Robotic Process Automation: A Systematic Literature Review

Seminar paper

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Abstract

This paper presents the current state of academic research on Robotic Process Automation and selects 24 out of 896 publications. I divided the founded literature into the categories benefits, limits, implementation, and upcoming trend for a better overview. In the implementation part, current concepts were brought into an overall context. Furthermore, future research is needed to summarize all current research approaches of RPA, as this paper is limited to the basics.

Keywords: RPA, Robotic Process Automation, Literature Review, Automation.

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1 Introduction

Bots are the basis for "virtualizing the workforce" is a common thought for Robotic Process Automation (van Chuong, Hung and Diep, 2019).

But RPA is not a physical robot that can move or process physical paper (non-digital document). RPA is a software technology that simulates human behaviour when interacting with a GUI. Performing rule-based tasks such as opening attachments, logging into SAP, moving files or folders, sending emails, and filling a form, scarping data from a webpage, or extracting structured data from files. (Romao, Costa and Costa, 2019).

This paper answers the research question,*" Is there a common basis in the academic research environment around RPA?".*

The method of a systematic literature review was used to answer the questions. Thereby the following elementary categories were used for classification benefits, limits, implementation, and upcoming trends.

The form of this paper starts with a short definition of RPA. Then the methodological procedures are explained, and an overview of the results found is given. This is followed by a more detailed explanation of the clustered findings. The discussion briefly compares and considers the results, the business value, limitations and future research approaches. The paper ends with a short conclusion on the clustered result.

2 Background

The widely used definition of RPA in the literature comes from the Institute of Electrical and Electronics Engineers Standards Association.

"A preconfigured software instance that uses business rules and predefined activity choreography to complete the autonomous execution of a combination of processes, activities, transactions, and tasks in one or more unrelated software systems to deliver a result or service with human exception management. "('IEEE Guide for Terms and Concepts in Intelligent Process Automation', 2017, p. 11)

In concrete terms, this is about a preset software but not a technology. It is important to note that RPA is not an elementary technology, neither a physical nor mechanical robot but has evolved as a concept for the application of different technologies (Sibalija, Jovanović and Đurić, 2019). The word robot in the term of robotic process automation refers to a software-based bot programmed to carry out procedures, processes, or tasks in a repetitive way that is usually done by humans. Such a bot can run implemented processes 24 hours a day, seven days a week, 365 days a year. (KAYA, TURKYILMAZ and BIROL, 2019)

3 Literature Review

3.1 Database & Search criteria

For the keyword search, the related phrase " Robotic Process Automation" or the abbreviation RPA was searched for in the document title. The period of publication has been set to after 2018, as this work deals with the current aspect. Only literature that has been published in academic journals or at least peer-reviewed has been selected. Furthermore, English was chosen as the standard literary language.

IEEE Xplore, ACM Digital Library, and Ebsco. These databases were selected according to their respective focus on information systems and economics.

3.2 Selection process

In the beginning, a first overview was given with Google Scholar. A keyword search was then carried out in the three databases mentioned above.

If it was possible to access the literature, it was first screened for the abstract and then evaluated for full text. The abstract screening then excluded literature that did not belong to the subject. For example, when the abbreviation RPA was used for something else.

Literature referring to public institutions such as the army or administration was excluded from the qualitative analysis.

In addition to the database search, I performed a backward reference search and added the selected literature. The search included only literature that was recurrently listed in the direct sources and was therefore frequently cited. A detailed overview of the selection process and excluded literature can be found in the following diagram (Figure 1).

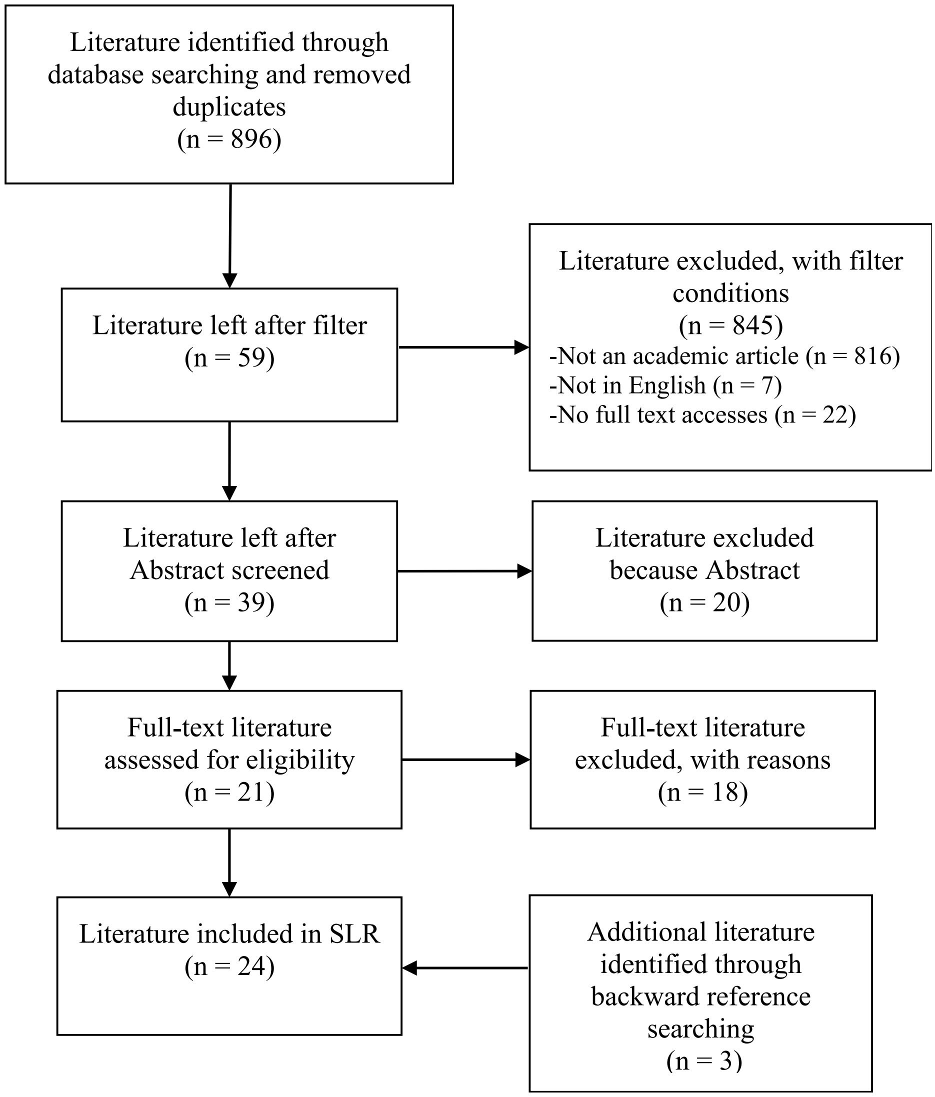

Figure 1 Prisma Flow Diagram of selection process

3.2 Overview selected literature

I grouped the selected 27 publications into benefits, limits, implementation and upcoming trend. These classifications are the most common aspect of the selected literature.

The following literature matrix (table 1) shows the classification of all selected papers.

Source	Database	Titel	Author	Year	Benefits	Limits	Implementation	Upcoming trend
1	EBSCO Host	USING ROBOTIC PROCESS AUTOMATION (RPA) TO ENHANCE ITEM MASTER DATA MAINTENANCE PROCESS.	Radke, Andreas; Minh Trang Dang; Tan, Albert	2020	x			x
4	EBSCO Host	Digital Business Value Creation with Robotic Process Automation (rpa) in Northern and Central Europe	KEDZIORA, DAMIAN; KIVIRANTA, HANNA-MAIJA;	2018	x			
7	EBSCO Host	Robotic Process Automation: Lessons Learned from Case Studies	OSMAN, Cristina-Claudia	2019				x
8	EBSCO Host	Impact of RPA Technologies on Accounting Systems	KAYA, Can Tansel; TURKYILMAZ, Mete ;BIROL, Burcu	2019	x			x
11	EBSCO Host	Setting Up a Robotic Process Automation Center of Excellence	ANAGNOSTE, Sorin	2018			x	
12	EBSCO Host	Robotic Process Automation for Auditing	Moffitt, Kevin C.; Rozario, Andrea M.; Vasarhelyi, Miklos A	2018				
20	IEEEE Xplore	Robotic Process Automation: An Overview and Comparison to Other Technology in Industry 4.0	Bernhard Axmann; Harmoko Harmoko	2020	x	x		
22	IEEEE Xplore	Development Prospect and Application Feasibility Analysis of Robotic Process Automation	Allam Maalla	2019				x
23	IEEEE Xplore	System Design and Development for Robotic Process Automation	Yi-Wei Ma; Dan-Ping Lin; Shiang-Jiun Chen; Hsiu-Yuan Chu;Jiann-Liang Chen	2019			x	
25	IEEEE Xplore	Method of Robotic Process Automation in Software Testing Using Artificial Intelligence	Nataliya Yatskiv; Solomiya Yatskiv; Anatoliy Vasylyk	2020	x	x		x
26	IEEEE Xplore	Towards a Method for Automated Testing in Robotic Process Automation Projects	Jesús Chacón Montero; Andres Jimenez; Jose Gonzalez Enríquez	2019			x	
31	IEEEE Xplore	Towards a Process Analysis Approach to Adopt Robotic Process Automation	Abderrahmane Leshob; Audrey Bourgouin; Laurent Renard	2018			x	
32	IEEEE Xplore	Robotic Process Automation: A Scientific and Industrial Systematic Mapping Study	J. G. Enríquez; A. Jiménez-Ramírez; F. J. Domínguez-Mayo; J. A. García-García	2020			x	
33	IEEEE Xplore	Robotic Process Automation Through Advance Process Analysis Model	Devansh Hiren Timbadia; Parin Jigishu Shah; Sughosh Sudhanvan; Supriya Agrawal	2020			x	
41	IEEEE Xplore	The Effectiveness of RPA in Fine-tuning Tedious Tasks	Sutipong Sutipitakwong; Pornsuree Jamsri	2020	x			
42	IEEEE Xplore	Recent Trends in Automation-A study of RPA Development Tools	Saurabh Gupta; Sangeeta Rani; Amit Dixit	2019				x
47	IEEEE Xplore	RPA in Finance: supporting portfolio management : Applying a software robot in a portfolio optimization problem	Ortiz, Felipe C.Magrin; Costa, Carlos J.	2020				x
50	ACM Digital Lib	The Key Factors Affecting RPA-business Alignment	Zhang, Ning; Liu, Bo	2018			x	
51	ACM Digital Lib	Towards Automated Testing of RPA Implementations	Cernat, Marina; Staicu, Adelina Nicoleta; Stefanescu, Alin	2020			x	
53	ACM Digital Lib	Robotic Process Automation and Opportunities for Vietnamese Market	van Chuong; Hung, Phan Duy; Diep, Vu Thu	2019	x			
55	ACM Digital Lib	Robotic Process Automation - Creating Value by Digitalizing Work in the Private Healthcare?	Ratia, M.; Myllärniemi, J.; Helander, N.	2018	x			
57	Backward Refe	Process Mining and Robotic Process Automation: A Perfect Match	Jerome Geyer-Klingeberg; Janina Nakladal; Fabian Baldauf; Fabian Veit	2018			x	
58	Backward Refe	On the Evaluation of Intelligent Process Automation	Deborah Ferreira; Julia Rozanova; Krishna Dubba; Dell Zhang; Andre Freitas	2020				x
59	Backward Refe	From Robotic Process Automation to Intelligent Process Automation	Tathagata Chakraborti; Vatche Isahagian; Rania Khalaf; Yasaman Khazaeni; Vinod Muthusamy; Yara RizkMerve Unuvar	2020	x			x

4 Results

4.1 Benefits

RPA comes with many benefits for companies, employees, and customers. (Axmann and Harmoko, 2020) The following analysis results of the literature are sorted according to these target groups. This classification provides a better overview.

For Companies

All performed actions during RPA are standardized, making them consistent and eliminating process output variations. (Yatskiv, Yatskiv and Vasylyk, 2020). RPA bots have full access to all applications that a human would have access to by acting on the GUI. Through this access, new systems can be connected quickly. The work of the bot is documented by logs during the process execution. (KAYA, TURKYILMAZ and BIROL, 2019). These logs are an excellent benefit for audit trail and essential for compliance (Yatskiv, Yatskiv and Vasylyk, 2020).

Another benefit is the short duration of RPA implementations and a quick return on investment (roi). For Yatskiv, Yatskiv and Vasylyk (2020) RPA projects run 9 to 12 months, while for Kedziora and Kiviranta (2018) an RPA standard implementation takes place in Two-Three months.

Due to the process automation's fast start-up, Yatskiv, Yatskiv and Vasylyk (2020) give a roi of below one year and Kedziora and Kiviranta (2018) a roi even within 6 months. The reliable working power of a digital bot is another consistent benefit in the literature. (Axmann and Harmoko, 2020); (Yatskiv, Yatskiv and Vasylyk, 2020)

For Customers

Within digitalization, the customer is often seen as the focus of all business orientations. RPA makes it possible to further increase the quality of service for customers. Through less susceptibility to errors, bots avoid human-error in processing (Axmann and Harmoko, 2020).

Besides, indirect value is created by the possibility of limitless system linkage of RPA. This functionality serves as the basis for new customer-oriented services and thus promotes innovation. (Ratia, Myllärniemi and Helander, 2018)

For Employees

In general, it can be said that RPA frees employees from mindless tasks and enables them to take on new innovative challenges. (Yatskiv, Yatskiv and Vasylyk, 2020)

They will have the opportunity to learn, increase knowledge, skills and creativity. (Axmann and Harmoko, 2020) With improved FTE and employee morale, employees go for higher value-added tasks (KAYA, TURKYILMAZ and BIROL, 2019).

4.2 Limits

RPA automates human behaviour based on rules at the presentation level. If the circumstances change, manual support is necessary. Therefore, any system interface changes or implemented new business steps require additional human development effort (Axmann and Harmoko, 2020). Also, input data must be available in a structured digital form to be processed. Further limitations are high acquisition costs, which do not pay off when selecting non-standardized processes, and lack of basic implementation knowledge (Yatskiv, Yatskiv and Vasylyk, 2020).

4.3 Implementation

The literature established the idea of a life cycle to represent the entire implementation of an RPA process. This life cycle contains six to seven phases, depending on the literature, and is very well suited to combine different concepts and implementation. (Enriquez *et al.*, 2020)

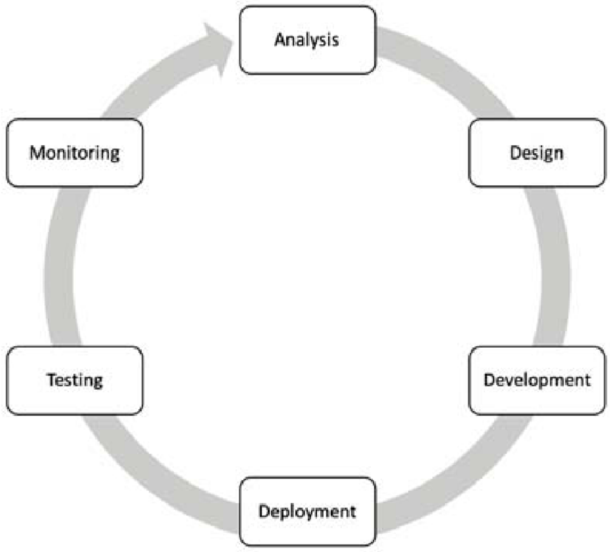

Figure 2 RPA Life Cycle

Multiple authors developed the idea of an RPA life cycle in the selected literature. Chacón-Montero, Jiménez-Ramírez and Enríquez (2019) used it to put individual phases into a general context. They divided the Cycle into the following stages analysis, design, development, deployment, testing, and monitoring. This Cycle is shown in figure 2. Furthermore, (Ma *et al.*, 2019) developed a similar model with the phases RPA Plan, RPA Demand and Definition, RPA Design, RPA Implement, RPA Test, RPA Operation and RPA Maintenance. In the following, I will use the life cycle from Chacón-Montero, Jiménez-Ramírez and Enríquez (2019) to classify the concepts found according to the appropriate phases.

4.3.1 Analysis

The first step is to select suitable processes for implementation. As a basis, the process must comply with the most common RPA criteria. First, standardized processes are more automatable. Because RPA robots currently still need an established logic of action to complete flows successfully. Second, high volume, repeated tasks can benefit more from automation since the development costs are distributed over the runs. Third, mature processes should be targeted. They have fewer deviations and so less human error handling (Geyer-Klingeberg *et al.*, 2018). OSMAN (2019) also mentions these three criteria but adds the requirement that processes should be rule-based and low in Complexity.

However, these criteria do not represent a suitable procedure for identifying methodically relevant business processes with implementation potential. That's why Leshob, Bourgouin and Renard (2018) have developed a method of analyzing and weighing suitable processes.

Step 1: Validate Process Eligibility

The validation is based on a measurement of the maturity and standardization of the processes.

Step 2: Evaluate RPA Potential of a Business Process

The potential for the feasibility of human work in software configuration is measured.

Step 3: Evaluate RPA Relevance of a Business Process

Evaluate the RPA use case according to the high-volume of transactions and a low-level of Complexity.

Step 4: RPA Classification of a Business Process

Assigns an RPA classification (Not suitable, less suitable, moderately suitable, or

highly suitable) to a business process based on its RPA potential (Step 2) and its RPA relevance

Leshob, Bourgouin and Renard (2018) performed an experiment with three selected RPA specialists to validate the method. The purpose was to apply the method independently using case studies. The experts' subsequent questioning revealed that the technique is generic, effective, and can be performed by users without becoming RPA experts (Leshob, Bourgouin and Renard, 2018). Timbadia *et al.* (2020) use this method to compare it with their proposed model. Their approach is based on three fundamental factors. The first factor, Automation Potential, evaluates and tells the user what type of automation is suggested. Second, Complexity analyses criteria like cognitive skills required or exception possibility and gives the Complexity of the given process. Third, FTE Savings considers the amount of data, staff-hours, and the processing time needed to analyze from a business point of view (Timbadia *et al.*, 2020).

4.3.2 Design, Development, and Testing

After a detailed analysis of the business processes and selected use cases, the process design phase begins. This phase aims to detail the set of actions, data flow, activities, design patterns, etc., that must be implemented in the RPA process (Enriquez *et al.*, 2020).

Following this, the development starts. Here we have to decide between the classic waterfall model and an agile approach. Ma *et al.* (2019) present a concrete agile approach and compare both methods according to their practical use. The central point of the plan is the division of the entire RPA process into N equal parts. These are completed in about one department and are developed according to the Cycle.

As a result, the implementation of the life cycle will run more frequently. But in contrast to the waterfall method, feedback from the departments comes much earlier, and nonconforming RPA sections can be identified more quickly. Therefore the total development time and effort is less (Ma *et al.*, 2019).

The developed flow must now be tested according to the requirements. In the general RPA environment, testing is essential but also a very critical part. This is because often, there is no testing environment available. Therefore, when the robot is implemented, it is deployed in production and then tested to determine whether it behaves correctly (Chacón-Montero, Jiménez-Ramírez and Enríquez, 2019). Moving directly from Development to Testing is also shown in the life cycle (Figure 1). Often test cases are mostly written in an Excel file, containing pre-conditions, post-conditions, the expected and actual all fields being manually provided by business analysts. Which is usually quite time-consuming (Cernat, Staicu and Stefanescu, 2020). Chacón-Montero, Jiménez-Ramírez and Enríquez (2019) therefore complement the RPA life cycle (Figure 3) with two phases essential for testing, Test Environment Construction and Automatic Testing

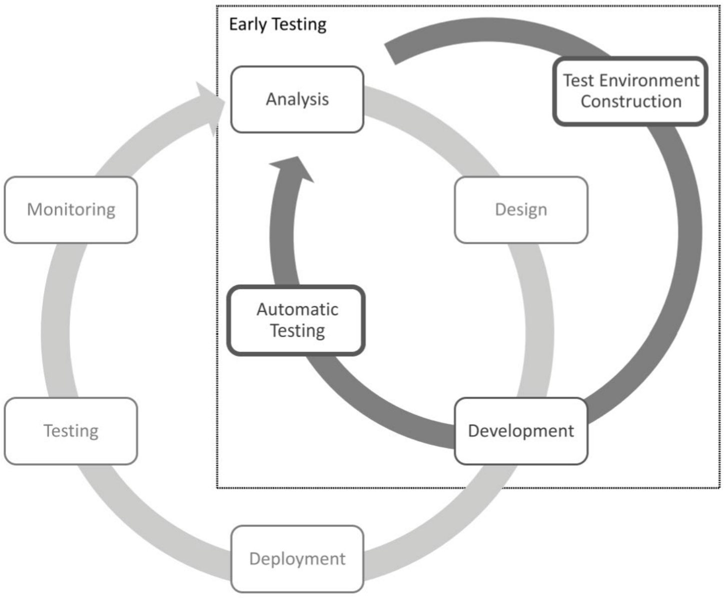

Figure 3 Modified RPA Life Cycle

The goal of this step is to generate a test environment that shows the real system's behaviour at the frontend. Therefore UI logs from the analysis phase can be used. (Chacón-Montero, Jiménez-Ramírez and Enríquez, 2019) Since the robots are implemented based on visual models such as flowcharts or state machines, the idea of applying model-based testing techniques comes in naturally as well. However, there is not a method known to autogenerate this kind of environment and test cases in the literature. (Ma *et al.*, 2019). But the current status of the development can be checked automatically against the test cases in the environment. (Chacón-Montero, Jiménez-Ramírez and Enríquez, 2019).

Also, in this second cycle, the performance of different RPA flow implementation should be benchmarked to identify the most effective RPA implementation. This can be done with the help of process mining. (Geyer-Klingeberg *et al.*, 2018)

4.4 Upcoming trend

There is a discussion in the selected literature about the use of RPA in conjunction with other emerging technology. The main focus is on process mining (OSMAN, 2019) and artificial intelligence (Radke, Dang and Tan, 2020). The goal is a higher degree of automation beyond the current limits of RPA (Maalla, 2019; Yatskiv, Yatskiv and Vasylyk, 2020). There is already a talk about RPA 2.0 (Chakraborti *et al.*, 2020) or a new term called IPA, which was already defined in 2017.

"A preconfigured software instance that combines business rules, experience-based context determination logic, and decision criteria to initiate and execute multiple interrelated human and automated processes in a dynamic context. The goal is to complete the execution of a combination of processes, activities, and tasks in one or more unrelated software systems that deliver a result or service with minimal or no human intervention." ('IEEE Guide for Terms and Concepts in Intelligent Process Automation', 2017, p. 11) In summary, Intelligent Process Automation (IPA) aims to generalize RPA and avoid human intervention and training on the bot.

5 Discussion

The most significant contrast in the results can be funded in the analysis phase. There Method of Leshob, Bourgouin and Renard (2018) faced the proposed form of Timbadia *et al.* (2020). According to Timbadia *et al.* (2020) the proposed model is preferable to the known method because of the high number of parameters considered. The individual evaluation of these ensures that the process is viewed multidimensionally. While the general way only carries out a one-dimensional observation.

The demarcation between RPA and IPA is only established in the definition. In RPA, cognitive decisions cannot be mapped, and a clear logic implemented by humans is required. IPA, on the other hand, observes human activity and identifies patterns in it. These are then used for process automation. Therefore, it is also possible that IPA reacts to new unknown input data with an action pattern that fits best. (Ferreira *et al.*, 2020). One of the few limitations of RPA is thus remedied in IPA. However, this benefit over RPA has its price. Businesses must spend much more on the development of an IPA process than on Robotic Process Automation. This difference is caused by the technical implementation of artificial intelligence and requirements for a high data stock (Chakraborti *et al.*, 2020).

The literature does not indicate the role of AI and machine learning within RPA.
Agostinelli et al. (Agostinelli, Marrella, and Mecella 2019) provide an analysis of several RPA tools; none of the studied tools has self-learning ability and cannot automatically understand which actions belong to which process. Therefore, IPA sounds like a promising approach that implements the technologies end to end.

Practical implications

This paper gives an overview of the direction of the current academic literature. Nevertheless, it can also be used as an entry point and a very rough model for practical work, as modern implementation concepts are sorted according to the RPA life cycle.

Limitations

The systematic literature search includes only three scientific libraries so that relevant literature in other databases can be overlooked. Furthermore, there was no access to 22 papers of the founded literature, which probably could also have been reliant. Besides, the full breadth of topics represented in the RPA literature could not be expressed; due to the partly small niches, a general clustering was not possible.

Future research

Future research, in a similar direction, should be guided by the limitations of this paper. Therefore, more comprehensive analysis with all research branches around the topic of RPA would be desirable. Furthermore, the practical distinction between RPA and IPA is just beginning. Here, an approach-oriented model of when which procedure (RPA or IPA) should be used would be conceivable. Since the literature, in general, is still divided on the topic of IPA, it could also be examined to what extent RPA and IPA merge.

6 Conclusion

RPA brings benefits in increased productivity, reduced personnel costs, increased customer satisfaction, and increased employee skills and creativity. However, the implementation of RPA still faces some challenges, such as technological limitations in processing non-digital data and different form formats. Besides, RPA cannot optimize the process flow design and has to be redesigned every time there is a change in the process. This is where the new IPA trend comes in. Intelligent process automation is not intended to map rule-based processes but data-driven processes.

Throughout this paper, is an overview of the current state of academic research on the essential topics of RPA was made possible. The literature review shows the high distributed volume of academic research on Robotic Process Automation. Furthermore, the research results on the basics are already very mature. It goes beyond basic research, as the method on the suitability of processes for RPA shows.

Therefore, it can be concluded that RPA is a relevant and accepted topic in the academic literature and is not just a hype. Much work is being done on implementation concepts to push the already fast adoption of RPA even further.

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