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A Method for Selecting Processes for Automation

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ABSTRACT Organizations are more frequently turning towards robotic process automation (RPA) as a solution for employees to focus on higher complexity and more valuable tasks while delegating routine, monotonous and rule-based tasks to their digital colleagues. These software robots are capable of handling a wide variety of rule-based, digital, repetitive tasks. However, currently available process identification methods are not qualified for accurately selecting suitable processes for automation. Wrong process selection and resulting failed attempts are often the origin of process automation's bad reputation within organizations and often result in the avoidance of this technology. As a result, in this research, a method for selecting processes for automation combining two multi-criteria decision-making techniques, Analytical Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), will be proposed, demonstrated, and evaluated. This study follows the Design Science Research Methodology (DSRM) and applies the proposed method for selecting processes for automation to a real-life scenario.

INDEX TERMS RPA, Robotic Process Automation, Software Robots, Process Suitability, Process Selection

I. INTRODUCTION

ORGANIZATION leaders are becoming increasingly curious about robots' potential to improve businesses and increase returns [1]. The term "robot" is most commonly imagined as physical machines moving around the office and performing human tasks. However, in the context of this article, this term is associated with service automation and refers to something less threatening. Robots are, in this scope, software that performs particular rule-based, repetitive, monotonous tasks previously performed by humans. As a result, humans can focus on more complex creative tasks [2]. Because it is software, it is used as a layer of logic on top of the underlying IT infrastructure without interfering. This non-invasive approach is achieved because these robots mimic the way humans perform tasks. They can log in using the user credentials, interpret text, tables, and figures, interact with the mouse through motion and clicking, write emails, fill out application forms and interact with data in multiple systems [1], [3].

The term robotic process automation (RPA) means applying these robots to business tasks that humans previously executed. Since its first implementation, RPA has evolved from the automation of simple tasks performed by one user to a platform-based application with the ability to undertake large volumes of work and automate more complex business rules by orchestrating dozens of software "robots" [4].

Robotic process automation (RPA) is a recent technology that promises to generate significant returns on investment for companies and organizations [3]. Enabling companies to free up resources and reallocate them to activities focused on creating business value and customer satisfaction, RPA can foster the emergence of new work forms and drive organizational competitiveness in the digital age [5]. The adoption of RPA in organizations, due to its cost reduction, efficiency improvement, productivity increase, and service quality enhancement has rapidly increased in recent years. However, specific core questions must be revisited and answered, as with any emerging technology, as most conducted researches are either case studies or market research [6]–[8].

One central question of RPA projects pertains to selecting the most suitable processes for automation [9]. Robotic process automation is not a one-size-fits-all solution. It requires careful analyses and informed decision-making, and, as a result, the success of these projects is highly dependent on a process's automation potential and its characteristics. Hence, companies must understand where their processes stand in the scope of RPA to ensure that its' adoption is successful and provides the desired return on investment [5]. Accordingly, this paper aims to provide organizations with a method to evaluate RPA automation candidates and rank them according to their automation potential. This process evaluation depends on the characteristics that make processes suitable for automation found in the current literature.

This research proposes a method to help organizations achieve better results when selecting the processes for automation through Multi-Criteria Decision Making (MCDM). When presented with multiple criteria, these methods provide support for decision-making. Each MCDM method has its' theoretical foundations, strengths, and weaknesses [10], [11]. In this study, the chosen method is AHP-TOPSIS. This Multi-Attribute Decision Making (MADM) method first uses the Analytic Hierarchy Process (AHP) for determining the decision criteria weights. Once criteria weights are defined, the Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) is used to evaluate and rank the processes regarding their closeness to the optimal solution.

The AHP, developed by Saaty, is an approach that simplifies complex and ill-structured problems through a series of pairwise comparisons by organizing the decision criteria in a hierarchical structure and attributing them a weight regarding their contribution to the desired goal [12], [13]. This method is commonly applied in complex scenarios, where collaboration is required to make decisions, and human perceptions, judgments, and consequences have long-term repercussions.

The rank reversal issue, a prevalent topic in decision-making, is the change in the ranking of alternatives when a non-optimal alternative is introduced. The TOPSIS method has been demonstrated to be one of the best methods to deal with this issue [14]. In addition, the rank reversal in TOPSIS is insensitive to the number of solutions and performs worst only in the case of a few criteria [14], [15]. An advantage of TOPSIS against other MADM methods is its ability to identify the best alternative faster than other methods [16].

This paper is organized as follows. In Section II, a theoretical background with information related to the topics of robotic process automation, process suitability, and the AHP-TOPSIS method is provided. In Section III, the research methodology is described. In Section IV, the proposed method is explained. In Section V, a demonstration of the method application is made. In Section VI, an evaluation of the results of applying the method is presented. Finally, a concluding remark is presented in Section VII, which includes the present work contribution, limitations, and possible future work.

II. THEORETICAL BACKGROUND

In this chapter, a theoretical background on the topics related to this research is presented.

A. ROBOTIC PROCESS AUTOMATION (RPA)

In this section a context to robotic process automation and the adoption of this technology is provided.

One of the core areas of business IT is the optimization and automation of business processes [9]. This area ranges from individual activities to automation of complete end-to-end processes [17] and is one of the current main digitization challenges for organizations [18]–[20].

In the past decades, several traditional methods of business process automation, such as core application systems, BPM systems, and middleware systems [21], [22], have been implemented. Unlike these solutions, RPA is a lightweight approach that allows non-intrusive automation of existing application systems [2], [23], [24]. These robots can be created through scripts, screen scraping, and macros and use ready-made standard modules. Because of its low implementation cost and high potential benefits, the interest of companies in adopting this technology has been increasing in recent years [25]–[27].

A clear framework for RPA application has not yet been established [28]. However, most reported case studies follow the same foundation procedure that consists of 4 steps: process selection, process modification, RPA implementation, and process monitoring [25], [29], with minor variations happening between adoption in different organizations. Case studies also suggest that RPA adoption usually starts with an initial proof of concept (PoC) [28] to demonstrate RPA capabilities and potential. The process selected for this case would be of low complexity and high volume/value [24], [29], [30].

However, selecting other processes to automate becomes more challenging, as their complexity, volume, or value are not so evidently more significant than the remaining [23].

B. PROCESS SUITABILITY

Being the first step of any RPA adoption, process selection is core for its' success, as choosing an unsuitable process will lead to poor outcomes and a negative outlook on the technology. In principle, various processes are suitable for automation [35], with the literature emphasizing specific process characteristics. The following characteristics are most commonly found in literature:

1) Rule-based - clear and concise rules govern most decisions along the process [9], [31]–[34];
2) Mature - minimal changes in the past and the expectation of future changes also being minimal to none [31], [34]–[37];
3) Structured and digital data - data need to be structured to consistently provide the same information for the robot in the same place. Data should also be digital for the robot to access and then process. Physical documents can be digitized but are more prone to errors, such as misreading, during processing [32], [35]–[37];
4) Volume - processes performed frequently by several people or take longer to be done [31], [32], [34], [35], [37];

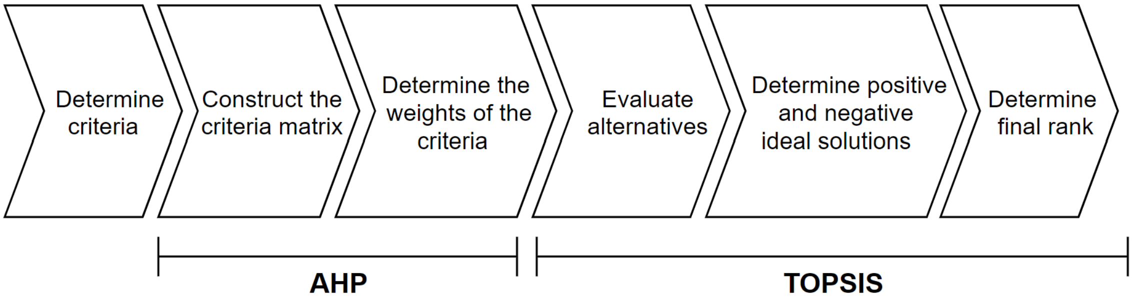


FIGURE 1. Generic AHP-TOPSIS methodology

5) Complexity - processes should be sufficiently simple that allows for faster robot development and deployment. Increased process complexity causes increased robot complexity and, with it, operation costs [38], [39];
6) Multiple systems - under the same conditions, processes that interact with more systems are more suitable for automation. As a result, the technology acts as a top layer providing integration between the different systems [32], [34];
7) Human input - repetitive, monotonous tasks that require human input are more prone to errors from fatigue [33], [37].

C. AHP-TOPSIS

This section provides a context to the used Multi-Criteria Decision Making algorithm, AHP-TOPSIS.

Numerous researchers have dedicated their effort to developing the best decision-making methodologies over the last decades. AHP-TOPSIS is designed with the most efficient use of Multiple-Criteria Decision Making techniques possible. AHP and TOPSIS, two of those techniques, are combined to rank alternatives according to specific criteria. In this research, the AHP technique is used to structure the decision hierarchy of the problem, while TOPSIS is employed to rank the existing alternatives. An illustration of the application of this techniques is presented on Fig. 1.

1) Analytic Hierarchy Process (AHP)

The analytic hierarchy process (AHP) [12] is a flexible and effective MCDM method. This method helps establish priorities and make the best decision when both quantitative and qualitative aspects of a decision need to be assessed [40], [41].

AHP is one of the most vastly used decision-making techniques in cases when the decision is based on several criteria. It has been applied in various fields, such as management, governance and agriculture, to name a few, with the purpose of making strategic decisions of significant importance and responsibility [42].

Although this method consists, on the problem decomposition into a hierarchy structure which consists of the goal, the criteria the alternatives [43], in this research it will only be used to obtain the criteria weights. This process consists of the following steps [44], [45]:

1.

1) Structure the decision hierarchy with a top-down approach (Fig. 2). The hierarch starts with the goal of the decision at the top, then the intermediate levels with the criteria and sub-criteria, to the lowest level (which usually is a set of the alternatives);

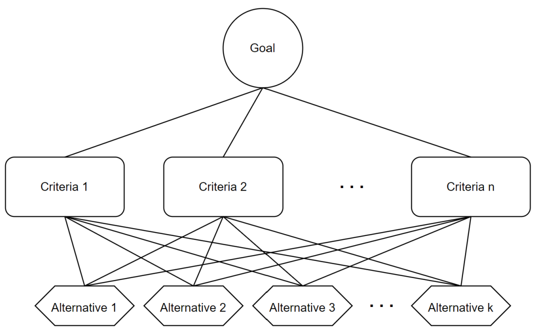


FIGURE 2. Generic Three-Layer AHP Hierarchy

2) According to the "Fundamental Scale of AHP" (Table 1), fill the comparison matrix in which every element from the set of criteria is compared to itself through a pair-wise comparison;
3) Given the comparison matrix $M \in \mathbb{R}^{n \times n}$, using the average of normalized column (ANC) method, obtain the vector of priorities $V \in \mathbb{R}^{n}$. In mathematical form,

TABLE 1. Fundamental scale of AHP from [12].

Intensity	Definition	Explanation
1	Equal Importance	Two criteria contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one criteria over another
5	Strong importance	Experience and judgment strongly favor one criteria over another
7	Very strong importance	One element is favored very strongly over another, its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation

[a]Intensities of 2, 4, 6 and 8 can be used to express intermediate values.
[b]If a criteria c1 has an intensity I compared to c2. By comparing c2 to c1, I is obtained.

the vector can be calculated as:

$$V = \begin{bmatrix} V_1 \\ V_2 \\ \dots \\ V_n \end{bmatrix} \;,\; V_i = \frac{\sum_{j=1}^{n} \overline{M_{ij}}}{n}. \tag{1}$$

where,

$$\overline{M_{ij}} = \frac{M_{ij}}{\sum_{i=1}^{n} M_{ij}} \;,\; \forall j \in \{1, n\}. \tag{2}$$

4) Verify that the consistency of judgments is valid by, calculating the Principal Eigen Value (λ) of the pair-wise comparisons matrix,

$$\lambda = V_1 \times \sum_{i=1}^{n} M_{i1} + V_2 \times \sum_{i=1}^{n} M_{i2} + \dots + V_n \times \sum_{i=1}^{n} M_{in}, \tag{3}$$

and then obtaining the Consistency Index (CI),

$$CI = \frac{\lambda - n}{n - 1}. \tag{4}$$

The Consistency Ratio (CR) is then defined by:

$$CR = \frac{CI}{RCI}, \tag{5}$$

where RCI is a random consistency index, depending on the number of criteria (Table 2). For the judgments to be coherent, a value of CR less than 0.1 is generally acceptable, otherwise the pair-wise comparisons should be revised to reduce incoherence [12].

2) Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

Hwang and Yoon created the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) technique [46] based on the fundamental idea that the chosen alternatives should be the closest to the positive ideal solution (S+) and the farthest distance from the negative ideal solution (S-) [47]. This approach presumes that each criterion leans towards a monotonically decreasing or increasing utility [48], and the preference order of the presented alternatives could be determined by comparing these relative distances [15].

Several exciting studies have focused on the TOPSIS technique and applied it in several fields, from supplier selection to tourism destination evaluation, financial performance evaluation, location selection, and others. In the literature, we can find examples of these studies, such as ETL software selection [49], customer-driven product design process [50], and open-source EMR software packages [51].

The steps of the TOPSIS approach are as follows [52], [53]:

1) Establish a decision matrix for the ranking, where each row represents an alternative and each column a criterion;
2) Normalize the decision matrix using the following equation:

$$\overline{A_{ij}} = \frac{A_{ij}}{\sqrt{\sum_{i=1}^{m} (A_{ij})^2}} \tag{6}$$

3) Using the weights previously attributed to the criteria, calculate the weighted normalized decision matrix $\overline{A^*} \in \mathbb{R}^{m \times n}$. Given the priority vector $V \in \mathbb{R}^n$, then

$$\overline{A^*_{ij}} = V_i \times \overline{A_{ij}} \;,\; \forall j \in \{1, n\} \tag{7}$$

4) Calculate the positive and negative ideal solutions as follows,

$$S^+ = \begin{bmatrix} \max(\overline{A^*_{11}}, \overline{A^*_{21}}, \dots, \overline{A^*_{m1}}) \\ \max(\overline{A^*_{12}}, \overline{A^*_{22}}, \dots, \overline{A^*_{m2}}) \\ \dots \\ \max(\overline{A^*_{1n}}, \overline{A^*_{2n}}, \dots, \overline{A^*_{mn}}) \end{bmatrix}, \quad S^- = \begin{bmatrix} \min(\overline{A^*_{11}}, \overline{A^*_{21}}, \dots, \overline{A^*_{m1}}) \\ \min(\overline{A^*_{12}}, \overline{A^*_{22}}, \dots, \overline{A^*_{m2}}) \\ \dots \\ \min(\overline{A^*_{1n}}, \overline{A^*_{2n}}, \dots, \overline{A^*_{mn}}) \end{bmatrix} \tag{8}$$

5) Compute the Euclidean distance to evaluate how close each alternative is to the ideal positive and negative solutions,

TABLE 2. Random Consistency Index Table from [12]

n	1	2	3	4	5	6	7	8	9	10
Random Index	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

$$D^+ = \begin{bmatrix} \sum_{i=1}^{n}(\overline{A_{1i}^*} - S_i^+)^2 \\ \sum_{i=1}^{n}(\overline{A_{2i}^*} - S_i^+)^2 \\ \dots \\ \sum_{i=1}^{n}(\overline{A_{mi}^*} - S_i^+)^2 \end{bmatrix},$$

$$D^- = \begin{bmatrix} \sum_{i=1}^{n}(\overline{A_{1i}^*} - S_i^-)^2 \\ \sum_{i=1}^{n}(\overline{A_{2i}^*} - S_i^-)^2 \\ \dots \\ \sum_{i=1}^{n}(\overline{A_{mi}^*} - S_i^-)^2 \end{bmatrix} \quad (9)$$

6) The closeness to the optimal solution (C_i), for every alternative i can be calculated as:

$$C_i = \frac{D_i^-}{D_i^- + D_i^+} \quad (10)$$

where the larger C_i the better the performance of the alternative, with the optimal alternative being the one with the value closest to 1. This technique usually deals with benefit and cost data. In this paper, all criteria are of benefit type. Therefore, the higher the value attributed to the criteria, the better.

III. RESEARCH METHODOLOGY

Design science research is one of the two paradigms that characterize research in Information Systems. This paradigm aims to create and evaluate new technological artifacts that help organizations handle core information-related tasks [54]. The Design Science Research Methodology (DSRM) requires a strict procedure to design artifacts that aim to solve problems, make research contributions, evaluate the designs, and communicate the results to the appropriate audiences [55]. IT artifacts can be: 1) constructs that compose the language by which the problems and solutions are defined and communicated [55], 2) models that use constructs to represent a real-world situation - the design problem and its solution [56], 3) methods that provide a solution to the problems [55] or 4) instantiations that show that the implementation of constructs, models, or methods in a working system is feasible [55].

As a result, a six-step procedure is followed for conducting the DSRM [57]: 1.

1) Problem Identification and Motivation: In the first step occurs the identification and specification of the research problem, followed by an explanation of the value of developing a solution;
2) Definition of the Goals for a Solution: In the second step occurs the expression of the purposes of finding a solution for the problem identified in the previous step;
3) Design and Development: In the third step, the decision on the technological artifact's desired functionality and determination of its architecture takes place. The artifact, which can be any designed object with an included research contribution in its design, is then created;
4) Demonstration: In the fourth step, the aim is to demonstrate how the artifact developed in the previous step helps solve one or more cases of the problem;
5) Evaluation: In the evaluation, occurs observation and measurement of the artifacts' effectiveness to support a solution for the problem. This solution is then compared with the results from the demonstration;
6) Communication: In the last step of the process occurs an exposition of the problem and its relevance, the artifact and its utility, uniqueness, and effectiveness to researchers and other relevant audiences.

The application of the DSRM to this research is presented in Fig. 3 and will be further explained throughout the following sections of this paper.

IV. PROPOSAL

This section corresponds to the second phase of the DSRM methodology and is where a solution to the problem of process selection for RPA adoption will be proposed.

A. OBJECTIVE

The primary objective of this paper is to provide a method that allows organizations to obtain a list of processes prioritized by their suitability for robotic process automation. This method considers both processes characteristics and the organizations' goals.

Given the purpose of this proposal, it is possible to infer that the proposed method tries to capture all real benefits associated with proper RPA adoption and attempts to either solve or mitigate the previously identified errors: poor outcomes of RPA implementation resulting from the lack of frameworks and consequently choosing unsuitable processes (Section I).

To guarantee that the method is of any value, the criteria used for process selection are coherent with the literature's characteristics and previously presented (Section I). As a result, the method will not only be evaluated on its ability to solve the identified problem but also on its ability to provide value to organizations in real-world scenarios.

B. DESCRIPTION

The AHP-TOPSIS is adopted to solve the previously mentioned problem. An application of this method to the problem

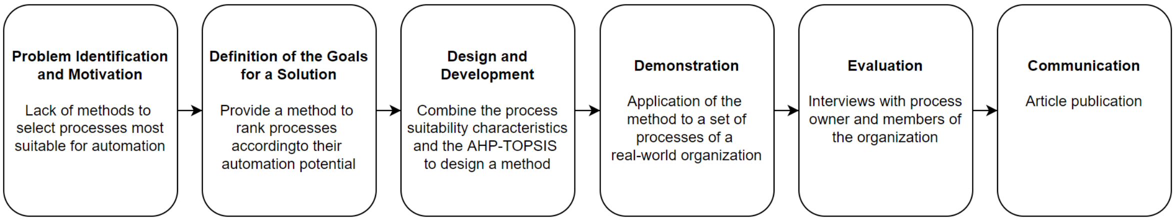


FIGURE 3. Six steps from DSRM adapted from [57]

context requires the criteria and their relative importance, the alternatives and their evaluation:

1) Criteria: the criteria chosen for AHP-TOPSIS consist of 9 criteria based on the previously conducted literature review. These criteria, previously presented (Section II-B), are rule-based, maturity, data structure, digital data, human input, complexity, multiple systems, frequency, and duration;
2) Relative importance: the pair-wise comparison matrix was filled according to the "Fundamental Scale of AHP" (Table 1) and the information found across the examined literature;
3) Alternatives: in this context, the alternatives for the AHP-TOPSIS method are the processes to be automated potentially;
4) Evaluation: the evaluation of these processes (alternatives) according to their characteristics (criteria) should be done by those with a more practical understanding of them, for example, the process owner. This evaluation requires the design of a scale for each chosen criteria.

It should be noted that the provided set of criteria and their relative importance are only a basis, and that can be customized if desired. One of the advantages of this method is that it gives the organization complete control over the chosen criteria, alternatives, relative importance and evaluation scales, enabling any addition or removal of process characteristics. It also allows for hypotheses and theories testing regardless of the purposes being scientific or businesslike. As mentioned, any characteristics can be added or removed without affecting the normal working of the method. When a new characteristic is added, it is only necessary to provide its relative importance to the remaining ones such that the coherency ratio remains below 10%.

The provided method for selecting processes for robotic process automation (Fig. 4) can be divided in the following 6-steps:

1) Determine Process Characteristics

At first, the process characteristics used as criteria for the process selection are defined. This paper provides a standard set of criteria based on the found literature. Organizations can, however, modify these criteria to their own goals as intended.

2) Construct pair-wise comparison of characteristics

Once criteria are defined, pair-wise comparison of these criteria must be made, according to the "Fundamental Scale of AHP". As in the previous step, this paper also provides a standard pair-wise comparison matrix based on the literature that may also be adapted.

3) Determine the weights of the criteria

In this step occurs the application of the AHP method calculations. The weights of each criterion are obtained according to the equations 1 and 2. To guarantee the validity of the proposed comparison matrix, equations 3, 4 and 5 are applied, and the obtained Consistency Ratio is evaluated against the threshold value of 10

4) Evaluate different processes

At this stage occurs the evaluation of processes according to the criteria defined in the first step. This evaluation requires the design and application of a properly defined scale. To ensure a proper evaluation, it is required for this step to be done by someone very acquainted with the processes, such as the process owner or a related business actor.

5) Determine positive and negative solutions

Once the process evaluation is done, the TOPSIS method calculations occur. The negative and positive ideal solutions are obtained by applying equations 6, 7 and 8 to the matrix containing the process evaluations and using the criteria weights obtained on step 3.

6) Determine the rank

In this final step, equations 9 and 10 are applied to obtain each process closeness to optimal. Processes are then ranked decreasingly according to the obtained value.

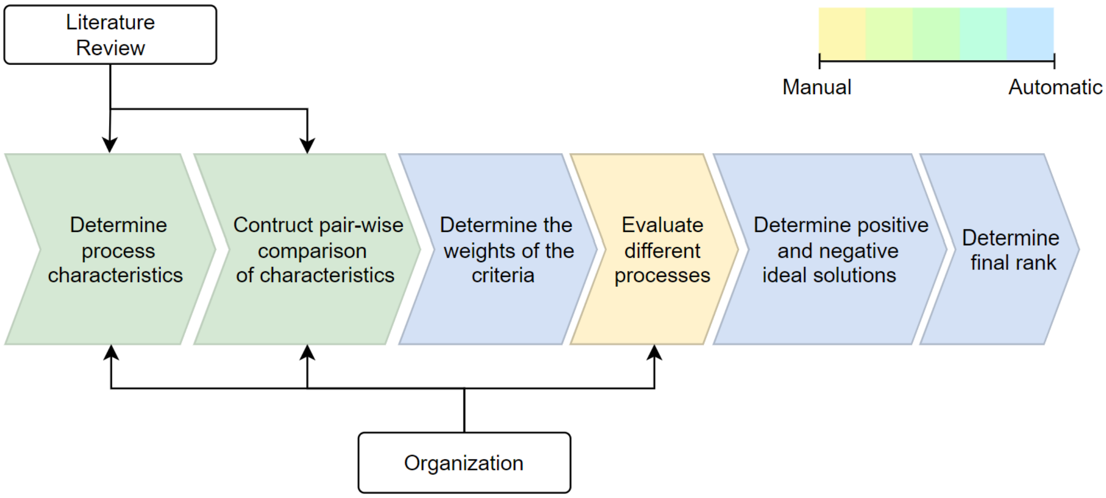


FIGURE 4. Method for selecting processes for automation.

V. DEMONSTRATION

This section relates to the fourth phase of the DSRM, and discusses how the previously defined method was used to solve a real-world scenario of the research problem.

A brief overview of Técnico+ business background will be provided, to support the context for demonstrating this implementation. Técnico+ provides over 35 advanced education courses, adapted to all technical levels of professional necessities, for both organizations and individuals. It partners with more than 70 teachers and researchers, to provide courses on dozens of areas of specializations. Like all organizations, Técnico+ process efficiency needs to scale up to match their business growth while keeping costs low to thrive in the highly competitive education market. To achieve this outcome, Técnico+ needs to understand whether adopting robotic process automation will provide a return on their investment, if their processes are suitable for automation and, in that case, which processes should be prioritized at this stage.

A. DETERMINE PROCESS CHARACTERISTICS

The standard process characteristics found in the literature were used as the criteria to apply the method (Table 3).

B. CONSTRUCT PAIR-WISE COMPARISON OF CHARACTERISTICS

With criteria already defined, a pair-wise comparison of the process characteristics suitable for automation occurred. The comparison matrix was then filled (Table 4) according to the "Fundamental Scale of AHP", and the existing literature on robotic process automation.

TABLE 3. Criteria for Técnico+ Process Selection

Code	Process Characteristics	Explanation
RB	Rule-Based	Activities do not require human decision-making
M	Maturity	Process has not been recently adjusted or modified
DS	Data Structure	Data appears in documents in a structured format
DD	Digital Data	Data is stored in documents in digital format
HI	Human Input	Activities do not rely on human input prone to error, such as copying and inserting data
C	Complexity	Process is simple, with low variation and few execution paths
MS	Multiple Systems	Process interacts with several different systems
F	Frequency	Process happens frequently
D	Duration	Process execution takes a long time

TABLE 4. Pair-wise comparison matrix for Técnico+

	RB	M	DS	DD	HI	C	MS	F	D
RB	1	3	1	2	9	5	9	0.2	5
M	0.33	1	0.33	0.33	7	2	9	0.33	5
DS	1	3	1	1	9	7	9	1	6
DD	0.5	3	1	1	9	7	9	1	5
HI	0.11	0.14	0.11	0.11	1	0.25	0.25	0.14	0.2
C	0.2	0.5	0.14	0.14	4	1	1	0.14	1
MS	0.11	0.11	0.11	0.11	4	1	1	0.11	1
F	5	3	1	1	7	7	9	1	7
D	0.2	0.2	0.17	0.2	5	1	1	0.14	1

C. DETERMINE THE WEIGHTS OF THE CRITERIA

By applying the AHP method calculations mentioned on the equations 1 and 2 we obtain the normalized comparison matrix (Table 6) and the vector of priorities (Table 5).

To guarantee that the proposed comparison matrix is valid and coherent, equations 3, 4 and 5 are applied, obtaining

TABLE 5. Vector of priorities

Criteria	Weight
RB	17.75%
M	9.51%
DS	19.11%
DD	24.32%
HI	1.53%
C	3.40%
MS	2.75%
F	24.32%
D	3.52%

a Consistency Ratio $(CR) \approx 9.88\%$, which is below the specified threshold.

D. EVALUATE DIFFERENT PROCESSES

Once the weights of each process's suitability characteristics are calculated, evaluation of processes according to their characteristics occurs. For this evaluation, the scale on Table 8 was designed. A member of the organization with a vast knowledge of the processes was then responsible for evaluating them according to the scale (Table 7). The organization's CEO then revised this evaluation.

E. DETERMINE POSITIVE AND NEGATIVE SOLUTIONS

Once the process evaluation finished, the negative and positive ideal solutions were calculated by applying TOPSIS equations 6, 7 and 8 to the Table 7 with the process evaluations and using the criteria weights on Table 5.

F. DETERMINE THE RANK

In the last step of the method, equations 9 and 10 were applied to obtain each process closeness to optimal. Processes were then ranked decreasingly according to the obtained value (Table 9).

VI. EVALUATION

This section corresponds to the evaluation stage of the DSRM, where an evaluation of the proposed method will is conducted. According to Pries-Heje et al. [58], evaluating an Information System depends on its' chronologic relationship to the artifact construction and its' environment. The evaluation timing can either be: "ex ante", if it occurs before the artifact is developed, or "ex post", if it takes place once the artifact exists. Regarding the evaluation environment, if it happens in a real-life setting, it is labeled naturalistic. However, it is labeled artificial if the evaluation is achieved through simulation, criteria-based analysis, or laboratory experiments.

The method developed as a result of this research proposal was evaluated according to its demonstration. Therefore, this evaluation is categorized as "ex post" and naturalistic. Through the demonstration, the usefulness and effectiveness of the developed artifact were tested in a real-world scenario to verify if the proposed method is applicable in a realistic context.

A semi-structured interview was conducted with the Técnico+ business actors responsible for the processes evaluation to capture their assessment of the methods' results and their subsequent applicability to their RPA adoption.

In the conducted interview, after analyzing the results, as demonstrated in Table 9, the interviewees pointed out that it stood out that the presented results were adapted to their specific business goals, which was aligned with one of the main goals of using this method: adaptability. The highest-ranked business process (7.08) further demonstrated the aforementioned individual adaptability. Previous to developing this method, the organization had already proposed this process as a potential Proof of Concept. The interviewees also stated that, during process evaluation, the tables were filled according to the AS-IS business processes. Had there been the possibility to reengineer the business processes in order for them to achieve the same goals, the evaluation would have been different.

VII. CONCLUSION

Robotic process automation is one of the emerging technologies drawing increasing interest for its' academic and business applications.

Our paper investigates a method for selecting and prioritizing processes suitable for automation based on multi-criteria decision-making techniques. While the method contributes to evaluating processes potential for automation, the results of the application of the method are still limited. Future research could consider validating the method using a quantitative research design of the results of automating the proposed processes.

Despite the positive results obtained from the demonstration of this research, more empirical work is required to reveal how applicable this method is to different scenarios and organizational contexts. Further, this technology is still very recent, and its research is still very restricted, consisting mostly of case studies. Therefore, researchers are invited to follow this technology and methods applicability as literature provides more knowledge on this technology adoption. This increase in available information may allow for a more complete, robust pair-wise comparison of criteria and improved alternative evaluation. Likewise, data science, recommender systems, and machine learning could also be used to explore new patterns and connections between criteria. Given that these methods require large amounts of data, which are not yet available, it was impossible to follow these paths in this research.

In our research, we limited the set of possible criteria to process characteristics. Studying how the sequentiality of processes may contribute to their suitability for automation is a possible future research direction. Furthermore, as with any multi-criteria decision-making method, AHP-TOPSIS has its limitations. Other MCDM techniques could be investigated as alternative methods for process selection.

TABLE 6. Normalized pair-wise comparison matrix for Técnico+

	RB	M	DS	DD	HI	C	MS	F	D
RB	0.118	0.215	0.206	0.339	0.164	0.160	0.187	0.049	0.160
M	0.039	0.072	0.069	0.057	0.127	0.064	0.187	0.082	0.160
DS	0.118	0.215	0.206	0.170	0.164	0.224	0.187	0.246	0.192
DD	0.591	0.215	0.206	0.170	0.127	0.224	0.187	0.246	0.224
HI	0.059	0.215	0.206	0.170	0.164	0.224	0.187	0.246	0.160
C	0.013	0.010	0.023	0.019	0.018	0.008	0.005	0.035	0.006
MS	0.024	0.036	0.029	0.024	0.073	0.032	0.021	0.035	0.032
F	0.013	0.008	0.023	0.019	0.073	0.032	0.021	0.027	0.032
D	0.024	0.014	0.034	0.034	0.091	0.032	0.021	0.035	0.032

TABLE 7. Evaluation of Técnico+ processes according to the scale 8

Code	RB	M	DS	DD	HI	C	MS	F	D
7.01	1	5	3	3	3	5	4	4	3
7.02	2	5	5	2	5	3	2	3	3
7.03	3	5	5	3	5	4	3	4	3
7.04	5	4	5	3	5	5	5	1	1
7.05	4	5	5	3	3	4	2	4	5
7.06	3	4	4	3	5	4	5	3	2
7.07	4	5	5	4	5	4	5	3	2
7.08	4	5	5	4	5	5	5	3	3
7.09	2	5	4	4	5	4	5	3	1
7.10	3	4	4	3	5	4	2	3	4
7.11	2	4	3	3	4	4	2	3	3
7.12	1	5	5	3	4	4	4	2	2
7.13	4	5	1	3	2	5	5	1	1
7.14	5	5	5	3	5	5	5	2	1
7.15	3	4	2	3	5	3	4	3	3
7.16	2	4	5	3	5	4	4	2	2
7.17	3	4	5	3	5	4	2	3	3
7.18	3	5	5	2	5	4	2	5	4

Note: To apply this method, each process was attributed a specific code ranging from 7.01-18 to identify it.

REFERENCES

[1] ACCA. The robots are coming? Implications for finance shared services., 09 2015.

[2] Mary C Lacity and Leslie P Willcocks. A new approach to automating services. MIT Sloan Management Review, 58(1):41–49, 2016.

[3] Petri Hallikainen, Riitta Bekkhus, and Shan L Pan. How opuscapita used internal rpa capabilities to offer services to clients. MIS Quarterly Executive, 17(1), 2018.

[4] Ilan Oshri and Albert Plugge. Introducing rpa and automation in the financial sector: Lessons from kas bank. Journal of Information Technology Teaching Cases, page 2043886921994828, 2021.

[5] Jonas Wanner, Adrian Hofmann, Marcus Fischer, Florian Imgrund, Christian Janiesch, and Jerome Geyer-Klingeberg. Process selection in rpa projects -towards a quantifiable method of decision making. International Conference on Information Systems 2019 (ICIS), 2019.

[6] Jerome Geyer-Klingeberg, Janina Nakladal, Fabian Baldauf, and Fabian Veit. Process mining and robotic process automation: A perfect match. In BPM (Dissertation/Demos/Industry), pages 124–131, 2018.

[7] Jan Mendling, Gero Decker, Richard Hull, Hajo A Reijers, and Ingo Weber. How do machine learning, robotic process automation, and blockchains affect the human factor in business process management? Communications of the Association for Information Systems, 43(1):19, 2018.

[8] Manfred Schmitz, Christoph Stummer, and Michael Gerke. Smart automation as enabler of digitalization? a review of rpa/ai potential and barriers to its realization. Future Telco, pages 349–358, 2019.

[9] Wil MP Van der Aalst, Martin Bichler, and Armin Heinzl. Robotic process automation, 2018.

[10] Oleg I Larichev. Ranking multicriteria alternatives: The method zapros iii. European Journal of Operational Research, 131(3):550–558, 2001.

[11] Valerie Belton and Theodor Stewart. Multiple criteria decision analysis: an integrated approach. Springer Science & Business Media, AH Dordrecht, Netherland, 2002.

[12] Roseanna W Saaty. The analytic hierarchy process—what it is and how it is used. Mathematical modelling, 9(3-5):161–176, 1987.

[13] Madjid Tavana and Adel Hatami-Marbini. A group ahp-topsis framework for human spaceflight mission planning at nasa. Expert Systems with Applications, 38(11):13588–13603, 2011.

[14] Stelios H Zanakis, Anthony Solomon, Nicole Wishart, and Sandipa Dublish. Multi-attribute decision making: A simulation comparison of select methods. European journal of operational research, 107(3):507–529, 1998.

[15] Evangelos Triantaphyllou and Chi-Tun Lin. Development and evaluation of five fuzzy multiattribute decision-making methods. international Journal of Approximate reasoning, 14(4):281–310, 1996.

[16] Celik Parkan and ML Wu. On the equivalence of operational performance measurement and multiple attribute decision making. International Journal of Production Research, 35(11):2963–2988, 1997.

[17] Marlon Dumas, Marcello La Rosa, Jan Mendling, and Hajo A Reijers. Bpm als unternehmensfähigkeit. In Springer Berlin Heidelberg, editor, Grundlagen des Geschäftsprozessmanagements, pages 553–585. Springer, Berlin, Germany, 2021.

[18] Christoph Meier, Sabine Seufert, and Josef Guggemos. Arbeitswelt 4.0 und smart machines: Augmentation als herausforderung für die personalentwicklung. HMD Praxis der Wirtschaftsinformatik, 56(4):823–839, 2019.

[19] Christian Czarnecki, Frank Bensberg, and Gunnar Auth. Die rolle von softwarerobotern für die zukünftige arbeitswelt. HMD Praxis der Wirtschaftsinformatik, 56(4):795–808, 2019.

[20] Tim Niesen, Constantin Houy, and Peter Fettke. Digitale transformation von prozessen in der rechtsberatung: Anwendungsszenarien im steuerbereich am beispiel des argumentum-systems. HMD Praxis der Wirtschaftsinformatik, 56(4):766–779, 2019.

[21] Sanjay Mohapatra. Business process automation. PHI Learning Pvt. Ltd., New Delhi, 2009.

[22] Esko Penttinen, Henje Kasslin, and Aleksandre Asatiani. How to choose between robotic process automation and back-end system automation? In European Conference on Information Systems 2018, 2018.

[23] Ralf Plattfaut. Robotic process automation - process optimization on steroids? In 40th International Conference on Information Systems, 12 2019.

[24] Mary Lacity, Leslie P Willcocks, and Andrew Craig. Robotic process automation at telefonica o2. 2015.

[25] Feiqi Huang and Miklos A Vasarhelyi. Applying robotic process automation (rpa) in auditing: A framework. International Journal of Accounting Information Systems, 35:100433, 2019.

[26] Piotr Marciniak and Robert Stanisławski. Internal determinants in the field of rpa technology implementation on the example of selected companies in the context of industry 4.0 assumptions. Information, 12(6):222, 2021.

[27] Dalibor Šimek and Roman Šperka. How robot/human orchestration can help in an hr department: A case study from a pilot implementation. Organizacija, 52(3):204–217, 2019.

[28] Rehan Syed, Suriadi Suriadi, Michael Adams, Wasana Bandara, Sander JJ Leemans, Chun Ouyang, Arthur HM ter Hofstede, Inge van de Weerd, Moe Thandar Wynn, and Hajo A Reijers. Robotic process automation: contemporary themes and challenges. Computers in Industry, 115:103162, 2020.

[29] C Gex and M Minor. Make your robotic process automation (rpa) implementation successful. Armed Forces Comptroller, 64(1):18–22, 2019.

TABLE 8. Scale for process evaluation for Técnico+

Criteria	Scale				
	1	2	3	4	5
RB	% of activities that do not require human decision-making				
	0-20%	20%-40%	40%-60%	60%-80%	80%-100%
M	how many times was the process adjusted, modified or revised (in the last year)				
	5+	4	3	2	0-1
DS	% of stuctured data and documents				
	0-20%	20%-40%	40%-60%	60%-80%	80%-100%
DD	% of digital data and documents				
	0-20%	20%-40%	40%-60%	60%-80%	80%-100%
HI	% of activities that require human input				
	0-20%	20%-40%	40%-60%	60%-80%	80%-100%
C	how complex are the process variations and execution paths				
	Very Complex	Somewhat Complex	Neutral	Somewhat Simple	Very Simple
MS	how many systems are involved in the process				
	1	2	3	4	5+
F	how often does the process happen				
	Less than once a month	Monthly	Every 2 weeks	Weekly	Daily
D	how much working time does the process require				
	Less than 15min	15min-1h	1h-3h	3h-6h	More than 6h

TABLE 9. Process ranking according to suitability for automation

Rank	Code	Closeness to Optimal
1	7.08	0.98
2	7.07	0.97
3	7.14	0.93
4	7.04	0.92
5	7.05	0.87
6	7.03	0.83
7	7.17	0.82
8	7.10	0.79
9	7.06	0.78
10	7.09	0.70
11	7.18	0.67
12	7.16	0.66
13	7.15	0.59
14	7.02	0.52
15	7.11	0.47
16	7.12	0.44
17	7.13	0.43
18	7.01	0.25

[30] Christian Flechsig, Franziska Anslinger, and Rainer Lasch. Robotic process automation in purchasing and supply management: A multiple case study on potentials, barriers, and implementation. Journal of Purchasing and Supply Management, 28(1):100718, 2022.

[31] Shailendra Hegde, Sriram Gopalakrishnan, and Mike Wade. Robotics in securities operations. Journal of securities operations & custody, 10(1):29–37, 2018.

[32] Julia Kokina and Shay Blanchette. Early evidence of digital labor in accounting: Innovation with robotic process automation. International Journal of Accounting Information Systems, 35:100431, 2019.

[33] Julia Kokina, Ruth Gilleran, Shay Blanchette, and Donna Stoddard. Accountant as digital innovator: Roles and competencies in the age of automation. Accounting Horizons, 35(1):153–184, 2021.

[34] Laurence Viale and Dorsaf Zouari. Impact of digitalization on procurement: the case of robotic process automation. In Supply Chain Forum: An International Journal, volume 21, pages 185–195. Taylor & Francis, 2020.

[35] Julia Siderska. Robotic process automation—a driver of digital transformation? Engineering Management in Production and Services, 12(2):21–31, 2020.

[36] Martin Zelenka and Marek Vokoun. Information and communication technology capabilities and business performance: The case of differences in the czech financial sector and lessons from robotic process automation between 2015 and 2020. Review of Innovation and Competitiveness: A Journal of Economic and Social Research, 7(1):99–116, 2021.

[37] Judith Wewerka and Manfred Reichert. Robotic process automation–a systematic literature review and assessment framework. arXiv preprint arXiv:2012.11951, 2020.

[38] Mary Lacity and Leslie P Willcocks. Innovating in service: the role and management of automation. In Dynamic Innovation in Outsourcing, pages 269–325. Springer, Berlin, Heidelberg, 2018.

[39] Capgemini Consulting. Robotic Process Automation - Robots conquer business processes in back offices, 2016.

[40] Fikri Dweiri, Sameer Kumar, Sharfuddin Ahmed Khan, and Vipul Jain. Designing an integrated ahp based decision support system for supplier selection in automotive industry. Expert Systems with Applications, 62:273–283, 2016.

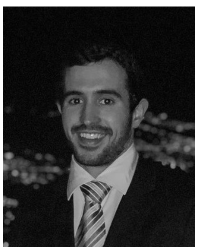
[41] Guo-Niu Zhu, Jie Hu, Jin Qi, Chao-Chen Gu, and Ying-Hong Peng. An integrated ahp and vikor for design concept evaluation based on rough number. Advanced Engineering Informatics, 29(3):408–418, 2015.

[42] Husam Jasim Mohammed, Maznah Mat Kasim, and Izwan Nizal Shaharanee. Evaluation of e-learning approaches using ahp-topsis technique. Journal of Telecommunication, Electronic and Computer Engineering (JTEC), 10(1-10):7–10, 2018.

[43] Nina Begičević, Blaženka Divjak, and Tihomir Hunjak. Prioritization of e-learning forms: a multicriteria methodology. Central European Journal of Operations Research, 15(4):405–419, 2007.

[44] Thomas L Saaty and Luis G Vargas. How to make a decision. In Models,

methods, concepts & applications of the analytic hierarchy process, pages 1–25. Springer, Berlin, Heidelberg, 2001.
[45] Thomas L Saaty. Decision making with the analytic hierarchy process. International journal of services sciences, 1(1):83–98, 2008.
[46] Ching-Lai Hwang and Kwangsun Yoon. Methods for multiple attribute decision making. In Multiple attribute decision making, pages 58–191. Springer, Berlin, Heidelberg, 1981.
[47] Chandra Prakash and Mukesh Kumar Barua. Integration of ahp-topsis method for prioritizing the solutions of reverse logistics adoption to overcome its barriers under fuzzy environment. Journal of Manufacturing Systems, 37:599–615, 2015.
[48] Ji-Feng Ding. An integrated fuzzy topsis method for ranking alternatives and its application. Journal of Marine Science and Technology, 19(4):2, 2011.
[49] Mohamed Hanine, Omar Boutkhoum, Abdessadek Tikniouine, and Tarik Agouti. Application of an integrated multi-criteria decision making ahp-topsis methodology for etl software selection. SpringerPlus, 5(1):1–17, 2016.
[50] Ming-Chyuan Lin, Chen-Cheng Wang, Ming-Shi Chen, and C Alec Chang. Using ahp and topsis approaches in customer-driven product design process. Computers in industry, 59(1):17–31, 2008.
[51] Miss Laiha Mat Kiah, Ahmed Haiqi, BB Zaidan, and AA Zaidan. Open source emr software: profiling, insights and hands-on analysis. Computer methods and programs in biomedicine, 117(2):360–382, 2014.
[52] Ruey-Chyn Tsaur. Decision risk analysis for an interval topsis method. Applied Mathematics and Computation, 218(8):4295–4304, 2011.
[53] JF Ding. Using fuzzy mcdm model to select middle managers for global shipping carrier-based logistics service providers. WSEAS Transactions On Systems, 11(3), 2012.
[54] Alan R Hevner, Salvatore T March, Jinsoo Park, and Sudha Ram. Design science in information systems research. MIS quarterly, pages 75–105, 2004.
[55] Alan R Hevner, Salvatore T March, Jinsoo Park, and Sudha Ram. Design science in information systems research. Management Information Systems Quarterly, 28(1):6, 2008.
[56] Herbert A Simon. The Sciences of the Artificial, reissue of the third edition with a new introduction by John Laird. MIT press, London, England, 2019.
[57] Ken Peffers, Tuure Tuunanen, Marcus A Rothenberger, and Samir Chatterjee. A design science research methodology for information systems research. Journal of management information systems, 24(3):45–77, 2007.
[58] Jan Pries-Heje, Richard Baskerville, and John R Venable. Strategies for design science research evaluation. 2008.



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