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Research article

A method for selecting processes for automation with AHP and TOPSIS

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A R T I C L E I N F O

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Robotic process automation
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Process suitability
Process selection

A B S T R A C T

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 can handle various rule-based, digital, repetitive tasks. However, currently available process identification methods must be qualified to select suitable automation processes accurately. Wrong process selection and 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, 'Analytic 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. The result will be a method to support the proper selection of business processes for automation, increasing the success of implementing RPA tools in an organization.

1. 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 how 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

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“robots” [4].

Robotic process automation (RPA) is a recent technology that promises to generate significant returns on investment for companies and organizations [3]. By enabling companies to free up resources and reallocating them to activities focused on creating business value and customer satisfaction, RPA can foster 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 pro-cess 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 research 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) to determine 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 introducing a non-optimal alternative. 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].

The main objective of this research is to offer a method that enables organizations to get a list of procedures ranked by how suitable they are for automation with RPA. The organization’s aims are considered together with the peculiarities of the process.

This paper is organized as follows. In Section II, atheoretical 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, ademonstration 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.

2. Theoretical background

This chapter presents a theoretical background on the topics related to this research.

2.1. Robotic process automation

This section provides a context of robotic process automation and the adoption of this technology.

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 using 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 yet to be 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’s 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 less significant than the remaining [23].

2.2. Process suitability

Being the first step of any RPA adoption, process selection is core to its success. Choosing a suitable process will lead to better outcomes and a positive technological outlook. 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 frequently performed by several people or took longer to be done [31,32,34,35],
(5) [37];
(6) Complexity - processes should be sufficiently simple, allowing for faster robot development and deployment. Increased process complexity causes increased robot complexity and, with it, operation costs [38–40];
(7) Multiple systems - under the same conditions, pro-cesses interacting 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];
(8) Human input - repetitive, monotonous tasks that require human input are more prone to errors from fatigue [33,37].

All this information can be found with much more detail in Ref. [38], which presents and discusses a Systematic Literature Review identifying the most general implementation features of successful RPA adoption cases, observed benefits, challenges commonly faced by organizations, characteristics that make processes more suitable for RPA, and research gaps in the current literature.

The findings described in that work provide not only a way for companies and organizations to become more familiar with good practices regarding robotic process automation adoption, but also to foster further research on the subject by complementing the current knowledge and proposing new paths for research, which we are using to conduct the current research.

From the literature review, appears to be a dearth of guidelines for RPA deployment in smaller firms, showing the opportunity for research in the field.

2.3. 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 and TOPSIS, two of those techniques, are combined to rank alternatives according to specific criteria. AHP-TOPSIS is designed with the most efficient use of Multiple-Criteria Decision Making techniques possible. 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 these techniques is presented in Fig. 1.

2.3.1. 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 [41,42].

AHP is one of the most widely used decision-making techniques 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, to make strategic decisions of significant importance and responsibility [43].

Although this method consists of the problem decomposition into a hierarchy structure consisting of the goal, the criteria, and the alternatives [44], this research will only be used to obtain the criteria weights. This process consists of the following steps [45,46].

(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);
(2)According to the "Fundamental Scale of AHP" (Table 1 [12],), fill the comparison matrix in which every element from the set of criteria is compared to itself through a pairwise comparison;

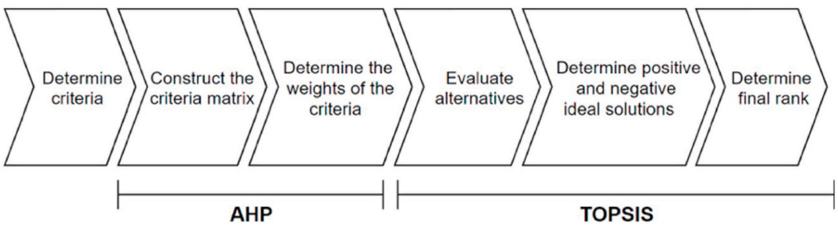

Fig. 1. Generic AHP-TOPSIS methodology.

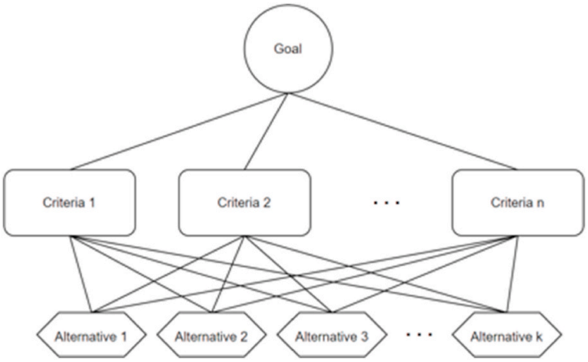

Fig. 2. Generic three-layer AHP hierarchy.

Table 1
Fundamental scale of AHP from Ref. [12].

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

(3)Given the comparison matrix $M \in R^{n \times n}$, using the average normalized column (ANC) method, obtain the vector of priorities $V \in R^n$. In mathematical form, the vector can be calculated as:

(3) Given the comparison matrix $M \in R^{n \times n}$, using the average normalized column (ANC) method, obtain the vector of priorities $V \in R^n$. In mathematical form, 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 pairwise comparisons matrix,

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

and then obtaining the Consistency Index (CI),

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

The Consistency Ratio (CR) is then defined by:

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

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

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

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

Hwang and Yoon created the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) technique [47] 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-) [48]. This approach presumes that each criterion leans towards a monotonically decreasing or increasing utility [49], 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 [50], customer-driven product design process [51], and open-source EMR software packages [52].

The steps of the TOPSIS approach are as follows [53,54].

(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:

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

(3) Using the weights previously attributed to the criteria, calculate the weighted normalized decision matrix

$\overline{A^*} \in R^{m\times n}$. Given the priority vector $V \in R^n$, 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,

$$S^+ = \left[\begin{array}{c} max\left(\overline{A_{11}^*}, \overline{A_{21}^*}, \cdots, \overline{A_{m1}^*}\right) \\ max\left(\overline{A_{12}^*}, \overline{A_{22}^*}, \cdots, \overline{A_{m2}^*}\right) \\ \cdots \\ max\left(\overline{A_{1n}^*}, \overline{A_{2n}^*}, \cdots, \overline{A_{mn}^*}\right) \end{array} , S^- = \left[\begin{array}{c} min\left(\overline{A_{11}^*}, \overline{A_{21}^*}, \cdots, \overline{A_{m1}^*}\right) \\ min\left(\overline{A_{12}^*}, \overline{A_{22}^*}, \cdots, \overline{A_{m2}^*}\right) \\ \cdots \\ min\left(\overline{A_{1n}^*}, \overline{A_{2n}^*}, \cdots, \overline{A_{mn}^*}\right) \end{array} \right] \right] \tag{8}$$

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

$$D^+ = \left[\begin{array}{c} \sum_{i=1}^{n} \left(\overline{A_{1i}^*} - S_i^+\right)^2 \\ \sum_{i=1}^{n} \left(\overline{A_{2i}^*} - S_i^+\right)^2 \\ \cdots \\ \sum_{i=1}^{n} \left(\overline{A_{mi}^*} - S_i^+\right)^2 \end{array} , D^- = \left[\begin{array}{c} \sum_{i=1}^{n} \left(\overline{A_{1i}^*} - S_i^-\right)^2 \\ \sum_{i=1}^{n} \left(\overline{A_{2i}^*} - S_i^-\right)^2 \\ \cdots \\ \sum_{i=1}^{n} \left(\overline{A_{mi}^*} - S_i^-\right)^2 \end{array} \right] \right] \tag{9}$$

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

$$C_i = \frac{D_i^-}{D_i^- + D_i^+} \tag{10}$$

where the larger Ci 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.

3. 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 [55]. 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 [56]. IT artifacts can be: (i) constructs that compose the language by which the problems and solutions are defined and communicated [56], (ii) models that use constructs to represent a real-world situation - the design problem and its solution [57], (iii) methods that provide a solution to the problems [57] or (iv) instantiations that show that the implementation of constructs, models, or methods in a working system is feasible [56].

As a result, a six-step procedure is followed for conducting the DSRM [58].

(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; 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;
(2) Definition of the Goals: In the second step the objectives of a solution are inferred from the problem definition and knowledge of what is possible and feasible;
(3) Design and Development: In the third step, the decision on the technological artifact's desired functionality and its architecture is taken 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, observation and measurement of the artifacts' effectiveness occur 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 [57], and will be further explained throughout the following sections of this paper.

We want to point out that although the DSR method provides for the possibility of iterations, in the research work that is summarised in this paper we have performed only a single iteration of the DSR method.

4. 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.

4.1. 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, considering both process's characteristics and the organization's 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.

To guarantee that the method is of any value, the criteria used for process selection are coherent with the literature's characteristics

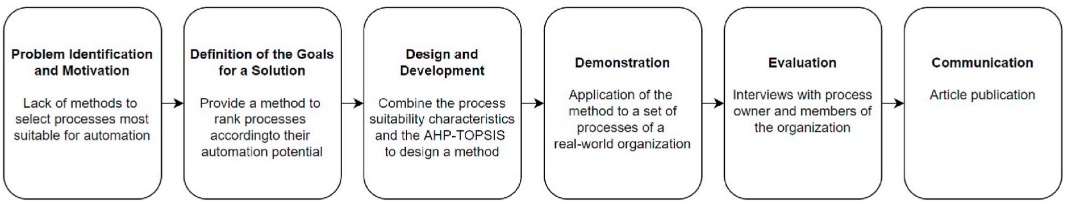

Fig. 3. Six steps from DSRM adapted from [57].

and previously presented. As a result, the method will be evaluated not only on its ability to solve the identified problem but also on its ability to provide value to organizations in real-world scenarios.

4.2. Description

The AHP-TOPSIS is adopted to solve the previously mentioned problem. An application of this method to the problem 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 are: rule-based, maturity, data structure, digital data, human input, complexity, multiple systems, frequency, and duration;
(2) Relative importance: the pairwise 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 criterion.

It should be noted that the provided set of criteria and their relative importance are only a basis 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 theory testing regardless of scientific or business-like purposes. 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 into the following 6-steps:

Step (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. However, organizations can modify these criteria to their goals as intended.

Step (2) Construct pairwise comparison of characteristics - Once criteria are defined, a pairwise 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 pairwise comparison matrix based on the literature that may be adapted.

Step3) 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 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

Step (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.

Step (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 in step 3.

step (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.

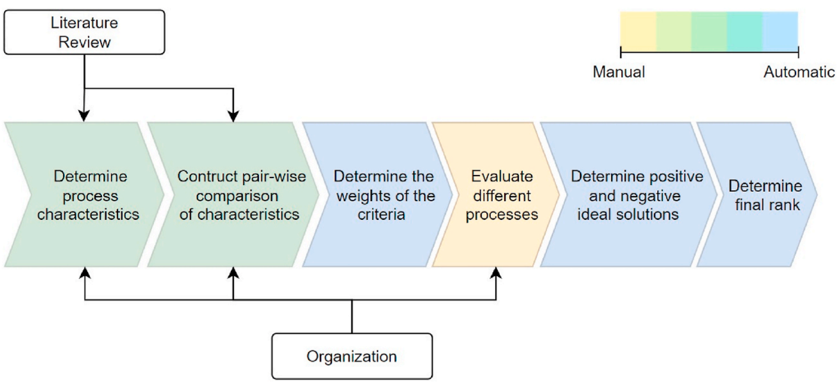

Fig. 4. Method for selecting processes for automation.

5. 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 specialization. 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.

Step 1. Determine process characteristics.

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

Step 2. Construct Pairwise Comparison of Characteristics

With criteria already defined, a pairwise 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.

Step 3. Determine the Weights of the Criteria

By applying the AHP method calculations mentioned on 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)–(5) are applied, obtaining a Consistency Ratio (CR) $\approx$ 9.88%, which is below the specified threshold.

Step 4. 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.

Step 5. Determine Positive and Negative Solutions

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

Step 6. 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).

6. 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. [59], evaluating an Information System depends on its' chronologic relationship to the artifact's construction and environment. The evaluation timing can either be: "ex ante" if it occurs before the artifact is developed or "ex post", if it occurs once the artifact exists. Regarding the evaluation environment, if it happens in a real-life setting, it is labelled naturalistic. However, it is labelled 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 process evaluation to capture

Table 3
Criteria for Técnico + process selection.

Code	Process Characteristics	Description
RB	Rule-Based	Activities do not require human decision-making
M	Maturity	The 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	The 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
Pairwise 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

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%

Table 6
Normalized pairwise 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.

	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

Table 8
Scale for process evaluation for Técnico+.

	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 15 min	15 min–1 h	1 h–3 h	3 h–6 h	More than 6 h

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

their assessment of the methods' results and their subsequent applicability to their RPA adoption. In this semi-structured interview, conducted as part of the evaluation of the proposed method, the interviewees were the CEO of the organization and the responsible for administration and logistics. These interviewees were directly involved in the execution of the processes selected for automation in the demonstration. The interviews were conducted by video call, and both interviewees were asked to assess the results presented in Table 9. The interviewees were asked three questions:

Question 1: Is the rank realistic and appropriate?

Question 2: The rank benefits the organization the most?

Question 3: The processes were the most suitable for automation?

The interviewees were also asked to add other relevant comments.

In the conducted interviews, after analyzing the results, 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. The evaluation would have been different if it had been possible to reengineer the business processes to achieve the same goals.

Thus, we can conclude that the proposed method is suitable to support the appropriate selection of business processes for automation. Thus, it constitutes an important contribution to increase the success of implementing RPA tools in an organization.

7. Conclusion

Robotic process automation is one of the emerging technologies drawing increasing interest for its academic and business applications. However, there are still several challenges to its implementation, with the lack of frameworks and methods being one of them.

Starting RPA adoption by not correctly choosing the best-fit processes to be automated will likely fail. Being aware of the drawbacks and challenges posed by RPA adoption, as described in Ref. [38], we propose a method addressing some of those challenges by allowing a process prioritization for automation. In this work, we proposed, evaluated and demonstrated an essential contribution to implementing RPA tools in an organization. We did this by providing a method that allows organizations to obtain a list of processes prioritized by their suitability for robotic process automation. The method considers both the process's characteristics and the organization's goals.

This work investigates a method for selecting and prioritizing processes suitable for automation based on multi-criteria decision-making techniques. We achieved this by creating a technique that enables businesses to obtain a prioritized list of processes based on how well they lend themselves to robotic process automation. This strategy takes into account both organizational goals and process characteristics.

The current study's findings provide practitioners with a method for developing a plan for process automation inside an organization based on a process's suitability for automation. They had to make decisions based only on their sensitivity prior to this study because they lacked a methodical methodology. Although several methods have been proposed in the literature, they all rely on the experience of the consultants, rather than a formal approach. At the same time, we contribute to the current research area (process automation) by proposing a method for formally specifying the order in which processes within an organization should be automated, which was previously highlighted as a gap in the previous literature revision [38] performed by the authors. 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.

In terms of limitations and future work, 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. 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. Further, this technology is still very recent, and its research is still very restricted, mainly consisting 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 pairwise 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 have yet to be available, it was impossible to follow these paths in this research.

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. In our research, we limited the possible criteria to process characteristics. Other MCDM techniques could be investigated as alternative methods for process selection.

Declarations

Author contribution statement

Diogo Silva Costa, Henrique S. Mamede, Miguel Mira da Silva: conceived and designed the experiments; performed the experiments; analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; wrote the paper.

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Data included in article/supp. material/referenced in article.

Declaration of interest's statement

The authors declare no competing interests.

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