	3	▪ Redesign end-to-end processes to optimize their performance; ▪ Document the design of the end-to-end processes; ▪ Deploy and execute some of the documented processes; ▪ Control and measure some of the sector's processes, with an established method; ▪ Establish methods to be used to improve some processes.
Information Technology	2	▪ Use an IT system, even fragmented (without communication between the interested parties), to support the processes; ▪ Provide the necessary equipment to support the processes; ▪ Control and measure any of the processes with the help of an IT system; ▪ Discuss possible improvements and innovations applicable to processes.
	3	▪ Use an IT system built from functional components to support the processes; ▪ Provide specific equipment and software to support the processes; ▪ Control and measure the sector's processes with the help of an IT system; ▪ Apply projects to improve and innovate processes supported by an IT system.
People	2	▪ The sector must have some servers that have skills in executing the processes; ▪ Discuss possible training plans for civil servants; ▪ Work as a team in some occasional processes; ▪ The management must be responsible for the results of the processes; ▪ The sector must change the hierarchical style, from top to bottom, to an open and collaborative style.
	3	▪ The sector must have some servers that have the ability to execute and manage isolated processes; ▪ Eventually providing training courses for civil servants; ▪ Work as a team in process improvement projects; ▪ The employees and the management must be responsible for the results of the processes; ▪ The sector must show the need to change, considering processes as the main tool for change.
Culture	2	▪ Increased acceptance by management about the need to make minor changes to processes; ▪ Increased acceptance by stakeholders in accepting process changes; ▪ The management must carry out the process management actions aimed at complying with the rules; ▪ The sector must take actions for the smooth running of the processes; ▪ The leadership, even if focused only on their activities, should pay some attention to the management of the sector's processes.
	3	▪ The management must be prepared for significant changes in the way the work is carried out; ▪ Stakeholders in the processes must accept significant changes;

		▪ The management must carry out the process management actions, not only aiming to comply with the rules, but spontaneously; ▪ The sector must propose improvements to guarantee the progress of the processes; ▪ The management must seek more actions in the management of the sector's processes.