LAPPEENRANTA–LAHTI UNIVERSITY OF TECHNOLOGY LUT

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EX-ANTE PROFITABILITY EVALUATION OF ROBOTIC PROCESS AUTOMATION BY APPLYING THE PAY-OFF METHOD

Master's Thesis 2023

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Examiner 2: Postdoctoral Researcher Mariia Kozlova

ABSTRACT

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The primary objective of this thesis is to develop a novel framework that incorporates the pay-off method for evaluating the profitability of Robotic Process Automation (RPA) prior to implementation. The study explores the existing academic literature on this topic, identifying challenges and requirements for the successful evaluation of RPA. Furthermore, the suitability of the pay-off method for conducting this type of evaluation is thoroughly examined. Motivated by the current research gap in the ex-ante evaluation of RPA profitability, this study contributes to the understanding and implementation of effective evaluations in this context.

This study employs the Design Science Research (DSR) methodology to address its objective. It utilizes a qualitative case study approach for data collection, examining prior research on successfully executed RPA projects to gather relevant data. The collected data is analyzed using the Grounded Theory (GT) method. Based on the insights derived from this analysis, a comprehensive four-step framework for ex-ante evaluation of RPA profitability is developed, using both the collected data and the chosen methodology. The framework incorporates the pay-off method as an integral component and its validity is examined through numerical examples.

The findings of this study demonstrate that the developed framework enables the ex-ante evaluation of RPA investments. By effectively addressing the challenges and requirements identified in the study, which have previously constrained the implementation of such evaluations, the framework overcomes previous limitations and enables organizations to evaluate RPA investments more comprehensively and confidently. As a result, the framework is expected to enhance the effectiveness and value of the technology for organizations across various industries, fostering greater success and adoption of RPA.

TIIVISTELMÄ

Lappeenrannan–Lahden teknillinen yliopisto LUT

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Kauppatieteet

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Ohjelmistorobotiikan kannattavuuden ennalta-arviointi tuottojakauma-menetelmää soveltamalla

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Tämän Pro Gradu -tutkielman tavoitteena on muodostaa uudenlainen työkalu ohjelmistorobotiikan kannattavuuden ennalta-arvioinnin toteuttamiseen soveltamalla tuottojakauma-menetelmää. Tämä tutkimus pyrkii selvittämään, millaista kyseiseen aiheeseen liittyvää akateemista tutkimusta on aikaisemmin toteutettu, sekä millaisia haasteita ja edellytyksiä onnistuneen arvioinnin toteuttamiseen liittyy. Lisäksi se tutkii tuottojakauma-menetelmän soveltuvuutta tämänkaltaisten arviointien toteuttamiseen. Tutkimuksen syntymistä on motivoinut ohjelmistorobotiikan kannattavuuden ennalta-arvioimisen akateemisesta tutkimuksesta tunnistettu tutkimusaukko.

Tutkimus on toteutettu hyödyntämällä Design Science Research (DSR) -metodologiaa. Aineistonkeruumenetelmäksi on valittu kvalitatiivinen tapaustutkimus, jossa tutkittavina tapauksina toimivat aikaisemmin tehdyt tutkimukset onnistuneesti toteutetuista ohjelmistorobotiikkaprojekteista. Tapauksien pohjalta kerätyt aineistot on analysoitu Grounded Theory (GT) -menetelmää käyttäen. Tutkimusongelman mukainen työkalu on muodostettu valitun metodologian mukaisesti kerättyä aineistoa hyödyntäen. Työkalun validointi on lopuksi suoritettu numeeristen esimerkkien avulla.

Tutkimuksen tulokset osoittavat, että muodostetulla tuottojakauma-menetelmää soveltavalla työkalulla on mahdollista toteuttaa ohjelmistorobotiikkaprojektin kannattavuuden ennalta-arviointi. Tulosten perusteella kyseisen työkalun avulla pystytään vastaamaan tutkimuksessa tunnistettuihin haasteisiin, jotka ovat aikaisemmin rajoittaneet tämän arvion toteuttamista. Työkalulla voidaan myös tukea ohjelmistorobotiikkaprojektin onnistumista, sillä se mahdollistaa organisaatioille perusteltujen päätösten tekemisen ohjelmistorobotiikka-investointien suhteen, ja siten lisää kyseisen teknologian tehokkuutta ja arvoa eri aloilla toimiville organisaatioille.

ACKNOWLEDGEMENTS

I've been working on this thesis for what feels like forever, and I can't begin to explain how excited I am to finally submit it. It's been a long and challenging journey, but I'm proud of myself for staying dedicated and focused throughout the process. Trying to balance a full-time job and competitive sports while working on this project hasn't been easy. But I decided to go for it anyway.

Despite the challenges, I'm happy with the topic I chose for my project. The research part was really interesting, although there were definitely times when I felt pretty confused and overwhelmed. Throughout the process, I learned a lot about the topic and developed valuable research skills that I know will benefit me in the future. I'm excited to see where this project will take me and what opportunities it may lead to.

The path to this moment has been long – a big thank you to everyone who has been involved in its different stages. I also really want to thank my supervisor for all the support and guidance throughout this whole process. And a big shout-out to my friends and family too.

In Järvenpää, 12th May 2023

Linda Stenqvist

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1 Introduction

This thesis presents a simplified four-step framework for ex-ante profitability evaluation of Robotic Process Automation (RPA). The need for such a framework arises from the lack of standardized methods for evaluating the profitability of RPA investments. RPA brings certain benefits that are difficult to measure or even unmeasurable, as well as some unpredictable benefits that may be revealed only after a certain period of use of the technology. Current evaluation methods are often too complex and do not consider the unique characteristics of RPA projects, which can result in incorrect automation solutions and project failure. Unfortunately, as shown by several case studies, many companies rely on the experiences of others and fail to conduct comprehensive pre-evaluations. This reinforces the need for a simplified yet comprehensive framework, specifically designed for evaluating RPA investments, which provides accurate and reliable results. The development of such a framework can help organizations to make informed decisions about the business case for RPA and improve the success rate of RPA projects. Being able to evaluate the profitability when information about the reachable benefits of the project is imprecise requires specialized methods: for this reason, the pay-off method is used for the analysis.

1.1 Background of the Research

The digital age is changing the nature of business sustainability. The continuous optimization and automation of business processes is regarded as vital parts of corporate activities to increase productivity and competitiveness. Recently, there has been a strong interest in the industry in a specific area of automation: Robotic Process Automation (RPA). RPA is a relatively new and fast-emerging process automation approach that uses software robots to replicate human tasks. RPA is said to offer several benefits, such as higher efficiency rates, improved quality and compliance, and increased customer and employee satisfaction, to name just a few. Based on those expectations, RPA has become widely adopted in businesses and industries with growing market revenue.

Even though RPA has drawn much corporate attention in recent years, many RPA projects still fail or lack behind expectations. A major reason is the automation of wrong processes, mainly driven by a lack of objective methods to identify and select suitable process candidates. RPA benefits are often cited from one author to another without providing further credentials and the feasibility of RPA bot implementation is usually based on general rules of thumb, especially when it comes to rather qualitative metric data like customer and employee satisfaction. Many companies select processes based on their complexity and volume but do not further quantify the economic value of RPA. This increases the risk of poor implementation strategies and project failure.

A significant gap in current research on RPA lies in the lack of empirical validation for design principles that can effectively ex-ante evaluate the potential value of RPA. Existing techniques for process selection are often complex and developed by specific RPA vendors, which may introduce biased recommendations and limit the generalizability of the approach. While some research has proposed concepts for selecting business processes based on their complexity, these approaches do not typically consider the economic value of RPA. To increase the effectiveness and value of RPA for organizations across various industries, there is need for a generalizable and easy-to-understand evaluation methods that can effectively demonstrate the value of RPA and assist organizations to make informed decisions about the business case.

1.2 Defining Robotic Process Automation

The emergence of digitalization has transformed the way organizations operate, and many have started digital transformation initiatives or at least planned for them (Kirchmer, Franz, Lotterer, Antonucci & Laengle 2016). The emergence of new digital tools presents opportunities for organizations to enhance their business sustainability. These tools enable the transformation of business processes to become more efficient, flexible, compliant, customer-focused, and of greater quality. RPA is one such digital enabler that has been applied or at least discussed in many organizations.

The literature suggests that the primary objective of RPA is to replace human tasks in business processes with software bots that interact with front-end systems in a similar way to human users. There are two different viewpoints regarding the nature of these software bots. Some definitions suggest that the bots are rule-based (ACCA Global 2015; Accenture 2016; Deloitte 2017; Geyr 2015; Lacity & Willcocks 2016a; Lacity, Willcocks & Craig

2016), primarily performing repetitive, high-volume, lengthy, mundane tasks (The Institute for Robotic Process Automation 2015), while others argue that the bots are trained with data and are advanced, complex, flexible, and adaptable to different circumstances (ACCA Global 2015; Deloitte 2015). In both cases, the software is leveraged to deliver business processes, including IT services (ACCA Global 2015). Only a few definitions (Lacity, Willcocks & Craig 2015; Lacity & Willcocks 2016b; The Institute for Robotic Process Automation 2015) considered the steps towards performing RPA in the definition, which is implied by the term "automation," indicating a process rather than an artifact.

From a technical perspective, RPA executes tasks based on simulating keyboard and mouse controls (Asatiani & Penttinen 2016). RPA performs best with regular, rule-based, high-volume tasks, that require employees to take inputs from one type of system, process it in a rule-based manner, and enter corresponding outputs into other types of systems (Willcocks, Lacity & Craig 2015a). More specifically, the robot can log into applications, copy and paste data, extract and process structured or semi-structured content from documents, scrape data from the Internet, or perform calculations (Wanner, Hofmann, Fischer, Imgrund, Janiesch & Geyer-Klingeberg 2019). According to the Institute for Robotic Process Automation (2015), RPA technology is not part of a company's information technology infrastructure but rather sits on top of it. In contrast to traditional automation solutions, RPA does not require changes to applications but can be adapted to a wide range of application interfaces (Grung-Olsen 2017). Hence, it can be used to automate back-office activities in different industries and application contexts without the need for application programming interfaces (API) (Asatiani & Penttinen 2016; Penttinen, Kasslin & Asatiani 2018).

RPA is positioned within a field of other concepts, as shown in Figure 1. While RPA is typically considered to be more rule-based and structured than artificial intelligence, cognitive automation, or expert systems (Agaton & Swedberg 2018; Olvasrud & Boulton 2022; Lacity & Willcocks 2016a; Lacity, Willcocks & Yan 2015; The Institute for Robotic Process Automation 2015) it may also incorporate these techniques as a part of its capabilities (Aggarwal, Modi & Bhadola 2018). However, The Institute for Robotic Process Automation (2015) indicates that RPA could be more aware and adaptable to change. Opposed to traditional software, which communicates with other IT systems via the back-end RPA integrates with its frontend to mimic human tasks by reacting to events on a computer screen. This entails that RPA projects focus on frontend automation and not backend automation. (Asatiani & Penttinen 2016; Penttinen et al. 2018) The creation of software robots can be achieved through different methods, such as programming or configuring them using a graphical user interface. Macro-like recordings can also be utilized to set them up. More advanced techniques include self-learning systems or machine learning, that enable the analysis of recorded employee activities to learn automatable tasks. (Wanner et al. 2019)

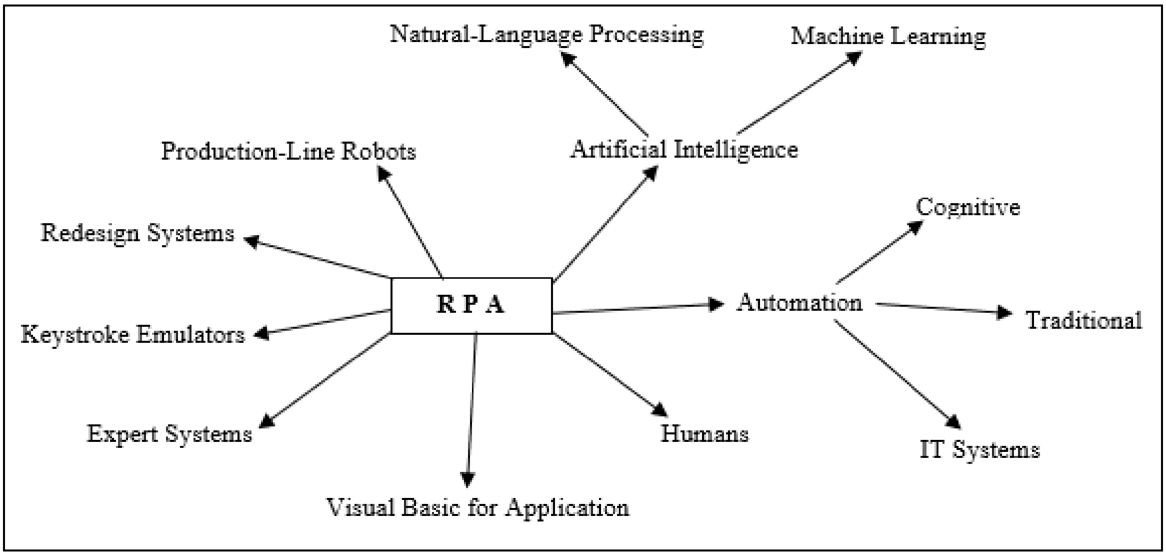


Figure 1. An RPA-centric graph showing the fields that RPA is compared with in literature (Syed et al. 2020).

RPA is about to become a mainstream trend relevant to many businesses. Despite the existence of a large number of RPA vendors and products in the market, there remains much hyperbole around what RPA represents for organizations, as well as uncertainty about how to successfully utilize this technology. According to newer statistics as many as 30–50% of RPA initiatives fail completely (EY 2016). The selection of RPA solutions through vendor and consultant guidelines and frameworks may not always provide unbiased recommendations. At the same time, academic research in the area has only recently begun to rise. A Google Trends Analysis shows that RPA only started to gain popularity (score: 25/100) in March 2017 but reached a score of 100 by September 2018, suggesting a peak in interest in the term. Hence, it is an appropriate time to assess the literature on RPA and to become aware of the gaps in our knowledge on successfully applying RPA. (Syed, Suriadi, Adams, Bandara, Leemans, Ouyang, ter Hofstede, van de Weerd, Wynn & Reijers 2020)

In this study, RPA is seen as a quickly evolving and rule-based process automation method that uses software robots to perform repetitive, long, large-scale, and routine tasks, thereby aligning with the viewpoints of ACCA Global (2015), Accenture (2016), Geyr (2015), Lacity et al. (2016), Lacity and Willcocks (2016a) and Deloitte (2017). It is important to note that robots typically do not automate complete end-to-end processes but only sub-processes or certain tasks thereof. Consequently, this research distinguishes processes referring to end-to-end or sub-processes, and tasks referring to individual activities within a process. An RPA investment might yield the automation of one process, or one or multiple tasks respectively.

1.3 Foundational Framework of the Research

The field of RPA research is relatively new, but it is rapidly growing as the technology becomes more widely adopted. The literature on new and emerging technologies often focuses on the potential benefits and advantages of the technology. This focus is understandable as it is what typically drives interest and adoption among organizations. On the other hand, this does not always provide a comprehensive understanding of the technology and its impact. Given the hyperbole around what RPA represents for organizations, as well as uncertainty about how to successfully utilize the technology, this study was motivated by the recognition that there is a need to provide a more comprehensive understanding of RPA investments.

After conducting an initial investigation into the literature on RPA, it became evident that a major reason behind RPA project failure is the incorrect automation of processes, often resulting from the absence of objective methods for evaluating the technology and selecting suitable process candidates. Based on this finding alone, it was assumed that there may be a gap in the literature on evaluating RPA investments. To verify the assumption, a logically progressive four-step approach was carried out to ensure that no prior research had been conducted on the assumed research gap at this stage. The first step involved defining appropriate terms for database searches using the best available information to ensure the highest chance of discovering existing academic evidence on the topic. Following this, in the second phase, the previously defined terms were utilized to conduct database searches. The third phase comprised a manual review of the academic literature obtained from the database searches, including analysis of titles, abstracts, and keywords. In the final stage, an individual assessment of each article's contribution to the research was conducted, and reference lists were carefully reviewed to identify new relevant sources.

Various databases, including Ebsco (Business Source Complete and Academic Search Complete), Elsevier (Science Direct and Scopus), Emerald eJournals, Springer Link eJournals, Primo Central Index, and Wiley Blackwell Online Library, were utilized in the second step of the approach described above. The database searches were carried out using with a focus on the concept of Robotic Process Automation. In addition, key terms such as (1) “ex-ante”, “pre”, “predict”, “forecast”, “future”, and “advance”, and (2) “profitability”, “evaluate”, “assessment”, “analysis”, “estimate”, “assess”, “measure”, “appraisal”, and “identify” and their various forms were used. After conducting a thorough review of the existing literature, it was apparent that a consensus existed on the need for comprehensive but easily understandable methodologies to solve complicated evaluation problems resulting from the complexity of evaluating RPA investments. Only four approaches (Aguirre and Rodriguez 2017; Geyer-Klingeberg, Nakladal, Baldauf & Veit 2018; Viehhauser & Doerr 2021; Wanner et al. 2019) were found that directly addressed the ex-ante evaluation of RPA investments. However, these approaches overlooked objectivity and generalizability. This lack of research on the topic motivated the present study to reduce the gap in the research. Next, the foundation of the study that has been formed through the described searches will be briefly summarized to provide context information for the literature review and help to guide the focus of the research.

The existing literature indicates that RPA has gained widespread adoption in businesses due to its potential benefits (Hindel, Cabrera & Stierle 2020; Statista 2023; Vitharanage, Bandara, Syed, Toman 2020). RPA’s main benefits are said to include efficiency improvements due to higher transaction volumes, shorter throughput times, and fewer delays (Kroll, Bujak, Darius, Enders & Esser 2016; Institute for Robotic Process Automation 2015; Leno, Dumas, Maggi & Rosa 2018; Ortiz & Costa 2020; Simek & Sperka 2019; Willcocks, Lacity & Craig 2015a; William & William 2018), which also improves availability (Anagnoste 2017; Carden, Maldonado, Brace & Myers 2019; IRPA 2015; Jimenez-Ramirez, Reijers, Barba & Del Valle 2019; Kroll et al. 2016, Slaby 2012; Syed et al. 2020). RPA is also associated with cost benefits, including higher returns on investment and shorter payback periods, as well as a reduction of quality, compliance, and FTE-related costs (Lacity

& Willcocks 2016b; Kroll et al. 2016, 13, Anagnoste 2017; Slaby 2012; Deloitte 2017; Lacity and Willcocks 2015; Radke, Dang, Tan 2020; Willcocks, Lacity, & Craig 2017; Cooper 2019; van der Aalst, Bichler, and Heinzl 2018; Beetz & Riedl 2019; Teli & Prasad 2020). Quality and compliance improvements are reportedly achieved through better transparency and documentation, promotion of process standardization, and adherence to predefined rules (Dey & Das 2019; IRPA 2015; Kroll et al. 2016; Lacity & Willcocks 2015a; Lacity & Willcocks 2016b; Leno et al. 2018; Ma, Lin, Chen, Chu & Chen 2019; Radke et al. 2020; Syed et al. 2020; Willcocks et al. 2015a).

RPA also improves scalability and flexibility, with easy configuration, modularity, and reusability of RPA components, enabling quick reactions to change conditions (Geyer-Klingeberg et al. 2018, Hofmann, Samp & Urbach 2020; Santos, Pereira & Vasconcelos 2020; Syed et al. 2020; Willcocks et al. 2017). The literature has also mentioned high interoperability with other application systems as well as lower implementation efforts (Aguirre & Rodriguez 2017; Enriquez, Jimenez-Ramirez, Dominguez-Mayo & Garcia-Garcia 2020; Hindel et al. 2020; Lacity et al. 2015; Ortiz & Costa 2020; Penttinen et al. 2018; Slaby 2012; Willcocks et al. 2017). Furthermore, RPA promises both higher employee and customer satisfaction and higher service quality, as employees are steadily relieved from mundane tasks and can turn to more creative and value-adding activities (Anagnoste 2017; Cooper 2019; Dey & Das 2019; Doguc 2020; IRPA 2015; Kroll et al. 2016; Lacity et al. 2015; Radke et al. 2020; Siderska 2020; Slaby 2012; Wewerka & Reicht 2020; Willcocks et al. 2015a; William & William 2019).

Despite the promised benefits, it is generally known and acknowledged that RPA investments typically fail to deliver the expected cost savings. According to a study by EY (2016), a leading RPA consultancy, 30-50% of RPA projects fail to meet expected profit levels. One major reason for this is the incorrect automation of processes (Rutaganda, Bergström, Javashekar 2017), often resulting from the absence of objective methods for evaluating RPA ex-ante (Viehhauser & Doerr 2021; Meironke & Kühnel 2022). The characteristics of RPA-suitable tasks are widely spoken about in the literature, but the economic value of the automation potential is not typically considered (Syed et al. 2020). It has also been suggested that traditional investment valuation metrics, such as return on investment (ROI) (Brealey & Myers 1988; Luehrman 1997; Myers 1974) and net present value (NPV) (Mills, Rowbotham, & Robertson 1998; Stewart 1991) may not be sufficient to fully capture the impact of new technology adoption on an organization's strategic direction and non-financial benefits. Short-term financial results are often prioritized, while qualitative factors like quality improvement and flexibility enhancement are overlooked. This approach may lead to missed opportunities for technological advancements that are not immediately reflected in financial metrics but can have a significant long-term impact on organizational success (Kim & Sanders 2002).

It is generally understood that the difficulty of evaluating RPA ex-ante is linked to the intangible characteristics of the benefit promised by the technology. RPA brings certain benefits that are difficult to measure or even unmeasurable, as well as some unpredictable benefits that may be revealed only after a certain period of use of the technology. In fact, there are numerous factors that can lead to imprecise ex-ante estimations of benefits and cost savings. It is under this kind of vague and imprecise information that an ex-ante evaluation must be performed when evaluating the potential profitability of RPA. This means that the methods used in the profitability analysis of RPA investments should be able to take into consideration the estimation inaccuracy. As stated above, RPA has been evaluated previously in some papers (Aguirre and Rodriguez 2017; Geyer-Klingeberg, Nakladal, Baldauf & Veit 2018; Viehhauser & Doerr 2021; Wanner et al. 2019). However, to the best of the authors' knowledge, no papers have considered the profound uncertainty and imprecision of different forecasts used when evaluating RPA investments. As such, this work makes a unique contribution by discussing this aspect.

Using cash flow scenarios is a widespread practice of modeling inaccurate and uncertain future outcomes, such as cash flows (Collan and Heikkilä, 2011), and it can also be applied to RPA investments. The idea with scenarios is that different future scenarios are thought out according to different future states of the world and cash flows or values connected to these states are estimated. Creating scenarios for RPA investments can be done based on the available information about the future. This information need not be precise because the scenarios allow for even a very wide variation of states of the world/value. In addition to quantifiable measures, the information used in creating the scenarios can come from qualitative sources as well. Usually, three scenarios are drafted for an investment: best guess, optimistic, and pessimistic. The information to support creating the scenarios can come directly from experts, most often from within the firm itself, from system vendors (with regards to the costs), and from external consultants. The scenarios reflect how the value of

RPA will fare under the most likely future circumstances and under better-than-expected and worse-than-expected states. It is commonly understood that any outcomes between these scenarios are possible. The scenarios approach is also compatible with and used in the valuation of other new technology investments.

The (fuzzy) pay-off method, introduced by Collan et al. (2009a) and further extensively presented in Collan (2012), is an easy-to-use and understand analysis method that is based on using value scenarios for building a pay-off distribution of the asset under analysis. The method is specifically designed for the valuation and analysis of investments that suffer from difficulties in the accurate estimation of timing and the size of the cash flows and allow for wide margins of uncertainty. Fuzzy logic is an established way to express imprecision precisely, and a usable tool also when the size of more or less vague benefits of an RPA investment will be evaluated. In this study, special interest is put in taking into account the profound uncertainty and imprecision of different forecasts used when evaluating RPA investments.

1.4 Focus of the Research

The primary objective of this thesis is to address the high failure rate of RPA investments by reducing the existing research gap on the ex-ante evaluation of RPA profitability. The study aims to contribute to the academic research on RPA by identifying the underlying factors that contribute to this gap and proposing a new theoretical framework to bridge it. By doing so, this paper can provide valuable guidance to organizations looking to embark on RPA initiatives. The pay-off method (Collan 2009) is presented in this study, and its suitability on ex-ante evaluation of RPA profitability is empirically evaluated based on information gathered from current literature and existing case studies. These objectives are addressed by answering the research problem and its sub-questions, which have been formulated based on the previously presented research objectives and the academic research conducted during the study. By addressing these questions, the study aims to provide a fresh perspective on RPA research and enhance the understanding of the factors that influence RPA profitability and its successful evaluation.

<u>Research Problem:</u>

(1) Developing a framework for an ex-ante evaluation of RPA profitability.

<u>Sub-Questions:</u>

(1) What are the challenges of evaluating RPA profitability ex-ante?

(2) What requirements can be found for a successful ex-ante evaluation of RPA profitability?

(3) What makes the pay-off method suitable for an ex-ante evaluation of RPA profitability?

The focus of this study is on developing a generalizable and easy-to-understand framework that can assist organizations to make informed decisions about the business case for RPA and to increase the effectiveness and value of the technology for organizations across various industries. This study shows how such a framework and valuation of RPA investments can be enhanced with the help of the pay-off method. Three numerical examples of how the pay-off method can be used in evaluating the RPA profitability are presented. These examples will be based on figures formed by the author, which although not based on real data but have been designed to be as realistic as possible. The formation of these figures will be explained in more detail later in the study, providing transparency and clarity on the assumptions and methodologies used. This will allow readers to understand how the framework can be applied in practice and how it can be adapted to different scenarios.

To be able to demonstrate transparency and honesty in the research process, as well as acknowledge any potential weaknesses or gaps in the study that may impact its validity or generalizability, it is important to acknowledge certain limitations. The main focus of this study is not on taking a stance on various RPA techniques, solutions, or tools, but rather on examining the overall connection between elements and the ex-ante profitability evaluation of RPA, based on the original RPA philosophy. Additionally, while there are existing methods and research on identifying processes that are suitable for RPA based on factors like volume and complexity, this study does not delve deeply into this aspect of pre-assessment. However, it is critical to understand the characteristics that make a process suitable for RPA to accurately evaluate its value ex-ante. The study assumes that if a process is unsuitable for RPA, it will not be profitable. Hence, the framework presented in this study assumes that the process suitability has already been assessed based on their characteristics before evaluating the economic value of RPA using the framework.

Another limitation of this study is that it does not discuss other approaches for evaluating RPA investments and their suitability in comparison with the framework developed in this research. Although the new framework is intended to provide a standardized approach to quantify and compare the automation potential of process tasks, there may be other methods that are equally effective or even superior for this purpose. For instance, some existing methods may focus on assessing the value of RPA implementation by considering factors such as system compatibility and process stability. Other methods may use machine learning algorithms to predict the automation potential of process tasks based on historical data. By not comparing the developed method with other available methods, the research may have limited its potential to provide comprehensive guidance on the ex-ante evaluation of RPA investments. Therefore, future research should explore the limitations and assumptions of the developed method and compare it with other available methods to provide further guidance for organizations.

The present study does not address the contentious debates surrounding the potential productivity gains that result from investments in RPA. While some studies suggest substantial productivity gains from the implementation of RPA, others argue that these gains may be limited or non-existent in certain contexts. The focus of this study is on developing a framework for evaluating RPA investments, rather than determining the actual value of these kinds of investments for organizations. As such, the study does not address the conflicting arguments regarding productivity gains from RPA investments but addresses the hypothesis that a more advanced profitability analysis method is needed to solve the complicated evaluation problem resulting from the complexity of measuring RPA investments.

The contributions of this research are threefold. First, it provides managers with insight into the complexity of evaluating and justifying RPA investments. Secondly, the research identifies the basic components of RPA values that can be used to justify an RPA investment, thereby providing a basis for valuing RPA in terms of economic value. And lastly, a four-step framework for ex-ante evaluation of RPA profitability is developed, which not only supports organizations in decision-making during process selection but also helps them to identify the processes and implementation strategies that yield the highest returns on investment. By providing a new perspective on evaluating RPA investments, it is hoped that this study will contribute to the continued advancement of knowledge in this important and rapidly evolving area and provide practical guidance for organizations considering implementing RPA initiatives.

1.5 Relation of the Research to Other Scientific Fields

This study aims to address the lack of previous research on pre-evaluating the value of RPA. By positioning itself at the intersection of various scientific fields, including finance, technology, and management, this paper aims to create a foundation for this new area of research. To achieve this aim, the present study utilizes results from the finance field by applying an existing investment analysis method, the pay-off method developed by Collan et al. (2009a), to the evaluation of RPA. The research methodology has been chosen from the field of technology, which complements the research on RPA in a favorable way. The application of research results from the fields of management and projects can also be seen as bringing significant benefits to the research on RPA in the future.

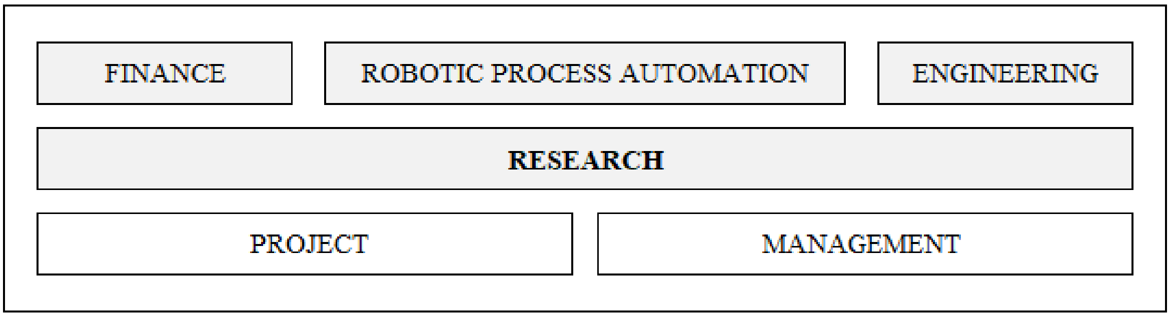


Figure 2. The interdisciplinary connections of the present study in various scientific fields.

This paper aims to contribute to the growing body of knowledge on RPA by examining how previous studies in this field can inform the development of the ex-ante evaluation framework. By combining insights from various scientific fields, this research aims to provide a comprehensive understanding of the potential benefits and limitations of valuing RPA investments.

1.6 Structure of the Paper

The structure of the paper is organized as follows: The next section discusses previous literature on the challenges and requirements for successful ex-ante evaluation of RPA profitability and introduces the pay-off method used in the analysis. Then, empirical research is conducted by studying existing case studies to address the challenges and requirements identified in the literature review. Based on the insights gained from the literature and case studies, a four-step framework is presented and yet illustrated using numerical examples based on realistic (but not real) figures. The formation of these figures will be explained in more detail when the solution proposal is introduced. Finally, the last section concludes the paper, further discusses the possible limitations and presents a set of recommendations for future research.

2 Literature Review

Literature reviews are important activities in scientific research, which aim to provide the synthesis of existing knowledge and support a research agenda. The goal of this literature review is to increase understanding of the factors behind the research gap and to create a new theoretical basis for reducing it. The following literature review consists of two separate sections.

The first sub-chapter of the literature review focuses on the challenges and requirements of ex-ante evaluation of RPA profitability. It is based on 29 previously published academic articles, which were found by conducting database searches and reviewing their results in the same way as the previously conducted database searches in sub-chapter 1.2 to confirm the existing research gap. The articles found in the previous database searches are also used in this part. The database searches were carried out using search terms that always included the term “Robotic Process Automation”. In addition, also the following key terms were used: “management”, “philosophy”, “implementation”, “project”, “investment”, “traditional investment method”, “successful”, “challenge”, “profitability”, “performance”, “efficiency”, “profit”, “cost”, “saving”, “potential”, “benefit”, “impact”, “effect”, “strategic”, “operational”, “financial”, “economic value”, “financial value”, “value” and “literature review”.

The second sub-chapter presents the pay-off method based on a review of 22 previous academic publications that discuss the method. The search for relevant literature was conducted using the search term "the pay-off method" in a manner consistent with previous searches conducted in this study. The author believes that this literature review covers the relevant academic literature on the systematic use of the pay-off method within the limitations of this study. The review also includes a book on the pay-off method by Collan (2012), which offers a more comprehensive overview of the method than other academic literature. The author considers this source to be a crucial primary reference for the study, as it was authored by the developer of the method. By including this literature review, the study aims to provide a comprehensive understanding of the pay-off method and its applications in the context of RPA investment evaluation.

2.1 Ex-Ante Evaluation of RPA Profitability

This part of the literature review focuses on the ex-ante evaluation of RPA profitability. It is divided into two parts. The first part examines the challenges of evaluating RPA profitability, including the factors that have contributed to the emergence of a research gap in this area. The second part focuses on the requirements of successfully evaluating the profitability of RPA ex-ante. The author has objectively selected relevant academic literature based on the previously described database search and has organized this literature into Table 1 in chronological order. The table includes the titles and objectives of the studies, and it is provided in appendices (Appendix 1).

2.1.1 Evaluation Challenges

The use of RPA has gained significant attention in recent years as a means of improving business efficiency and reducing costs (Hindel et al. 2020; Vitharanage et al. 2020). Based on those expectations, RPA has become widely adopted in businesses and industries with growing market revenue (Statista 2023). However, many of these promises lack traceable assessment or evaluation. RPA benefits are often cited from one author to another without providing further credentials (Hindel et al. 2020). This can lead to companies making misguided investments and failing to realize the full potential of RPA in their processes (Meironke & Kühnel 2022). Consequently, it is crucial to get a picture of RPA-specific benefits and associated metrics, indicators, and evaluation methods, as, e.g., Vitharanage et al. (2020) also state in their paper. First, in this sub-section, the difficulties of measuring the benefits of RPA are explored. Then, the limitations of traditional approaches to RPA and the importance of considering the broader strategic implications of RPA to fully realize its potential are discussed.

<u>The Difficulty of Measuring RPA Benefits</u>

The success of RPA projects can depend on a variety of factors, such as the complexity of the processes being automated, the level of integration with other systems, and the availability of skilled personnel to implement and maintain the automation (Syed et al. 2020). Often these factors vary from organization to organization and differ from each other given specific business contexts. As a result, it can be difficult to accurately forecast the potential cost savings and productivity gains that RPA can deliver (Meironke & Kühnel 2022). Furthermore, inaccurate value predictions can have a number of implications for the organization implementing the technology (Kim & Sanders 2002; Meironke & Kühnel 2022). For example, if the prediction overestimates the value of RPA, the organization may end up investing more in the technology than it ultimately yields in terms of cost savings and productivity gains. This could lead to financial losses and a negative return on investment. On the other hand, if the prediction underestimates the value of RPA, the organization may not invest enough in the technology, which could result in missed opportunities and potential competitive disadvantages. (Kim & Sanders 2002) Inaccurate predictions of RPA value can also impact decision-making and strategic planning within the organization (Lacity & Willcocks 2016b).

The benefits of RPA are typically measured in terms of reductions in time, cost, error, and human resources (Syed et al. 2020). However, it is important to consider that RPA benefits are not limited to these direct and tangible outcomes (as stated in sub-chapter 1.2) and that intangible benefits should also be considered when evaluating RPA investments. Tangible benefits refer to the measurable and quantifiable outcomes of RPA, such as cost savings and time savings. On the other hand, intangible benefits refer to the non-measurable and non-quantifiable outcomes of RPA, such as improved employee satisfaction and benefits from organizational change. (Koi-Akrofi 2017; Syed et al. 2020) While tangible benefits are important, they are often insufficient to fully capture the value of RPA investments. This is because tangible benefits often point to short-term corporate gains, and do not fully capture the long-term strategic benefits of RPA. The justification of intangible benefits can be challenging since they are often difficult to define and measure. Hence, the difficulty of measuring benefits should be carefully considered when constructing a new method for evaluating the profitability of RPA. It is also important to note, that intangible benefits are usually strategic, requiring some time for benefits to be realized (Koi-Akrofi 2017), and therefore, managers should not rush to get immediate results, but rather consider a long-term perspective when evaluating the benefits of RPA.

The Limitations of Traditional Approaches to RPA

Traditional investment analysis methods, such as ROI and NPV, have been widely used to evaluate the potential value of new technology adoption (Shank & Govindarajan 1992), such as those utilizing RPA. However, these traditional approaches have limitations when it comes to evaluating the potential of RPA. One major limitation is that traditional methods often fail to address important issues such as the impact of RPA on an organization's strategic direction (Kim & Sanders 2002). This is significant because RPA can have a transformative effect on an organization, enabling it to achieve greater efficiency and competitiveness (Hindel et al. 2020; Vitharanage et al. 2020). However, if the strategic implications of RPA are not fully considered, organizations may be at risk of poor selection decisions and project failure (Meironke & Kühnel 2022). Another limitation of traditional investment analysis methods is that they tend to focus on tangible benefits, such as cost savings, rather than less tangible benefits, such as improved customer and employee satisfaction (Shank & Govindarajan 1992; Kim & Sanders 2002). However, these less tangible benefits can have a significant impact on the success of RPA projects and the long-term value of RPA for an organization. To overcome the limitations of the traditional approaches, organizations should consider using more comprehensive evaluation metrics that consider the broader strategic implications of RPA and the less tangible benefits it can provide.

2.1.2 Evaluation Requirements

Since RPA is a relatively young field, the advice and recommendations for successful RPA adoption come in the form of lessons learned, guidelines, best practices, and experience reports of RPA implementations within organizations. From the analysis of the 34 publications with subjects related to RPA benefit realization, the themes that emerged included advice about various considerations that one should take into account before embarking on an RPA journey to discussions about how to choose suitable tasks for automation, and RPA life cycle management. The advice and recommendations found in the literature are from 4 different dimensions, aligning with Syed et al. (2020), namely (1) Organizational Readiness Assessment, (2) RPA Task Selection (3) Stakeholders' Buy-In, and (4) Active Development and Management of Benefits. Based on the dimensions, the author developed requirements for the framework. By incorporating these requirements, the tool aims to help organizations navigate the complexities of RPA adoption and achieve successful outcomes.

Organizational Readiness Assessment

Several studies have suggested that the benefits of new technology investment, such as RPA, primarily arise from the accompanying organizational change rather than directly from the technology itself (Peppard & Ward 2005; Hughes & Scott-Morton 2006). The organizational environment in which the project takes place is likely to have a significant impact on the attitudes and actions of the project team and wider stakeholders (Koi-Akrofi 2017). As such, more mature RPA adopters tend to show higher levels of satisfaction with their RPA returns. To achieve RPA maturity, a company must have the necessary resources, including funding and skilled personnel, to support and proceed with RPA deployment (ACCA Global 2015). Furthermore, when RPA is deployed in customer service areas, the company's customers also need to be ready and able to respond to the required technical requirements (Syed et al. 2020).

To be able to identify the potential opportunities and barriers, and optimize their resource utilization to achieve strategic objectives, organizations require guiding frameworks for the successful adoption of RPA. Each organization should be able to incorporate data, evaluation techniques, personal experience, personal knowledge, corporate or departmental politics, personal desires, and intuition in its evaluation process, for the fact that these are a range of input information required for the RPA evaluating process. (Syed et al. 2020) This promotes the uniqueness of each firm in terms of the process. As different characteristics (such as their execution frequency and length, the number of involved departments and stakeholders, and their variability in inputs and outcomes) influence a process's automation potential, RPA is not a one-size-fits-all solution but rather demands careful analysis and informed decision-making (Geyer-Klingeberg et al. 2018).

RPA Task Selection

The selection of initial tasks for RPA is an important aspect of the implementation process. Hence, companies must obtain a detailed understanding of their processes to ensure sufficient economic value and the overall success of their RPA initiatives (Geyer-Klingeberg et al. 2018). The literature suggests that a staged roll-out approach, starting from a pilot stage before scaling up to other processes, is often the most effective way to implement RPA in an organization to avoid the project from becoming too complex, time-consuming, and more expensive than originally intended. (ACCA Global 2015; Deloitte 2015; EY 2016; Fung

2014; Hallikainen, Bekkhus & Pan 2018; Anagnoste 2017; Alberth & Mattern 2017; Accenture 2016; Slaby 2012; Asatiani & Penttinen 2016; Lacity, Willcocks & Craig 2015; Lacity & Willcocks 2016c; Tornbohm & Dunie 2016). The roll-out of RPA is a complex process that requires careful planning and execution. This approach involves identifying a small number of low-risk tasks to automate initially, with the goal of gradually increasing the scope of automation over time. Additionally, it is important to note that performing an opportunity assessment is a recurring theme in the literature (Jalonen 2017; EY 2016; Seasongood 2016; Tornbohm & Dunie 2016). The Institute for Robotic Process Automation (2015) and Accenture (2016) also suggest that end-to-end automation of a process should be the next step after small, low-risk tasks have been automated. This approach is consistent with the nature of RPA, as the inherent risk of RPA, due to the lack of human oversight and the large scale at which bots can be rallied, means that it is better to start small.

Stakeholders' Buy-In

Another focus on the literature about RPA methodologies is the need to engender the buy-in of all stakeholders, from top-level management to end users, to ensure the success of an RPA project (Hallikainen et al. 2018; Lacity & Willcocks 2016a). The starting point of an RPA project should be to consider relevant stakeholders and how the investment will benefit them. This focus on benefits for customers and stakeholders is increasingly important as RPA is no longer just about automating internal processes and replacing people with technology but is also at the core of the delivery of products and services (Anagnoste 2017; Cooper 2019; Deloitte 2017; Dey & Das 2019; Doguc 2020; Hallikainen et al. 2018; IRPA 2015; Kroll et al. 2016; Lacity et al. 2015; Lacity & Willcocks 2016a; Olvasrud & Boulton 2022; Radke et al. 2020; Siderska 2020; Slaby 2012; Wewerka & Reicht 2020; Willcocks et al. 2015a; William & William. 2018). Stakeholders' buy-in can also help to ensure that RPA projects align with the overall goals and objectives of the organization. A report by ACCA Global (2015) raises the concern that CFOs may not fully appreciate the benefits of RPA compared to those closer to the process, and that it is important to demonstrate the value-added benefits of RPA in terms of how it is transformative for the organization, rather than just as a generic tool deployment.

Active Development and Management of Benefits

Active development and management of RPA benefits are crucial for organizations looking to maximize the value of their RPA investments and achieve their strategic objectives. It is important to note that benefits from new technology investment, such as RPA, are not outcomes that automatically occur (Lin & Pervan 2003; Markus 2004), and organizations must take a proactive approach to ensure that the potential value of their RPA investments is fully realized. RPA is an ongoing process, and existing automation should be regularly improved and upgraded, and new ones initiated and developed. Additionally, benefits from RPA investments will only be realized if they are measured and managed systematically. Therefore, organizations must be able to effectively monitor and evaluate the results of their RPA projects on an ongoing basis to ensure that their ability to deliver business value improves over time. Also, Ward and Daniel (2006) argue that organizations should not stop trying to leverage the benefits of a piece of business software once it has been implemented. The full potential of a particular application may not become apparent until it is fully operational, and the stakeholder community has gained experience using it (Eason 1988; Markus 2004). In this regard, the ability to work with new information is particularly crucial when assessing the value of RPA investment (Marchand et al., 2000; Davenport et al. 2001).

2.1.3 Need for A New Method

The evidence from the literature explains the need to identify and justify how RPA can contribute towards achieving diverse corporate strategies such as cost reductions, efficiency, higher service quality, and better compliance. However, there are many issues that may cause the ex-ante estimates of benefits and cost savings to be quite imprecise and complex to measure, and therefore the traditional evaluation metrics are not suitable for this kind of evaluation. As exposed to Meironke and Kühnel (2022), this research seeks to provide the development of missing RPA evaluation frameworks, thereby answering the research problem that has not adequately been addressed yet. It is understood that new comprehensive but easily understandable evaluation frameworks are needed to solve the complicated evaluation problems resulting from the complexity of measuring RPA benefits. Fortunately, there are applicable novel methods that may be used for the analysis as a part of such a framework. Therefore, the pay-off method (Collan et al. 2009a) will be discussed in the next sub-chapter of this study.

2.2 The Pay-Off Method

Next, in this second subsection of the literature review, the pay-off method is examined in more detail. This subsection is divided into two parts of which the first review the pay-off method and the corresponding investment analysis process. The idea of this section is to form a comprehensive overview of the method and its operations. After that, the second part provides an in-depth review of the previous academic literature on the use of the pay-off method. Because the method is relatively new, its prevalence is still quite limited. This review will focus on reviewing the academic publications that are within the scope of the study and systematically address the pay-off method. The aim of the review is to provide a deeper understanding of the possibilities of the method, by mapping out what it has been applied for in the past and what research results have been obtained based on these.

2.2.1 Description of the Pay-Off Method

The pay-off method, which was developed by Collan et al. (2009a), is a real option valuation technique that utilizes fuzzy logic, a mathematical system that was first introduced by Zadeh (1965) to deal with imprecision in a precise manner. Similar to the Datar-Mathews approach (Matthews, Datar & Johnson 2007), the pay-off method involves creating a set of cash flow scenarios, including a minimum, best guess, and maximum scenario, based on expert opinions, and calculating the cumulative cash flows for each scenario. This generates a triangular probability distribution of fuzzy numbers, which encompasses the best guess NPV (representing the most likely outcome), the maximum NPV (representing the highest possible outcome), and the minimum NPV (representing the lowest possible outcome). The pay-off distribution provides simple and informative key figures, including the real option value, success ratio, and standard deviation, which can help decision-makers compare the profitability of different investments. Crucially, the pay-off method does not rely on the rigid assumptions of perfect markets, instead, it is based on subjective managerial opinions and expertise, which makes it applicable in real-life situations. (Collan et al., 2009a)

The most commonly used profitability analysis methods, such as NPV and ROI, typically rely on a one-scenario approach that only considers the most likely numbers. However, incorporating additional scenarios into the analysis can provide greater insight into the impact of different situations. The pay-off method uses a pay-off distribution created from three or four cash flow scenarios. By using these scenarios, the pay-off method can account for a range of less probable variables that would not be included in a single scenario analysis. As a result, investment analysis using the pay-off method provides a wealth of information that goes beyond what is available from models based on only one scenario.

When future cash flows of RPA investment are estimated, all the relevant information that affects the outcomes of the investment needs to be gathered. In the absence of market data, cash flows often need to be constructed by taking an expert opinion on the investment cash flows: their size and timing. A typical question from a manager to an expert in terms of RPA investment may read: "What are the potential benefits and cost savings that can be expected from implementing RPA in the organization? The emphasis of this type of question is on the potential cash inflows and outflows associated with implementing RPA in an organization. Specifically, the focus is on understanding the potential benefits and cost savings that can be achieved through RPA, which would result in increased cash inflows or reduced cash outflows. The uncertainty concerning future cash flows can be considerable which is why it must not be overlooked. In this paper, to tackle the estimation uncertainty, the author has respected this by allowing information on three different scenarios of the (both cost and benefit) future cash flows of RPA to be used in the framework. Identifying relevant cash flows for RPA investment and an explanation of their formation will be done step-by-step later in sub-chapter 3.3.3 when the solution proposal is presented.

By asking organizations to consider different scenarios, constraining them to create averages that may be misleading is avoided. As a result of collecting expert opinions on cash flows, one gets cash flow scenarios like in the example shown in Figure 3. To consider the risk involved in these estimates and their implementation, a discount rate can be used to calculate the NPV of future cash flows in profitability analysis. The discount rate should be higher for the revenues, than for the costs. Investment analysis using the pay-off method can be based on any method that provides the necessary information. The three scenarios in Figure 3 represent the full range of possible NPVs for the investment and offer more information than a single scenario alone. In addition, the estimates from this example are utilized in further examples throughout this sub-section.

OPERATIONAL CASH FLOW SCENARIOS

	0	1	2	3	4	5	6
maximum	100,00	400,00	400,00	400,00	400,00	400,00	400,00
best guess	50,00	300,00	300,00	300,00	300,00	300,00	300,00
minimum	0,00	200,00	200,00	200,00	200,00	200,00	200,00

INVESTMENT COST CASH FLOW SCENARIOS

	0	1	2	3	4	5	6
maximum	1000,00	100,00	0,00	0,00	0,00	0,00	0,00
best guess	960,00	0,00	0,00	0,00	0,00	0,00	0,00
minimum	900,00	0,00	0,00	0,00	0,00	0,00	0,00

PRESENT VALUE SCENARIOS OF THE OPERATIONAL CASH FLOWS

	0	1	2	3	4	5	6
maximum	100,00	347,83	302,46	263,01	228,70	198,87	172,93
best guess	50,00	260,87	226,84	197,25	171,53	149,15	129,70
minimum	0,00	173,91	151,23	131,50	114,35	99,44	86,47

PRESENT VALUE SCENARIOS OF THE INVESTMENT COST CASH FLOWS

	0	1	2	3	4	5	6
maximum	1000,00	95,24	0,00	0,00	0,00	0,00	0,00
best guess	960,00	0,00	0,00	0,00	0,00	0,00	0,00
minimum	900,00	0,00	0,00	0,00	0,00	0,00	0,00

CUMULATIVE NET PRESENT CASH FLOW SCENARIOS FOR THE INVESTMENT

	0	1	2	3	4	5	6
maximum	-800,00	-452,17	-149,72	113,29	341,99	540,86	713,79
best guess	-910,00	-649,13	-422,29	-225,03	-53,51	95,65	225,34
minimum	-1000,00	-921,33	-770,10	-638,59	-524,24	-424,81	-338,34

Figure 3. A simple three cash flow scenario net present value analysis with the minimum possible, the maximum possible, and the best guess scenarios, citing Collan (2012, 14).

Aggregating the present value (PV) scenario information by adding for each year the optimistic scenario cash flows for costs and revenues and doing the same for the best guess and the pessimistic scenarios the PV for the investment will be obtained. The optimistic scenario is a combination of the PV of the maximum operational cash flows and the minimum investment cost cash flows. Conversely, the pessimistic scenario is a combination of the minimum operational cash flows and the maximum investment cost. The cumulative

PV for all three scenarios is calculated to determine the range of possible outcomes and the most likely outcome. The graphical representation of the cumulative PV for each scenario highlights the difference between the maximum and minimum possible scenarios and the relationship between the best guess scenario, the maximum, and the minimum scenarios. Figure 4 is a graphical presentation of the cumulative PV scenarios for the data in Figure 3. The cumulative PV for the scenarios over the estimation horizon is the scenario NPV.

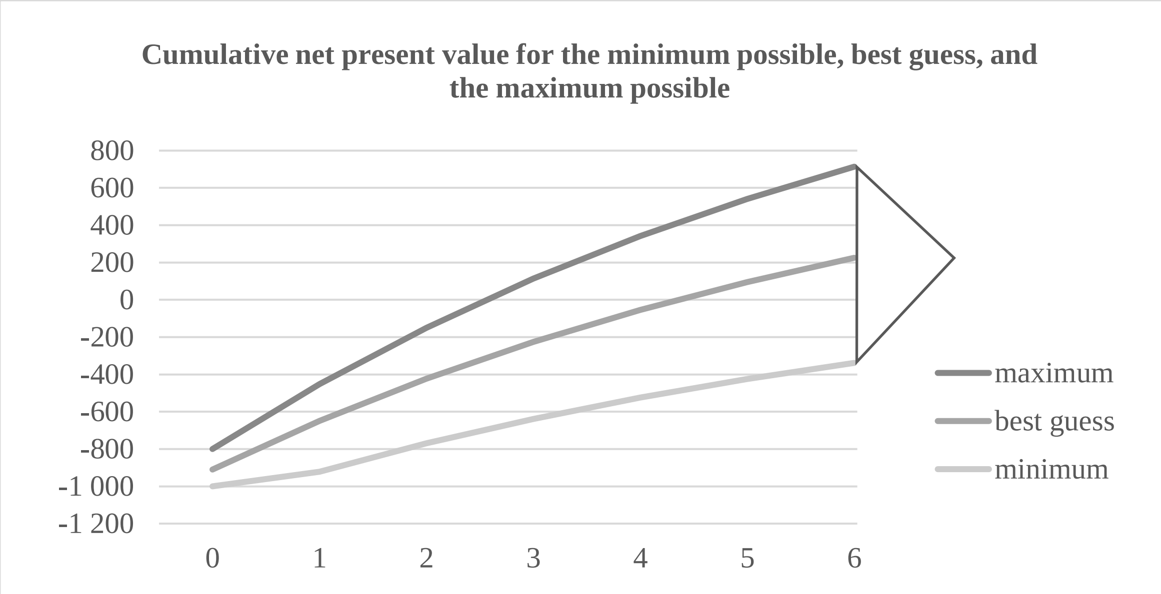


Figure 4. Cumulative net present values of three scenarios using the pay-off method, citing Collan (2012, 17).

Using the NPV of the three cash flow scenarios is a simple NPV distribution, that is, a pay-off distribution for the investment. Firstly, this is done by observing that the best guess scenario is the most likely one and assessing it full membership 1 in the set of possible outcomes. Secondly, the maximum and minimum scenarios are the upper and lower bounds of the distribution and have 0 membership in the set of possible values. Therefore, values near the peak of the distribution are the most probable, while the minimum and maximum values are the least probable. Any values that fall outside the minimum and maximum scenarios are disregarded. Although this assumption may not be very accurate, the simplification does not jeopardize the reliability of the results which remain at a good enough level. Thirdly, it is assumed that the shape of the pay-off distribution is triangular. These three steps allow us to easily construct the triangular pay-off distribution, based on three scenarios constructed for the RPA investment needed and presented later in the study.

The pay-off distribution is a graphical presentation of all possible NPVs that the investment can take and can be represented vertically or horizontally. It illustrates the potential profit, expressed in the currency used for the investment, that could be attained by investing in the project. A triangular pay-off distribution can be treated as a triangular fuzzy number, commonly denoted as (*a, α, β*).

<u>*Definition 1*</u>. A triangular fuzzy number is defined as:

$$\begin{cases} 0 \text{ if } x < a - \alpha \\ 1 - \frac{a-t}{\alpha} \text{ if } a - \alpha \le x \le a \\ 1 - \frac{t-a}{\beta} \text{ if } a \le x \le a + \beta \\ 0 \text{ if } x \; > a + \beta \end{cases}$$

This type of number can be described by identifying the minimum, maximum, and best guess cumulative NPVs of the distribution as (a-α), (a+β), and (a), respectively. It is then possible to determine the distance between the best guess and the maximum NPV (β) and the distance between the best guess and the minimum NPV (α). Using this information, a triangular pay-off distribution that corresponds to the fuzzy number (a, α, β) can be constructed. The creation of a simple pay-off method, as shown in Figure 5, allows a visual inspection of what the investment profitability looks like. It shows how much of the distribution lies above positive NPV values and how much above the negative values. This is very important information for supporting the decision-making of the investment.

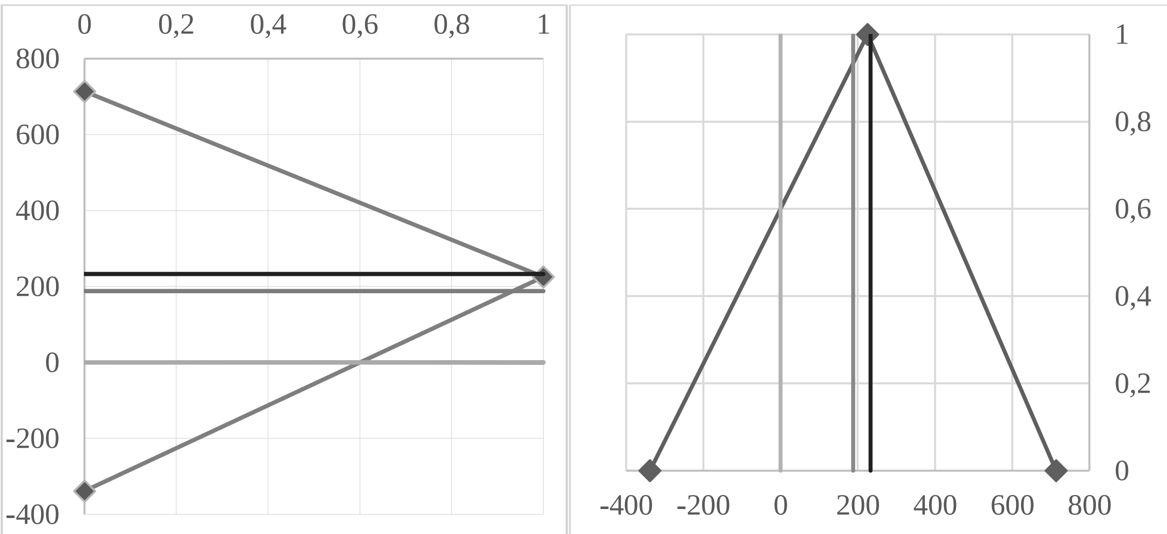


Figure 5. Example of a vertical and horizontal pay-off triangle, citing Collan (2012, 18).

Defining a triangular fuzzy number is particularly useful since it enables precise mathematical operations to be performed on it. Most of the time visual inspection alone is not satisfactory and more analysis of the investment profitability is required. For this purpose, single number descriptives that allow consideration of more detailed aspects of the investment profitability can be calculated. These descriptives, (1) mean NPV, (2) real option value, (3) a risk factor, and (4) success factor – are defined below.

a) Mean NPV gives a single number measure that takes into consideration the shape of the pay-off distribution. It is based on the area of the whole pay-off distribution including not only the best guess scenario but also the upside and the downside numbers. By comparing the mean NPV to the best guess NPV, the expectations with regard to the whole distribution of possible NPVs can be better understood. Mathematically the mean is called a possibilistic mean as it is dealt as a fuzzy number. This is calculated differently based on the values of the cash flow estimates:

   Definition 2. The possibilistic mean value for triangular fuzzy numbers:

$$E(A_+) = \begin{cases} a - \alpha > 0 \quad then\ E(A_+) = a + \dfrac{\beta - \alpha}{6} \\ a > 0 > a - \alpha \quad then\ E(A_+) = \dfrac{(\alpha - a)^2}{6\alpha^2} + \alpha + \dfrac{\beta - \alpha}{6} \\ 0 > a \quad then\ E(A_+) = \dfrac{(a - \beta)^2}{6\beta^2} \\ a + \beta < 0 \quad then\ E(A_+) = 0 \end{cases}$$

b) Real option value (ROV) is another single number descriptive for the distribution. It can be used as a measure of the value of the potential within the investment. The higher the ROV is the better. ROV can be defined as the possibilistic mean of the positive side of the value terrain weighted by the positive area of the pay-off distribution over the whole area of the pay-off distribution.

   Definition 3. Calculation of the ROV from a pay-off distribution

$$ROV = \frac{\int_0^\infty A(x)dx}{\int_{-\infty}^{\infty} A(x)dx} E(A_+)$$

ROV is calculated by dividing the area above the positive values of the pay-off distribution by the whole area of the distribution and multiplying this by the mean of the positive side of the pay-off distribution. The calculation of the mean of the positive side, E(A+) of the triangular pay-off distribution is presented in detail in Collan et al. (2009a).

c) The risk factor is the possibilistic standard deviation of the pay-off distribution as a measure of the overall risk of the investment. Standard deviation is a commonly accepted measure of financial risk. For the calculation of the possibilistic standard deviation, the method introduced by Carlsson and Fullér (2001) and Fuller and Majlender (2003) is used. It is to be observed, that the standard deviation is in absolute numbers, i.e., not as a percentage. A percentage of, e.g., the mean NPV can be easily calculated, and it is suggested that the risk factor % is to be calculated. The risk factor provides a numerical representation of what can be seen from the pay-off distribution, that is, it gives a numerical value to how widely the values in the distribution are spread on average. A broader distribution indicates higher risk, while a narrower distribution suggests lower risk.

Definition 4. The possibilistic standard deviation for a triangular fuzzy number:

$$Possibilistic\ standard\ deviation = \sqrt{\frac{(\alpha + \beta)^2}{24}}$$

$$Possibilistic\ standard\ deviation\ as\ a\ \%\ of\ the\ mean\ NPV = \frac{\sqrt{\frac{(\alpha + \beta)^2}{24}}}{E(A)}$$

d) The success factor is determined by calculating the percentage of the pay-off distribution that lies above zero profitability, representing the area of the NPV distribution on the positive side. To calculate the success factor, the area of the positive side of the pay-off distribution is divided by the area of the entire distribution, and the result is multiplied by 100% to obtain a percentage of the total distribution. The calculation is again simple due to the fact that a triangle-shaped pay-off distribution is used. A higher proportion of the distribution area falling over positive values indicates a more favorable outcome. The success ratio characterizes the likelihood of achieving a profitable investment and simplifies the comparison of investment alternatives with comparable NPVs.

Using the pay-off method to first create a triangular NPV distribution from the three scenario NPVs and then by calculating a single number descriptive to further support decision-making it is possible to offer smart decision-support to the difficult problem of ex-ante analyzing an investment. The pay-off method for real option valuation is very easy to use compared to the other real option valuation methods. It is adaptable to the way the profitability analysis is presently done in companies and can be used with the most commonly used spreadsheet software without any add-ins. The method is useful in the analysis for decision-making regarding investments that have an uncertain future, especially so if the underlying data is in the form of cash flow scenarios. The method is flexible and accommodates easily both one-stage investments and multi-stage investments (compound real options). The results from the method are clearly presentable, easy for everyone to understand, and do not hide inaccuracy or uncertainty. A more detailed description of the pay-off method and its mathematical basis can be found in Collan et al. (2009a) and Collan (2012).

2.2.1 Use of the Pay-Off Method

Collan, Fuller, and Mezei (2009b) employ the pay-off method to assess the probability of R&D investments and note that this approach allows for adjustments to estimates in response to changing information during the project's lifespan. Consequently, decision-making can be based on more realistic projections. Hassan, Collan, and Modarres (2012) utilize the method to develop a portfolio selection model for effective R&D valuation while addressing the issue of uncertainty in portfolio optimization. They posit that the pay-off method is suitable for R&D investment valuation, given its capacity to manage input data uncertainty and determine the optimal portfolio. Likewise, Collan and Luukka (2014) create a model based on the pay-off method to evaluate and compare R&D projects as investments. Stoklasa, Luukka & Collan (2020) extend the original pay-off method by presenting a new variant of the method for real option valuation. The new variant is comparatively analyzed with the original method and the use of the new variant is illustrated with a set of numerical examples including examples of R&D investment analysis.

Collan and Heikkilä (2011) show how patent valuation can be enhanced with the help of the pay-off method. The numerical valuation of patents is a difficult task due to great uncertainty regarding the future and inaccuracy in estimation. They find the pay-off method to be suitable for this since it is specifically designed for the valuation and analysis of assets that suffer from difficulties in the accurate estimation of timing and size of cash flows and allows for wide margins of uncertainty. In addition, Collan (2013) finds the method to be suitable also for evaluating intellectual property rights (IPR) as information about IPR is often imprecise. He shows how the method can be used as input in IPR scorecard analysis and how the analysis can benefit from using it. Collan, Fedrizzi, and Luukka (2013) use the pay-off method to create a decision support system that ranks patents based on multiple expert evaluations. They use a numerical example to show how the system works in practice. Similarly, Collan and Kyläheiko (2013) use the method in the valuation of forward-looking patent portfolios. They illustrate with a numerical example how the use of the pay-off method allows the valuation of strategic patent portfolios to be adjusted when more precise information arrives. This makes it possible for decision-makers to compare the pay-off distribution at two different times for information about the direction the value of the portfolio is taking and about the changes in the amount of risk that is connected to the portfolio value which has been difficult to identify in the past.

Collan (2010) presents how ex-ante analysis of large construction projects can be considered as compound real options and illustrates with a numerical example how the compound real-option valuation of a potential project can be performed by using the pay-off method for real-option valuation. By comparing the pay-off distributions from the different ways to implement the project it is possible to easily understand the value of these different involvement strategies and select the most profitable combination. Vimpari, Kajander, and Junnila (2014) recognize that the pay-off method can be used for assessing the monetary value of flexibility in real estate investments. They find the applicability of the fuzzy pay-off method in a practical investment case to be straightforward because the assignment of probabilities into different uncertainty scenarios is unnecessary. Kajander, Sivunen, and Junnila (2014) use the method to evaluate the life-cycle profitability of investments in indoor air quality. In the ex-ante analysis of the IAQ investments they use the potential cost savings of better IAQ as economic benefits and compare them to the costs of the ventilation system.

Collan and Kinnunen (2011) discuss how a rapid pre-acquisition screening of target companies can be performed with the pay-off method for real option valuation. The presented procedure can cope with highly inaccurate estimates of the future cash flows and hence is capable of handling the type of imprecise information often only available for the valuation of acquisition synergies and available generally for rapid type analyses. This real-options valuation approach was extended from fuzzy target analysis to a portfolio setting by Kinnunen and Georgescu (2013). Turek and Sojda (2013) recognize the possibility of the application of the fuzzy pay-off method in calculating the company value of mining enterprises. They find that, in particular, the method's ability to assess the risk associated with an uncertain industry makes it suitable for performing this type of calculation.

Collan (2011) analyzes the applicability of the pay-off method to the ex-ante evaluation of the probability of industrial giga-investments. With an example, he shows that the method is capable of supporting the decision-making of such an investment, both in the short and long term. According to him, these investments have a lot of special features and uncertainty about the future which can be met by the method. Additionally, Collan, Fedrizzi & Luukka (2016) illustrate how triangular fuzzy numbers are very suitable in modeling the insurance of giga investment projects as it allows for the estimation of imprecision and the value of managerial flexibility. They demonstrate how the method can be used to determine the optimal coinsurance rate in a group possibilistic framework and contribute to the project insurance pricing literature.

Collan, Kyläheiko, and Björk (2014) propose a three-step methodology for ex-ante profitability evaluation of an information systems investment using the pay-off method. They note that such investments are difficult to assess due to imprecise data on benefits and costs. The pay-off method is used in the analysis to enable decision-makers to recognize the perceived imprecision in the analysis, both in terms of costs and benefits, thereby facilitating decision-making. Collan, Fedrizzi, and Luukka (2014) also evaluate the applicability of the pay-off method to large industrial investments, but they deepen the research by examining the use of the method to estimate the profitability of these investments for stakeholders. Hietanen, Kozlova, and Collan (2020) analyze renewable energy support designs in the context of auction-based support mechanism implementation. The results show that the process is relatively simple to use and able to produce intuitively understandable relevant information for design selection.

In summary, the pay-off method's ability to handle uncertainty and adapt to new information during the life of a project makes it a popular choice for decision-makers. In addition to the previous applications presented in this section, the pay-off method has been used directly or adapted for the valuation of real options by Collan, Fullér, and Mezei (2012) and Rodger (2013). While the pay-off method has been widely employed in the field, the specific aspect of its use in the valuation of real options is not further examined in this study. Based on the academic literature reviewed in this sub-section, a summary of the characteristics and purposes of the pay-off method is provided in Table 2 below.

Table 2. Summary of the key features and purposes of the pay-off method based on previous academic research.

THE PAY-OFF METHOD																						
REFERENCE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
CHARACTERISTICS OF THE METHOD																						
- generizable	•	•	•	•	•	•	•	•		•					•					•	•	•
- easy to use and easy to understand	•	•	•	•	•	•	•	•		•					•					•	•	•
SUITABILITY OF THE METHOD																						
- is suitable for forming an evaluation that can be practically implemented	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
- is suitable for pre-evalaution of profitability	•		•	•		•				•	•				•	•	•	•	•	•	•	•
- is suitable for estimating difficult-to-determine returns and costs	•		•	•	•	•				•					•	•	•	•		•	•	•
- is suitable for forming a quick preliminary assessment					•	•				•												
- is suitable for estimating based on inaccurate and limited information	•		•	•	•	•	•		•	•					•	•	•	•		•	•	•
- is suitable for estimating based on expert opinion						•			•	•	•	•				•			•			
- is suitable for estimating with significant uncertainty on the outcome	•		•	•	•	•	•		•	•			•	•	•	•	•	•	•	•	•	•
is suitable for estimating that can be updated if necessary		•	•	•		•				•						•				•		
LIMITATIONS OF THE METHOD																						
- is unlikely to be suitable for in-depth analysis.					•	•				•												

(1) Collan, Fullér & Mezei (2009a); (2) Collan, Fullér & Mezei (2009b); (3) Collan (2010); (4) Collan (2011); (5) Collan & Kinnunen (2011); (6) Collan & Heikkilä (2011); (7) Hassanzadeh, Collan & Modarres (2012); (8) Collan, Fullér & Mezei (2012); (9) Collan (2013); (10) Collan & Kyläheiko (2013); (11) Roger (2013); (12) Collan, Fedrizzi & Luukka (2013); (13) Kinnunen & Georgescu (2013); (14) Turek & Sojda (2013); (15) Vimpari, Kajander & Junnila (2014); (16) Collan, Kyläheiko & Björk (2014); (17) Collan & Luukka (2014); (18) Kajander, Sivunen & Junnila (2014); (19) Collan, Fedrizzi & Luukka (2014); (20) Collan, Fedrizzi & Luukka (2016); (21) Hietanen, Kozlova & Collan 2020; (22) Stoklasa, Luukka & Collan (2021)

The previous research has discussed the versatility and usefulness of the pay-off method in various contexts, as highlighted in Table 2. This summary serves as a foundation for evaluating the method's suitability in assessing RPA value in this study. Additionally, it provides a concise overview of the pay-off method and its applications for readers who wish to explore its use further in real options valuation.

3 Empirical Research

The successful implementation of RPA in organizations depends heavily on the accuracy of evaluating the profitability of such investments ex-ante. Comprehensive and easily understandable methodologies are needed to solve the complicated evaluation problems resulting from the complexity of evaluating RPA investment. In this empirical part of the study, a four-step framework is designed for the ex-ante profitability evaluation of RPA to assist organizations in evaluating and justifying RPA investments. The Design Science Research (DSR) methodology will be used to solve this main research problem.

3.1 Research Method

The focus of this first section of the empirical study is on examining the chosen research method, and it is divided into three sub-sections. The first sub-section aims to provide a comprehensive examination of the research methodology chosen for the study. The second sub-section delves into the research method selected for data collection and introduces the method used in analyzing the collected data. Finally, the third and final sub-section critically evaluates the reliability of the research to ensure its validity and credibility. By examining the research methodology and methods used in the study, this section seeks to establish a strong foundation for the research findings and conclusions.

3.1.1 Methodology

This empirical part of the study was carried out during the latter half of 2022 and the beginning of 2023. The research methodology selected for the study is Design Science Research (DSR) Methodology. The goal of the DSR research project is to push the limits of human and organizational capabilities by creating new and innovative artifacts represented by constructs, models, methods, and instantiations (Hevner et al. 2004; Peffers, Tuunanen, Rothenberger & Chatterjee 2007; Gregor & Hevner 2013). It aims to create knowledge about how things can be designed or arranged to achieve specific goals. This knowledge is referred to as design knowledge (DK), and it is typically generated through the use of human agency.

For example, in the context of the Information Systems (IS) discipline, DK can include knowledge of how to structure and construct database systems, model business processes, align IS with organizational strategy, and use data analytics for effective decision-making (Becker, vom Brocke, Heddier & Seidel 2015). Additionally, DK can also involve using information technology to support sustainable practices (Seidel, Recker & vom Brocke 2013; vom Brocke & Seidel 2012). DSR is a highly impactful research approach in the IS discipline, leading to significant economic and societal benefits. Its results have helped organizations to improve their operations and decision-making processes, leading to increased efficiency and effectiveness (Gregor & Hevner 2013; vom Brocke, Watson, Dwyer, Elliot & Melville 2013).

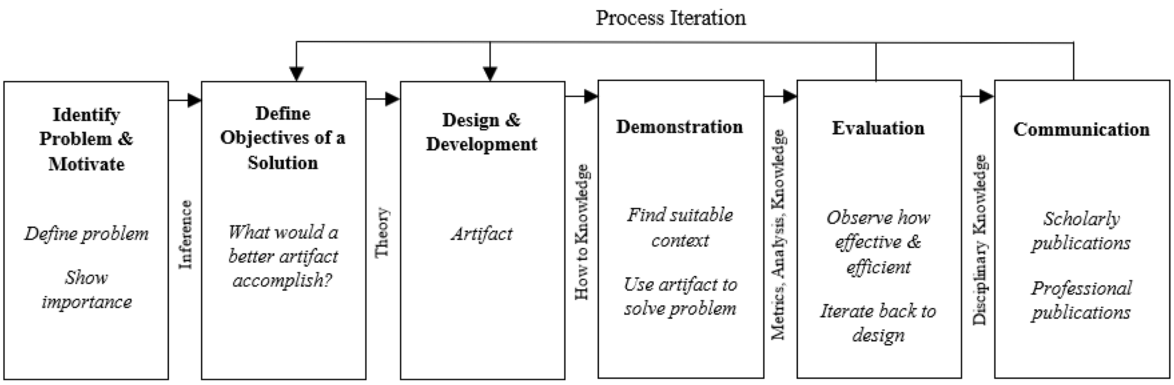


Figure 6. DSR Methodology Process Model (Adapted from Peffers et al. (2007)).

Mitroff, Betz, Pondy, and Sagasti (1974) recognize in their article that academic problem-solving does not have a clear-cut form. Because of this, the methodology used in this study was implemented by selecting only the essential parts of the original model. The methodology is visually presented in Figure 6, which will subsequently be discussed in more detail. The presented model also constitutes the empirical structure of this study, which is presented in the same context.

This research, according to its methodology, began with the identification of a practical problem, based on which a research gap in academic literature was also identified. This phase is described in more detail in the introduction chapter of this paper. Based on this, the author of the study created a conceptual model of the problem situation in her mind. In this model, the structure of the research problem was identified, and decisions about what things are significant for its solution and what are not were made during this process. Based on the perspectives selected on the basis of these decisions, the modeling of the objectives according to the methodology of the research has begun. Initially, a theoretical literature review of this research has been formed. It clarifies the relationship of this research to previous academic literature and what assumptions and bases it has to offer for this research. After this, based on the conceptual model and literature review, previously conducted case studies have been examined, and the research data analyzed using the Grounded Theory (GT) (Glaser & Strauss 1967) method is presented on the basis of these studies. This approach allows for the integration of the insights and findings from the case studies into the research and provides a more comprehensive understanding of the problem and the proposed solution.

Based on the conceptual model of the research, the literature review, and the case study data, a coherent understanding of the challenges and requirements necessary for implementing the profitability analysis of RPA has been formed. From this, it has been observed that the pay-off method developed by Collan et al. (2009a) appears to be applicable to the profitability assessment of RPA to a significant extent. Therefore, there has been no need to construct a completely new scientific model in the research, but rather, the original pay-off method is being adapted into a tool for this kind of assessment. This approach has the advantage of leveraging existing knowledge and expertise in the field, while also allowing for the incorporation of insights and findings from the research into the tool. Overall, the pay-off method is expected to provide valuable insights and a comprehensive understanding of the profitability of RPA. It is believed that this method will support the goals and objectives of the research and provide a useful tool for decision-making in the field of RPA.

Finally, the developed framework for addressing the research problem has been successfully demonstrated and evaluated. The framework’s effectiveness was demonstrated by its ability to facilitate the resolution of the identified research problem, and its evaluation included an assessment of its usability, functionality, and overall effectiveness. The results of the evaluation have been reported, discussed, and interpreted, allowing for a comprehensive understanding of the tool's contributions and limitations. Furthermore, effective communication of the study's findings has been achieved through the development of robust conclusions that summarize the key takeaways of the research. The conclusions drawn from the study provide a concise and accurate overview of the research problem, methodology, and results, allowing for an easy-to-digest summary of the study's key contributions.

The choice of data collection and analysis methods in the research and how they support the chosen methodology are justified in the following section. The selection of these methods was guided by the aim of the research and the nature of the problem being studied. The chosen methods are expected to provide valuable insights and a comprehensive understanding of the problem and the proposed solution.

3.1.2 Data Collection and Analysis

The method chosen for data collection in this research is a qualitative case study. The case study method was chosen as the research strategy because it is seen as the best way to support the resolution of the research problem due to its revealing nature. The Grounded Theory method (Glaser & Strauss 1967) was chosen as the data analysis method for this qualitative research because it is seen as the best way to support the methodology's aim of deepening the understanding of the problem and the previously unexplored factors behind it. The method's ability to provide a thorough explanation of the case, for which there is no existing theoretical and organized knowledge, also supports the choice. Among other factors, the Grounded Theory method is seen as suitable for forming models that correspond to reality. Therefore, it is believed to support the methodology and goals of this research very well (Strauss & Corbin 1990). The use of the Grounded Theory method is expected to provide valuable insights and a comprehensive understanding of the research problem.

3.1.3 Reliability and Validity

To assess the reliability of a qualitative research study, it is essential to evaluate the implementation of the research in order to determine its credibility. In this study, the aim is to focus on this aspect and carefully evaluate the implementation of the research. This evaluation is conducted in the above sub-chapters that discuss the methodology and data collection and analysis methods, as well as in the conclusion chapter where it will be reflected on the contributions and limitations of the research. By carefully assessing the reliability of the research it can be ensured that the results and conclusions of the study are credible and can be trusted (Hirsjärvi, Remes, Sajavaara 2007, 231).

In evaluating the reliability of qualitative research, the concept of right or wrong data does not apply. Instead, the validity and reliability of the research are used to assess its reliability and reproducibility. Validity can be evaluated in terms of internal and external validity. The conduct of the research should be thorough and careful to ensure the trustworthiness of the research results. However, it is not necessary to strive for perfection, as this can hinder the potential for discovering new knowledge. Over-conservatism can often lead to risk aversion, which can also hinder the creation of new knowledge (Koskinen, Alasuutari & Peltonen 2005, 253-259). This research aims for a logically progressing research process and comprehensive reporting. The researcher also strives for neutral and objective behavior throughout the research and accurately describes the decisions made and the underlying factors. Overall, the validity and reliability of the research can be considered to be in good shape. In the following sections, these aspects of this specific research will be delved deeper into.

Internal and external validity are important considerations in conducting research. Internal validity refers to the internal logic and consistency of the interpretation of the research, while external validity refers to the generalizability of the interpretations of the research to cases other than the one studied in this research (Koskinen et al. 2005, 253─259). In a few-case case study, the results can only be cautiously generalized, and for this reason, the importance of internal validity is emphasized in this study. The researcher aims to work systematically and consistently, and to accurately describe the research in the reporting. The chosen methodology and methods also support this work, by allowing for a comprehensive description of the research process. In the analysis of the data, the same main categories are used throughout the research process, allowing for the comparison of the data and the detection of inconsistencies. In addition to existing literature, data has been collected from previously conducted case studies to ensure that there are no interpretive errors in the analysis of the literature data.

These measures, which aim to focus on external validity, can also have a significant impact on the reliability of the research. In this study, reliability refers to the degree of consistency, or how well the research can be replicated (Koskinen et al. 2005, 253─259). As previously mentioned, this study emphasizes comprehensive reporting, focusing on detailed descriptions of the implemented measures and the underlying factors. The chosen methodology also strengthens the reproducibility of the research, as it allows for a comprehensive description of the steps of academic operations research. The overall picture of this study, based on this methodology, allows for the replication of this research, either based on the collected data or by collecting similar data from other cases. Therefore, the reliability of this research can be seen as being of a reasonably good level.

3.2 Examining Case Studies: Factors Affecting RPA Profitability Evaluation

In this second section of the empirical research, the information collected from previously conducted case studies is presented with the aim of increasing understanding of the factors that influence evaluating the profitability of RPA ex-ante. This is done based on the finding from the literature review. The collected information is grouped according to the Grounded Theory method, into three main categories: (1) Evaluation Challenges, (2) Evaluation Requirements, and (3) The Need for A New Method.

The present study involves an examination of six case studies that focus on the challenges encountered during RPA projects. These case studies, conducted by Aguirre and Rodriguez (2017), Asatiani and Penttinen (2016), Lacity and Willcocks (2016b), Lacity et al. (2015), Schmitz et al. (2019), and Willcocks, Lacity, and Craig (2015b), shed light on the experiences of three highly automated businesses that offer outsourcing services in the domains of insurance (Xchanging), finance (OpusCapita), and CRM-systems (anonymous), as well as Deutsche Telekom, Telefonica O2, and one of Europe's largest utilizing companies (anonymous - bAN) in the telecommunications sector. Despite taking several preparatory steps to initiate RPA projects, such as defining objectives, selecting a software provider, and establishing a Center of Excellence (Lacity et al. 2015a; Schmitz et al. 2019), all companies began their RPA projects by collecting processes before proceeding to the process task selection phase for RPA automation.

3.2.1 Evaluation Challenges

The evaluation of the profitability of RPA can be a challenging task, as revealed by the findings of the case studies. In all the case companies examined, the objective was to use RPA to reduce the number of full-time employees (FTEs) and thereby save costs or allocate resources to more complex and creative tasks. However, the increased productivity resulting from the capacity of human resources saved from repetitive tasks was not measured. Prior to the implementation of RPA, most companies subjectively estimated the potential savings based on their individual experiences and opinions. It was only after the completion of the project that the actual savings were evaluated by measuring the reduction in throughput time for the automated process tasks (e.g. Lacity & Willcocks 2016b).

Out of these six case companies, only two conducted a more thorough assessment of the potential savings and costs of RPA. At Deutsche Telekom, the RPA team estimated potential savings and costs for each process candidate and conducted workshops with stakeholders from various departments to enhance their understanding of each task's characteristics. Similarly, bAN identified processes or tasks that had the potential to reduce costs by up to 200% compared to manual performance within a year. The assessment included both fixed and variable costs such as software licenses, hardware, IT service costs, and RPA staff. The company measured RPA benefits using metrics such as FTE avoidance, FTE redeployment, and FTE savings, and also considered throughput time and salaries of process tasks, and organizational overhead costs (Lacity et al. 2015).

A lack of indicators ensuring measurability and comparability was encountered. It was found that standardized tools were not used by any of the case companies to select the most appropriate process tasks for RPA. Instead, a wide set of highly individualized measures were used to attempt to quantify the automation potential of their process tasks. In particular, it was observed that a lack of adequate measures could yield low decision quality, eventually risking the success of the entire venture, as demonstrated by the cases of bAN and Xchanging (Lacity et al. 2015; Willcocks et al. 2015b). Companies that used measurable indicators such as complexity and execution frequency achieved better results, as demonstrated by Asatiani and Penttinen (2016), Lacity and Willcocks (2016b), and Schmitz et al. (2019).

In summary, most companies estimated potential savings in a subjective manner based on individual experiences and opinions, without considering the increased productivity resulting from human resources saved from repetitive tasks. Better results were achieved in the companies that conducted a more thorough assessment of the potential savings and costs of RPA. This suggests that accurately predicting the profitability of RPA can be a challenging task but conducting a precise assessment can lead to a better understanding of RPA benefits and costs. By considering a wide range of factors, including intangible effects (increased productivity, customer satisfaction, etc.), organizations can better understand the potential benefits and costs of implementing RPA and make more informed decisions.

3.2.2 Evaluation Requirements

The findings on the critical factors in predicting the profitability of RPA have been collected based on the examined case studies using the same themes as in section 2.1.2 of the literature review. These themes include (1) Organizational Readiness Assessment, (2) RPA Task Selection, (3) Stakeholders' Buy-In, and (4) Active Development and Management of Benefits.

<u>Organizational Readiness Assessment</u>

As stated in the literature review, the implementation of RPA in an organization can have significant impacts on its operations, but these impacts will depend heavily on the specific circumstances of the target organization. All of the case studies revealed that the success of an RPA project is not guaranteed but rather depends on a thorough understanding of the current state of the organization and its operations. While the overall idea of RPA is simple, for example, it was stated in Asatiani and Penttinen (2016) that OpusCapita devotes time to evaluation, analysis, and planning. Proper implementation of an RPA requires identifying inefficiencies in the organization's operations and selecting the most appropriate processes for automation. Therefore, having a method to identify the most profitable tasks is essential for project success. Additionally, understanding the current state of the organization is a necessary prerequisite for setting goals and intentions for the RPA implementation and developing a plan to achieve them. All of the case companies utilized the services of an external consultant to assess their RPA readiness. In this way, an external consultant can provide valuable support for organizations in achieving their RPA goals.

<u>RPA Task Selection</u>

All of the case studies agreed that one of the most important steps in implementing RPA is the selection of processes to be automated. When processes are selected correctly, automation can be implemented on schedule, the payback period for the investment is shortened, and the quality of work and satisfaction of employees improve. A common recognition in all case studies was that the implementation of RPA should start with a pilot before scaling it to broader organizational processes. For example, Lacity & Willcocks (2015b) argue that it may be beneficial to automate only part of the processes, rather than attempting to automate all processes at once. This can help organizations identify the most suitable tasks for automation and avoid automation of processes that are too complex or difficult to automate. Hence, it is essential to have a tool that can compare the value of different processes and implementation strategies, as well as the potential effects of phasing on the investment outcome.

Stakeholders' Buy-In

Five of the six case studies (Asatiani & Penttinen 2016; Lacity & Willcocks 2016b; Lacity et al. 2015; Schmitz et al. 2019; Willcocks et al. 2015b) indicate that the successful implementation of RPA requires the commitment and support of management and other key stakeholders within the organization. Without this support, the full potential of RPA may not be realized, and the project may be at risk of failure. For example, an interviewed provider of RPA services in Lacity et al. (2015) noted that the best results with RPA were achieved by customers who had strong support from top management. In these organizations, automation was seen as a key part of the culture of top management, and they actively supported the implementation of RPA. This support was most effective when RPA was understood to improve customer service and reduce costs. The return where much lower in organizations where the initiative to adopt RPA came from middle management with limited influence. In these situations, the lack of exponential growth in returns was largely due to the fact that the parties pushing for the adoption of automation did not have enough influence within the organization to move things forward. This highlights the need for top management to be fully committed to the success of the RPA project and to support its implementation. By presenting the value-adding benefits of RPA in a way that is understandable to everyone, the organization can view RPA as a change that is in line with its long-term goals.

Active Development and Management of Benefits

By examining the case studies, it was found that the automation potential of processes varies over time. Changes in processes, technologies, and organizational structures can impact the effectiveness of RPA in achieving its intended benefits. This is why Lacity et al. (2015) and Willcocks et al. (2015b) highlight the importance of continually improving the automated process to reap the greatest benefits from RPA. They suggest that if RPA projects are selected and managed appropriately over time, the short-term value realization can translate into the long-term strategic value of RPA. This is because RPA has the potential to free up resources and shift focus to value-creating activities, which can be beneficial for organizations in the long run. Furthermore, the transparency created by RPA can counteract the agency problem between the short-term benefit promises of consulting companies and the long-term strategic opportunities of their clients. Interestingly, while RPA is often sold on the premise of large savings on FTE costs, this did not emerge as a primary driver in Xchanging's case. Instead, Xchanging seemed to have a mature awareness of the multiple, even strategic payoffs that were possible through RPA adoption. In the view of Lacity et al. (2015), this gave RPA adoption dimensions of innovation, learning, and organizational acceptance, which were lacking in less successful cases. Furthermore, Schmitz et al. (2019) suggest that both an abstract and visual representation of how RPA will deliver value to the organization and its customers is a prerequisite for long-term success. Therefore, organizations using RPA must be able to effectively monitor and evaluate the results of their RPA projects on an ongoing basis to ensure that their ability to deliver business value improves over time. Managing benefits should not stop when the technical implementation of a project is completed. Instead, it should continue until each of the expected benefits has either been achieved or it is clear that it will not materialize. This requires organizations to have effective processes in place for monitoring and evaluating the results of RPA projects, as well as the flexibility to adapt and improve their RPA implementations over time.

3.2.3 Need for a New Method

The case studies clearly show that conducting reliable ex-ante evaluations is critical for the success of RPA projects. Unfortunately, many companies rely on the experiences of others and fail to conduct comprehensive pre-evaluations due to the difficulty of estimating less tangible benefits and the inadequacy of existing methods that do not consider the unique characteristics of RPA, such as its potential strategic effects. To accurately predict the profitability of RPA and ensure its success, new evaluation frameworks that comprehensively evaluate its potential benefits and account for its unique characteristics are needed. In the next section of the empirical study, the formation of such a framework is described, and a solution proposal is presented to address the problem. This is followed by a validation that has been carried out according to the chosen methodology.

3.3 Evaluation Framework Construction

This sub-section of the empirical study will describe the steps of the research process, according to the chosen methodology. The structure of this research has already been outlined, and this sub-section will follow that structure.

3.3.1 The Basis for Framework Construction

The theoretical and empirical data presented in this research will be used as the basis for the tool for predicting the profitability of RPA. Table 3 below presents the requirements for creating the tool and the sources from which they were identified.

Table 3. Summary of the challenges and requirements of ex-ante evaluation of RPA, as well as sources from which they have been identified.

	Measuring RPA benefits	Limitations of traditional approaches to RPA	Oraginzational readiness assessment	Selection of initial tasks
Literature Review	Hindel et al. (2020) Kim & Sanders (2002) Koi-Akrofi (2017) Lacity & Willcocks (2016b) Meironke & Kühnel (2022) Syed et al. (2020) Vitharanage et al. (2020)	Brealey & Myers (1988) Hindel et al. (2020) Kim & Sanders (2002) Meironke & Kühnel (2022) Mills et al. (1998) Shank & Govindarajan (1992) Stewart (1991) Vitharanage et al. (2020)	ACCA Global (2015) Geyer-Klingeberg et al. (2018) Hughes & Scott Morton (2006) Koi-Akrofi (2017) Peppard & Ward (2005) Syed et al. (2020) Willcocks et al. (2015a)	Accenture (2016) ACCA Global (2015) Geyer-Klingeberg et al. (2018) Hallikainen et al. (2018) IRPA (2015) Lacity et al. (2015) Tornbohm & Dunie (2016) EY (2016)
Case Studies	Aguirre and Rodriguez (2017) Asatiani and Penttinen (2016) Lacity & Willcocks (2016b) Lacity et al. (2015) Schmitz et al. (2019) Willcocks et al. (2015b)	Aguirre and Rodriguez (2017) Asatiani and Penttinen (2016) Lacity & Willcocks (2016b) Lacity et al. (2015) Schmitz et al. (2019) Willcocks et al. (2015b)	Aguirre and Rodriguez (2017) Asatiani and Penttinen (2016) Lacity & Willcocks (2016b) Lacity et al. (2015) Schmitz et al. (2019) Willcocks et al. (2015b)	Aguirre and Rodriguez (2017) Asatiani and Penttinen (2016) Lacity & Willcocks (2016b) Lacity et al. (2015) Schmitz et al. (2019) Willcocks et al. (2015b)

	Stakeholders' buy-in	Stages of roll-out	Active development and management of benefits	Need for a new method
Literature Review	Anagnoste (2017) Cooper (2019) Dey & Das (2019) Doguc (2020) Forrester Consulting (2014) Hallikainen et al. (2018) IRPA (2015) Kroll et al. (2016) Lacity & Willcocks (2016a) Lacity et al. (2015) Olvasrud & Boulton (2022) Radke et al. (2020) Siderska (2020) Slaby (2012) Wewerka & Reicht (2020) Willcocks et al. (2015a) William & William (2018)	Anagnoste (2017) Slaby (2012) Alberth & Mattern (2017) Accenture (2016) Asatiani & Penttinen (2016) EY (2016) Hallikainen et al. (2018) Jalonen (2017) Kämäräinen (2018) Lacity & Willcocks (2016c) Siguroardottir (2018) Seasongood (2016) Tornbohm (2016)	Davenport et al. (2001) Eason (1988) Lin & Pervan (2003) Marchand et al. (2000) Markus (2004) Ward & Daniel (2006)	Aguirre & Rodriguez (2017) Geyer-Klingeberg et al. (2018) Meironke & Kühnel (2022) Viehhauser & Doerr (2021) Wanner et al. (2019)
Case Studies	Aguirre and Rodriguez (2017) Asatiani and Penttinen (2016) Lacity & Willcocks (2016b) Lacity et al. (2015) Schmitz et al. (2019) Willcocks et al. (2015b)	Aguirre and Rodriguez (2017) Asatiani and Penttinen (2016) Lacity & Willcocks (2016b) Lacity et al. (2015) Schmitz et al. (2019) Willcocks et al. (2015b)	Aguirre and Rodriguez (2017) Asatiani and Penttinen (2016) Lacity & Willcocks (2016b) Lacity et al. (2015) Schmitz et al. (2019) Willcocks et al. (2015b)	Aguirre and Rodriguez (2017) Asatiani and Penttinen (2016) Lacity & Willcocks (2016b) Lacity et al. (2015) Schmitz et al. (2019) Willcocks et al. (2015b)

Next, the sources listed in the table will be used to formulate the starting points for the tool. These starting points will provide a solid foundation for the development of the tool, ensuring that it is comprehensive, reliable, and applicable to a wide range of organizations and processes. By considering the requirements and sources identified in Table 3, it will be possible to create a tool that effectively evaluates the profitability of RPA.

RPA is a rapidly growing technology that allows companies to automate repetitive tasks and processes. The profits of using RPA can be diverse because it can help companies save time and money by automating a wide range of tasks, from data entry and processing to customer service and more. Studies have shown that successful implementation of RPA can have positive effects on achieving organizational strategic goals, increasing staff productivity, and improving customer service. These benefits can be observed based on the profits and other benefits achieved through the use of RPA. While the assessment of these indirect effects of RPA can be difficult, their identification is crucial in understanding the full potential of the technology. By understanding the various ways in which RPA can benefit an organization, companies can make more informed decisions about how to implement and use the technology.

Effects of RPA are not limited to direct and concretely measurable results, as it can provide intangible benefits that are difficult to define in terms of monetary value. The literature review and case study data show that traditional methods do not take into account the strategic and less concrete advantages of RPA. As a result, their estimates provide incorrect information about the profitability of RPA. This can lead to incorrect investment decisions and the failure of the project being implemented. To address this issue, a tool is being developed to predict the profitability of an RPA project in advance. To be able to provide a realistic picture of the comprehensive effects of an RPA project, the tool should take into account both the strategic and intangible effects as well as the operational profits and costs. This is supported by several observations in the literature review, which show that there is currently no method for evaluating the effects of RPA that takes into account the indirect effects of RPA. This will enable companies to make more informed decisions about how to implement and use RPA technology.

The literature review of this study shows that the organizational climate and attitudes toward new technology significantly affect the success of an RPA project. Based on this finding, it can be concluded that if the positive effects of RPA can be presented clearly and concretely within the organization, the commitment of the staff and therefore the success of the project is much more likely. This is also supported by the observation in the literature review that the benefits achieved with new technology are primarily realized through organizational change, not directly from the technology itself. Therefore, a method is desired for evaluating RPA projects that make the results easily understandable and presentable to all stakeholders in the organization. This will enable companies to better understand the potential benefits of RPA and make more informed decisions about how to implement and use the technology. This is important because a positive organizational climate and attitudes towards new technology can help increase the chances of success for an RPA project.

The literature review of this paper and the examined case studies suggest that the implementation of RPA projects should begin with low-risk processes before moving on to automate more complex processes. This approach allows for the gradual integration of automation into the organization, reducing the risk of disruption and enabling the identification and addressing of potential issues early on. In order to properly evaluate the profitability of implementing RPA, it is important to have access to up-to-date information on the processes to be automated and the potential benefits of doing so. This information should be regularly updated to reflect any changes in the organization and its processes. Case studies also indicate that the need for process automation can vary over time, highlighting the importance of being able to adapt to changing circumstances. Once RPA has been implemented, it is important to regularly improve and develop automation to maximize its benefits. An RPA project is an ongoing process, and organizations that fail to keep up with advancements in automation may find themselves at a disadvantage. In order to track and evaluate the results of RPA over time, it is essential to have a tool in place that allows for continuous monitoring and analysis. This can help the implementing organization to improve its ability to produce value and stay ahead of the competition.

The literature review also highlights the observation that the impact of RPA varies greatly depending on the industry and the characteristics of the processes to be automated. This underscores the importance of conducting thorough analysis and making informed decisions when implementing RPA. Each company must be able to incorporate a wide range of data, including personal experience, knowledge, company policies, preferences, and intuition, into the evaluation process. To ensure that the evaluation tool is applicable to any organization, industry, or process, it is recommended that an external advisor works with the implementing organization to review all the data needed for the analysis at the outset of the evaluation process. This allows the advisor to use their expertise to develop a framework for predicting the profitability of RPA. A flexible evaluation tool that can be applied to any organization, industry, or process is essential for ensuring that RPA is implemented in a way that maximizes its potential benefits.

The evaluation criteria and methodology outlined in this research suggest that the pay-off method previously discussed in the literature review is well-suited as the basis for a tool for predicting the profitability of RPA. Instead of developing a completely new method, this research will focus on adapting the original pay-off method into a tool for conducting the evaluation. Researchers in the field of information systems have recommended the use of real option valuation methods for understanding and facilitating investment decisions related to new technologies. These methods not only provide information on the economic value of information technology but also on its indirect and strategic impacts. Therefore, adapting the pay-off method to incorporate real option valuation methods is likely to improve the reliability and comprehensiveness of the evaluation.

The pay-off method is an investment analysis model that includes real options valuation, which makes it suitable for predicting the value of indirect effects. However, this research will not address the real option valuation of the method according to its limitations. The choice of the pay-off method as the basis for this tool is also supported by observations in the literature review of this research, which suggest that new methods are needed for evaluating the feasibility of RPA. The next part of this section will examine the characteristics of the pay-off method that make it suitable as the basis for a tool for pre-evaluating the feasibility of RPA. In addition, the section will identify the characteristics of the original method that are not expected to bring additional value to this tool. By understanding the strengths and limitations of the pay-off method, it will be possible to adapt it in a way that maximizes its usefulness for evaluating the feasibility of RPA.

3.3.2 Method Suitability

The previous academic literature is very unanimous about the characteristics of the pay-off method and its suitable uses. The observations presented in this section are based on Table 3, which also shows the sources of the observations. Based on the previous use cases, the pay-off method can be seen to be particularly suitable for evaluations based on difficult-to-determine, imprecise, and limited information. Because the pay-off method is based on a set of assumptions and simplifications, it can be used to make estimates and predictions even when there is a lack of complete and precise information. This makes it useful in situations where the data is uncertain or limited, as is often the case in the evaluation of complex systems or technologies. Ex-ante evaluating the profitability of RPA can be seen as a case where the pay-off method would be particularly useful. Based on this, it can be concluded that the pay-off method is suitable for supporting the evaluation of such systems.

One of the main advantages of the pay-off method is its simplicity and ease of use. The results of the method are straightforward and easy to understand, making it accessible to all stakeholders regardless of their financial background. This is particularly important in the case of RPA investments, where all stakeholders need to understand the evaluation results and what RPA represents for the organization. Moreover, the pay-off method is a resource-efficient evaluation method that requires minimal effort and time to perform. The simplicity of this method means that the calculations can be done quickly and easily, saving time and resources. This is a significant advantage compared to other evaluation methods that are complex and time-consuming. The simplicity, ease of use, and resource efficiency of the pay-off method make it a good choice for evaluating RPA profitability.

The pay-off method has been successfully used in the past to make evaluations in conditions that are similar to those of RPA projects. The method has been applied in the evaluation of intangible rights and product development projects, among others, in which evaluations of the future have to be made based on imprecise and limited information. The framework to be constructed in this paper will also be used to conduct profitability assessments of RPA based on limited and imprecise information, which supports the selection of the method as its basis. Additionally, the pay-off method has been utilized for rapid initial evaluations, such as when choosing potential acquisition targets. This feature is seen as supporting the selection of the method as the basis for the framework with one of its uses being the quick formation of an evaluation of RPA investment during the decision-making phase. The pay-off method's ability to handle limited and imprecise information, as well as its use for rapid initial evaluations, make it a suitable choice for evaluating RPA investments.

The pay-off method is versatile in its ability to evaluate profits and costs, and to use these evaluations to make predictions about profitability. Its previous applications have demonstrated success in using both calculations and expert opinions as the basis for evaluations. This supports the use of the pay-off method as the basis for a tool that aims to provide a profitability assessment of RPA investments based on the expertise of an external advisor. Furthermore, the pay-off method has been used successfully in the past to evaluate potential savings as a measure of profit. This has been identified as the primary source of revenue for RPA projects based on the literature review and case data. The pay-off method's versatility and ability to handle different types of data make it a suitable choice for evaluating the profitability of RPA investments ex-ante.

The pay-off method is a flexible tool that can be tailored to an organization's specific circumstances and objectives. It can be used to evaluate the potential profitability of implementing RPA for a specific business process or a broader organizational initiative. In doing so, it can take into account a wide range of factors that may impact the returns of RPA, such as cost savings, productivity improvements, and enhanced customer satisfaction. By using the pay-off method, organizations can gain a more accurate and comprehensive understanding of the potential returns of RPA. This can provide a clear and transparent basis for decision-making, allowing organizations to compare the potential returns of RPA to other investment options and choose the option that offers the best potential payoff. In this way, the pay-off method can help organizations make informed and strategic decisions about the implementation of RPA.

The pay-off distribution resulting from a pay-off method-based assessment can provide valuable information for organizations considering RPA implementation. This distribution can be used to conduct a profitability assessment in a graphical and easily understandable form, making it an effective framework for evaluating the potential success of an RPA project. One of the key factors that have been identified as affecting the success of an RPA project is the commitment of upper management. This commitment is crucial for ensuring that the necessary resources and support are provided to the project, which in turn can greatly impact its outcome. The pay-off distribution resulting from the assessment can help to demonstrate the importance of this commitment by providing the organization with an estimated outcome of the RPA project in terms of profitability if no commitment is made. In addition, the assessment based on the pay-off method has also been shown to be easily updatable based on previous applications. For this reason, the profitability assessment based on the pay-off method can be used to set goals for the entire RPA project if it is implemented.

In this way, the pay-off method can be seen as supporting the factors underlying the development of the tool developed in this paper.

While the pay-off method is a commonly used and generally effective approach to evaluating the profitability of a business venture or investment, it is not without its limitations. The pay-off method is a static approach that does not take into account potential changes or developments of new better technologies over time. In the case of RPA, the technology is rapidly evolving and there may be significant changes or improvements in the future that could impact the profitability of RPA. The pay-off method does not account for these potential changes, which can make it less suitable for evaluating the long-term profitability of RPA.

3.3.3 Proposed Solution

In this section, a solution proposal for the research problem of developing a tool for evaluating the profitability of RPA ex-ante is presented according to the methodology of the study. The proposed solution framework is visualized in Figure 7 below.

1	**EFFICIENCY NUMBERS**	#		
	# of bots			
	# of processes			
	# RPA transactions per month			
	# of hours each process saves (on average)			
2	**TANGIBLE COSTS**	MINIMUM	BEST-GUESS	MAXIMUM
	INTANGIBLE COSTS	MINIMUM	BEST-GUESS	MAXIMUM
3	**TANGIBLE BENEFITS**	MINIMUM	BEST-GUESS	MAXIMUM
	INTANGIBLE BENEFITS	MINIMUM	BEST-GUESS	MAXIMUM
4	**RPA PROFITABILITY**	MINIMUM	BEST-GUESS	MAXIMUM
	Cumulative Net Present Value			
	DESCRIPTIVE NUMBERS	#		
	Success Ratio			
	Mean Net Present Value			
	Real Option Value			

Figure 7. A four-step framework for ex-ante evaluation of RPA profitability.

A four-step process is suggested for the ex-ante evaluation of the profitability of RPA investments. Therefore, the tool presented in Figure 7 is divided into four parts: (1) Efficiency Numbers, (2) RPA Costs, (3) RPA Benefits, and (4) RPA Profitability and Descriptive Numbers. The first step is to determine the efficiency numbers of the investment. The second step is to estimate the benefits of the investment. The third step is the estimation of the costs of the investment. In the final step, the investment analysis is done with the pay-off method using the results from steps 2, and 3. The outcome is presented clearly and concisely, highlighting the potential impact of the RPA project on the organization. Incorporating three distinct scenarios (the minimum, the best guess, and the maximum) into the analysis ensures that the factors which were the foundation of the pay-off method and have been recognized for adding value to this new framework as well are respected.

Given that RPA investments can have both tangible and intangible effects, the estimation of both RPA costs and benefits is divided into two levels: tangible and intangible. The tangible level focuses on the operational revenues and costs that are measurable and quantifiable outcomes of RPA, such as cost and time savings. On the other hand, the intangible level focuses on strategic revenues and costs that may be difficult to measure and not likely to be realized during the project period. Even though the intangible level is difficult to estimate, it is important to incorporate it into the evaluation of profitability since RPA-based actions have significant impacts that cannot be fully exploited without considering them. Next, each step of the process is discussed in more detail.

Step 1 *Determining the efficiency numbers of the RPA investment*

The first step of the process is to determine the efficiency numbers of the RPA investment. This involves analyzing the efficiency of processes that are used in the evaluation and identifying the number of bots that are needed for the automation. This step also allows the tool to be used for an evaluation of a single process or multiple processes together. Since the calculations in steps 2 and 3 are reliant on these efficiency numbers, this part should be completed before proceeding with the subsequent steps. Further explanation of the calculations and interrelation between the steps will be explained in more detail during the validation phase.

Step 2 *Evaluating the costs of the RPA investment*

To address the imprecision in estimation, the proposal suggests utilizing three scenarios for estimating investment costs. The use of scenarios is a widely accepted approach for modeling the uncertain future of projects and assets when dealing with imprecise information. The concept behind scenarios involves envisioning different future states of the world and estimating cash flows or the value of costs connected to these states (Collan et al. 2014). The estimation process involves considering "the minimum possible cost", "the most expected cost", and "the maximum possible cost" scenarios. These scenarios convey the full range of possibilities that the cost can take and force the experts doing the estimation to think about the lines between the impossible and the possible costs, both on the high and the low sides. The most expected cost scenario would often be the same as a single scenario used to estimate the investment cost if only one scenario were used. Moreover, it is widely recognized that any outcome falling between these scenarios is feasible.

This second step primarily focuses on the tangible costs of RPA, such as purchasing or licensing the technology. However, it is important to consider also the potential additional investments that the organization may need to take during the implementation process, such as employee training and upskilling, infrastructure upgrades, hiring of specialized RPA consultants or service providers, security measures to ensure data privacy and protection, and ongoing development and updates of RPA scripts and processes. The costs of these additional investments can be seen as strategic since they are complex and far-reaching. Therefore, a consideration of the intangible costs is included in the analysis.

Step 3 *Evaluating the benefits of the RPA investment*

The information needed for the evaluation of benefits is divided into two separate classes – tangible benefits and intangible benefits. Tangible benefits refer to the measurable and quantifiable outcomes of RPA, such as cost and time savings. On the other hand, intangible benefits refer to the non-measurable and non-quantifiable outcomes of RPA, such as improved employee satisfaction and benefits from organizational change. While tangible benefits are important, they are often insufficient to fully capture the value of RPA investments. This is because tangible benefits often point to short-term corporate gains, and do not fully capture the long-term strategic benefits of RPA. However, the justification of intangible benefits can be challenging since they are often difficult to define and measure.

This approach is based on the above recognition that it can be challenging to accurately determine the returns from intangible effects, which often only become apparent over a longer period of time. Despite the emphasis on tangible benefits, the intangible effects of RPA should not be overlooked in the analysis. Both the literature review and case study data indicate that it is not possible to fully evaluate the potential of RPA without taking into account its intangible effects at the strategic level. As such, the cost-benefit analysis should include a consideration of the intangible returns associated with RPA, even if these estimates are subject to change and should be updated as more information becomes available. Additionally, these can also be used at the beginning of the calculations to show how they are impacting the outcome of the RPA project. To address the uncertainty, the use of scenarios is again suggested. By using the available information as a basis, the creation of “the minimum possible benefits”, “the most expected benefits”, and “the maximum possible benefits” scenarios is proposed.

Step 4 *Profitability analysis with the pay-off method*

Before going to step 4, a discussion about the cost and the revenue scenarios created in steps 2 and 3 must be taken a bit further, or rather the issue of how the costs and the revenues are connected. It is important to determine if the estimated costs are related to the estimated benefits or if there is a possibility that the maximum outcome can be achieved with minimal spending, thereby indicating an absence of correlation between costs and benefits. While in most cases costs and benefits are unrelated, sometimes there may be at least parts of new technology investment projects, where more spending will create more benefits. These may be due to, for example, investing in staff training that can result in better acceptance and more efficient use of the system and increased benefits.

Understanding the interrelatedness of costs and benefits is crucial because estimates of costs and benefits must be aggregated in terms of PV to determine profitability. When costs and benefits are entirely unrelated, employing a min-max approach becomes imperative for scenario aggregation. In this context, the minimum costs are deducted from the maximum benefits and the maximum costs from the minimum benefits. Conversely, when scenarios are fully related, the maximum cost is deducted from the maximum benefit, and the minimum cost from the minimum benefit. In both cases, the most expected scenarios are aggregated together. If there exists a connection between the cost side and the benefits side, it becomes crucial to consider how this connection impacts the aggregation process. All aggregations must be done with PVs. It is noteworthy that the cost side and the benefits side are not exposed to the same risks, and therefore, the discount rate used in the calculation of present value can be different for cost and benefit scenario values.

After the aggregation of the cost and the benefit side PVs, three scenarios for the NPV of the RPA investment are available and can be used as input into the pay-off method.

In the proposed solution framework, it is desired to respect the factors that were originally the starting points of the pay-off method, as these factors have been identified as bringing added value to this tool as well. As a result, the tool has been designed to be as simple and user-friendly as possible. Additionally, the tool allows for the formation of estimates of the benefits and costs of RPA on a case-by-case basis, depending on the target company and the processes to be automated. It has also been desired that the results generated using the tool be in accordance with the starting points of the pay-off method. Thus, a pay-off distribution of returns is formed based on the results obtained using the tool, from which the success ratio and the mean of the positive area of the project are calculated. These steps are not discussed in further detail in this section, as they have already been discussed theoretically in the presentation of the pay-off method. Moreover, their application in the cost-benefit analysis of RPA will be carefully examined in the subsequent section through the validation of the tool.

3.3.4 Framework Validation

The present section offers a comprehensive validation of the framework that was developed in the previous section for the purpose of ex-ante evaluation of RPA profitability. This section aims to provide an outline of the validation process as well as various use cases of the framework. First, the framework is applied to predict the value of RPA in a single process. The process involves the automation of a particular task using RPA, and the tool is used to estimate the potential profitability of the project. This first part of the validation describes the complete evaluation process in more detail. This is followed by demonstrating how the tool can be used to compare the profitability of RPA between different processes, thereby enabling organizations to prioritize automating processes based on their expected returns. Finally, the tool is applied to analyze two different implementation strategies for RPA projects. This involves assessing the potential benefits and risks associated with different implementation approaches, such as a phased rollout versus a full-scale implementation. In Appendix 2, a GitHub link is provided to access the Excel template containing all the cash flow scenarios and calculations of the following numerical examples.

<u>Application of the Framework</u>

The estimates of the possible RPA costs and benefits in the examples used in this section are made by the author for simplification purposes only. In reality, organizations must conduct a thorough analysis of the RPA market and gather information from RPA vendors and consultants to obtain more precise values. This will ensure that organizations have an accurate understanding of the costs and benefits involved in implementing RPA and can make informed decisions about its adoption. It is important to note that the assumptions made in this study may not accurately reflect the costs and benefits of RPA in a real-world scenario as the focus is on developing a method for evaluating RPA rather than determining if it is actually beneficial for organizations.

A Single Process Case

In this numerical example, it is shown, with realistic (but not real) numbers, how an ex-ante profitability evaluation of RPA investment can be performed. The example is based on the four-stage process described above and done with the help of the pay-off method. The efficiency numbers and estimations of the possible RPA costs and benefits of the example case are presented in Figure 8 below. This is followed by a verbal explanation of how the evaluation process has been carried out.

1	EFFICIENCY NUMBERS	#
	# of bots	10
	# of processes	1
	# RPA transactions per month	1 700
	# of hours each process saves on average	1

2	TANGIBLE COSTS	MINIMUM	BEST-GUESS	MAXIMUM
	Cost of The Solution	50 000	100 000	150 000
	Infrastructure Cost	20 000	50 000	80 000
	Development and Deployment Cost	80 000	100 000	120 000
	Maintenance and Support Cost	31 000	52 000	75 000
	Additional Costs	0	0	0
	INTANGIBLE COSTS	**MINIMUM**	**BEST-GUESS**	**MAXIMUM**
	Additional Investments	0	0	0

3	TANGIBLE BENEFITS	MINIMUM	BEST-GUESS	MAXIMUM
	Savings from Manual Hours Saved	408 000	510 000	612 000
	Savings from Error Reduction	20 400	30 600	40 800
	INTANGIBLE BENEFITS	**MINIMUM**	**BEST-GUESS**	**MAXIMUM**
	Savings from Business Agility	0	30 000	50 000
	Savings from Productivity Gain	0	51 000	91 800
	Savings from Customer & Employee Satisfaction	0	18 000	34 000
	Savings from Compliance & Data Governance	0	31 000	56 500

4	RPA PROFITABILITY	MINIMUM	BEST-GUESS	MAXIMUM
	Cumulative Net Present Value	26 931	1 287 875	2 435 305

	DESCRIPTIVE NUMBERS	#
	Success Ratio	100 %
	Mean Net Present Value	1 268 956
	Real Option Value	1 268 956

Figure 8. The values of the numerical example.

The costs and benefits are assumed to be unrelated, which means that the aggregation is performed by using a min-max procedure (discussed above). The risk levels for the cost side and the benefit side are assumed to be different and that the discount rate for the cost side cash flows is 5% and the discount rate for the benefit side is 15%. This is because the risk connected to the benefits is assumed to be higher than the risk connected to the costs. The assumptions of the discount rates in the present example are made by the author for simplification purposes only. In a real-world case, the risk levels should be estimated by experts.

Step 1: Determining the efficiency numbers of the RPA investment

The use of 10 software bots in this numerical is assumed to deliver improvements in efficiency with a reduction of 1 hour per transaction on average resulting in 1,700 hours saved per month. It is important to note that the actual efficiency gains of RPA implementation may vary based on factors such as the complexity of the processes being automated, the quality of the bots' programming and maintenance, and the level of employee engagement and training. As such, it is critical for organizations to carefully evaluate their processes and consider the potential benefits and limitations of RPA before embarking on implementation.

Step 2: Evaluating the costs of the RPA investment

One of the costs associated with implementing RPA is the cost of purchasing or leasing the RPA software. The specific cost of a software bot will depend on the features and capabilities it offers, as well as the vendor or provider from which it is purchased. In addition to the cost of purchasing or leasing the bot itself, organizations may also incur costs for training employees to use the technology and integrating the bot into their existing systems. Leasing a bot can provide organizations with access to the latest technology and capabilities without the upfront cost of purchasing the bot. It can also allow organizations to easily upgrade or expand their RPA system as their needs evolve. Based on the information gathered from the web pages of RPA vendors, the yearly licensing cost of one software bot is assumed to range between $5,000 and $15,000, resulting in a total yearly licensing cost for all the bots to be $50,000 (minimum), $100,000 (best guess), and $150,000 (maximum) per year.

In addition to the software licenses, organizations also need to invest in hardware infrastructure such as servers, storage, and network devices to support the RPA implementation. Another infrastructure cost associated with RPA implementation is the cost of training and upskilling employees. While RPA technology is designed to automate repetitive tasks, it still requires skilled personnel to design, implement, and manage the automation process. Organizations need to invest in training their employees on RPA technology and associated tools to ensure they have the necessary skills to implement and manage the automation process effectively. The infrastructure cost in this example is assumed to be $20,000 (minimum), $50,000 (best guess), and $80,000 (maximum).

Development cost includes expenses related to designing, customizing, and training employees on the RPA software, as well as any additional resources needed to support the software. Deployment cost includes expenses associated with purchasing, installing, configuring, and testing the software. The costs of development and deployment vary depending on the size of the organization and the complexity of the processes being automated. For small businesses, the costs may be relatively low, while larger organizations may need to invest in multiple licenses and additional hardware and resources. The costs of development and deployment are assumed to be $80,000 (minimum), $100,000 (best guess), and $120,000 (maximum) in the first year of the implementation.

Maintenance cost refers to the expenses incurred for the upkeep and upkeep of the RPA software. This can include costs associated with regular software updates, security patches, and bug fixes to ensure the software continues to function correctly. Support cost refers to the expenses incurred for the assistance and assistance of the RPA software. This can include costs associated with providing technical support to employees who are experiencing issues with the software, as well as costs related to providing training and education to employees to ensure they can effectively use the software. It is important to note that the maintenance and support cost of RPA can be significant and often accounts for 20% of the total cost of the solution, which in this case is $31,000 (minimum), $52,000 (best guess), and $75,000 (maximum) per year.

There can be various additional investments that the organization may need to make during the RPA implementation process. The costs of these additional investments can be seen strategic since they are complex and far-reaching. The financial estimates of these costs should be updated in the future as more information becomes available and these estimates become more refined. Therefore, these costs are not taken into account in this numerical example. The tool is constructed in a way that updating them when new information becomes available is possible in the future.

Step 3: Evaluating the benefits of the RPA investment

The use of RPA in this numerical example is expected to deliver significant improvements in efficiency with a reduction of 1 hour per transaction on average resulting in 1,500 hours saved per month. Therefore, the total number of hours saved per year is 18,000 hours. The potential savings from the reduction of manual work hours are dependent on the cost per hour of manual labor, which in this case is assumed to range between $20-$30. Based on these assumptions, the savings from the reduction of manual work hours are estimated to be $408,000 (minimum), $510,000 (best guess), or $612,000 (maximum) per year. These values are calculated based on the estimated number of hours saved and the cost per hour of manual labor.

In this example, RPA is expected to eliminate the potential for human error, resulting in a more accurate and reliable process. An error is assumed to occur every 50 hours. Therefore, by automating the process using RPA, the total number of errors that would be prevented per year is estimated to be 408, given the total number of manual hours saved per year through the implementation of RPA is 20,400. To calculate the savings from error reduction, the average cost of one error is assumed to be $50 (minimum), $75 (best guess), and $100 (maximum). This includes the cost of rectifying the error, the time required to correct it, and the impact it may have on the business process. Based on this assumption, the total savings from error reduction range from $20,400 (minimum), $30,600 (best guess), to $40,800 (maximum) per year.

By automating tasks, RPA enables employees to focus on high-value activities, thereby increasing overall efficiency and productivity. This increase in productivity can have a significant positive impact on the organization's financial performance. To evaluate the potential productivity gain from implementing RPA, it is necessary to determine a percentage of additional productivity gain that is expected to be achieved through the automation process. This percentage is then multiplied by the total savings resulting from the reduction of manual work hours. In this numerical example, it is assumed that the percentage for additional productivity gain ranges from 0% to 15%, depending on the complexity and nature of the process being automated. Based on this assumption, the total savings from productivity gain resulting from the implementation of RPA in an imaginary RPA investment scenario is estimated to be zero (minimum), $51,000 (best guess), or $91,800 (maximum) per year.

One of the less tangible benefits, in this case, is assumed to be improved compliance. The use of RPA can ensure that all regulatory requirements are met and that there is greater transparency and accountability in the organization's operations. This can lead to reduced legal costs and penalties. Another less tangible benefit is increased business agility. RPA enables the organization to respond quickly to changes in the business environment, such as changes in customer demand or regulatory requirements. This can lead to increased revenue and market share. Additionally, this RPA investment is assumed to have benefits related to organizational change. For example, RPA can help to improve employee satisfaction by eliminating repetitive and low-value tasks and allowing employees to focus on more interesting and challenging work. This can lead to improved morale and reduced turnover bringing financial value to the organization.

Despite the fact that the financial estimates of these intangible benefits are difficult to determine, it is important to consider them in order to show their financial impact on the organization. The worst possible outcome in this example concerning all intangible benefits is assumed to be that no strategic advantages arise from the RPA investment. For the most likely and best possible outcomes, the author has made some possible estimates of the strategic level benefits in order to clarify how the effect of these benefits is shown in the evaluation. While these estimates may not be precise either in the real-world case, they can provide insight into the potential impact of RPA on the organization and inform decision-making. As new information becomes available, it may be necessary to update these estimates in order to ensure that the evaluation remains accurate and relevant.

Step 4: Evaluating RPA profitability with the pay-off method

The final step of the evaluation process is done first by constructing three cash flow scenarios, based on the results of steps 2 and 3, that present the minimum, the best guess, and the maximum situations for the RPA investment. Then, the cost and the benefit cash flow information is inputted into a calculation sheet, and performing the discounted cash flow analysis with the min-max aggregation of the scenarios to get NPV scenarios for the RPA investment. To create the maximum value of NPV distribution, the sum of PVs of the optimistic scenario (lowest cost) is deducted from the optimistic created value scenario (highest created value). Similarly, the minimum value for the NPV distribution is calculated by deducting the sum of the PVs of the highest cost scenario (pessimistic) from the sum of the PVs of the lowest created wealth scenario (pessimistic) The best guess scenario PVs for created value and costs are used to create the best guess scenario. As stated above, the discount rate for the cost side cash flows is 5% and the discount rate for the benefits side 15%. The cash flow table is visible in Figure 9, and a graphical presentation of cumulative NPV values is presented in Figure 10 for a more intuitive interpretation.

CASH-FLOW TABLE

rd cost	5 %
rd benefit	15 %

		0	1	2	3	4	5
SAVINGS	maximum		885 100	885 100	885 100	885 100	885 100
	best guess		670 600	670 600	670 600	670 600	670 600
	minimum		428 400	428 400	428 400	428 400	428 400
COST	maximum	435 000	225 000	225 000	225 000	225 000	225 000
	best guess	302 000	152 000	152 000	152 000	152 000	152 000
	minimum	181 000	81 000	81 000	81 000	81 000	81 000
PV SAVINGS	maximum		769 652	669 263	581 968	506 059	440 051
	best guess		583 130	507 070	440 930	383 418	333 407
	minimum		372 522	323 932	281 680	244 939	212 991
PV COST	maximum	435 000	214 286	204 082	194 363	185 108	176 293
	best guess	302 000	144 762	137 868	131 303	125 051	119 096
	minimum	181 000	77 143	73 469	69 971	66 639	63 466

PROJECT NPV	maximum NPV	2 435 305
	best guess NPV	1 287 875
	minimum NPV	26 931

Figure 9. Cash flow table of the RPA investment.

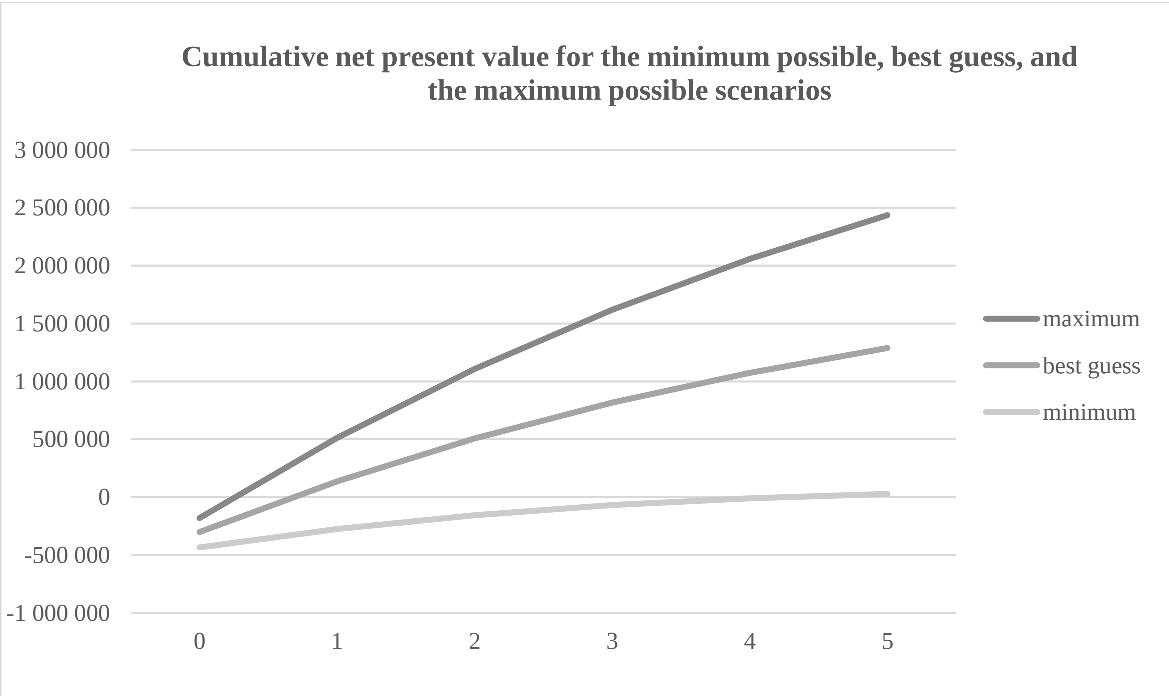
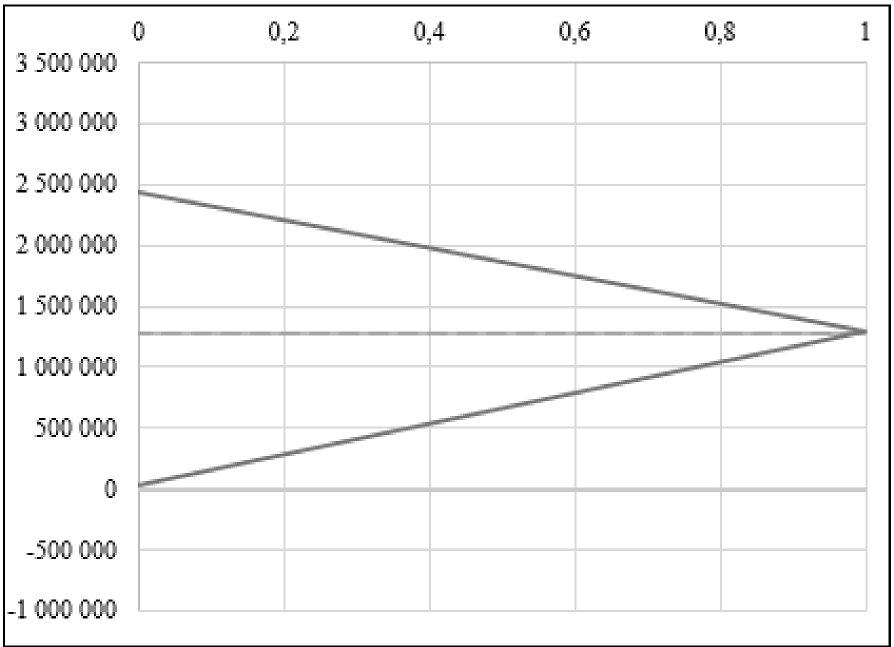


Figure 10. Cumulative net present values for the RPA investment.

Then a triangular pay-off distribution is built from the cumulative NPVs of the three scenarios for the RPA investment. This is visible in Figure 11 below. The pay-off distribution shows how much in today's dollars is expected to profit from taking the investment.



Maximum NPV	2 435 305
Best guess NPV	1 287 875
Minimum NPV	26 931
Success ratio	100 %
Mean NPV	1 268 956
ROV	1 268 956

Figure 11. The pay-off distribution and descriptive numbers of the RPA investment.

The whole area of the pay-off distribution is on the positive side, which indicates that the added value from the investment is expected to be positive. This is very great information, as the investment will most likely not be losing money, this is also shown by the success ratio of 100/100. Furthermore, the minimum scenario NPV of the project is $26,931and the maximum scenario is $2,435,305. These scenarios form a range within which the profitability of this project cannot go above or below. The most likely profit from this project, the best guess scenario NPV, is $1,287,875, and both the mean NPV and the ROV are $1,268,956. Since the mean NPV and the ROV are equal, the pay-off distribution is symmetrically distributed around the best guess NPV.

Moreover, the pay-off distribution also provides information about the probability of achieving certain levels of profitability. The x-axis of the pay-off distribution reflects the degree of membership, ranging from 0.0–1.0, of each value of the distribution in the set of possible values for the investment NPV. This axis illustrates the likelihood of different values occurring, with those near the peak being the most probable and the minimum and maximum values being the least probable. The best guess value, which is the most likely to occur, has a full membership of 1 within the set of expected values that the pay-off distribution represents. On the other hand, values that fall outside the distribution have a membership of 0, meaning that they are impossible outcomes. This information provides valuable insight into the probability of achieving certain levels of profitability and can aid in making informed investment decisions.

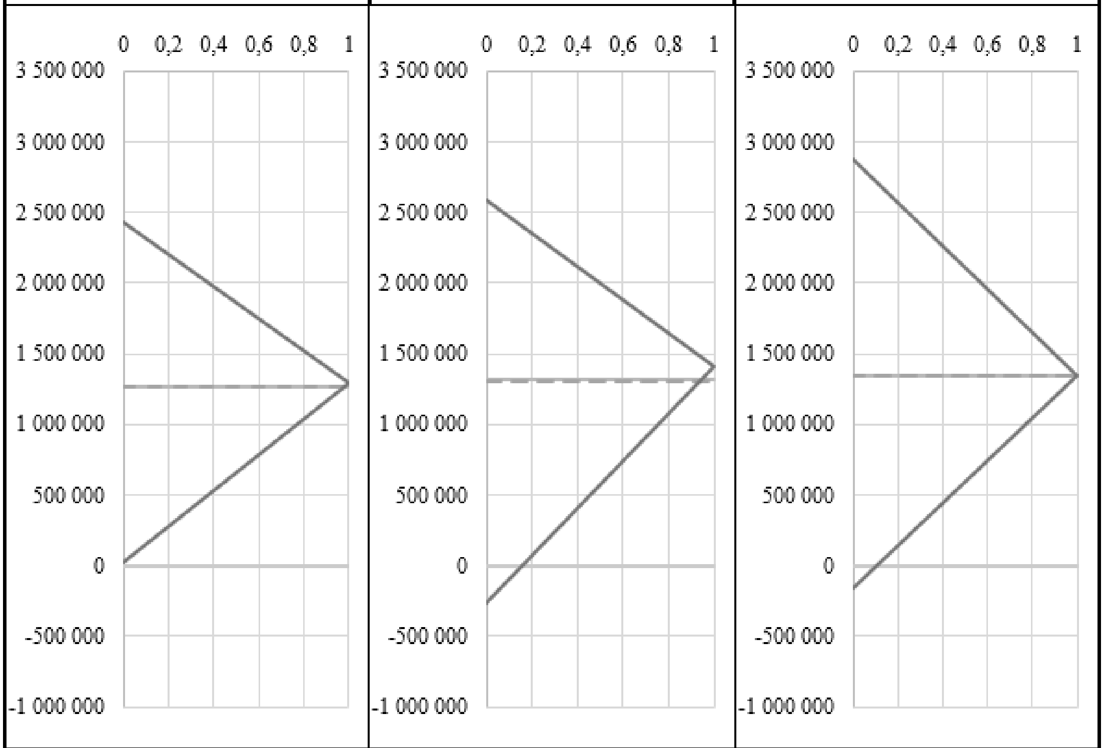
The pay-off distribution shows also the risk of the project in very intuitive terms. The wider the distribution is, the riskier the project is. The distribution, shown in Figure 11, is characterized by a relatively wide range, with a difference of $2,408,374 between the minimum and maximum scenarios. The wide range of possible returns signifies a significant level of risk associated with the project. Notably, the minimum scenario does not take into account the intangible impacts of the project, such as improved compliance and increased agility, as well as benefits related to organizational change. This highlights the significance of these intangible factors in determining the overall outcome of the project, and the importance of considering them when assessing the potential returns of the project. It is important to note that the intangible impacts of the project may have a significant impact on the outcome and should not be overlooked.

Finally, the values of the descriptive numbers are calculated; the mean NPV, the ROV, and the success factor according to what is presented above. The results are visible in Figure 11, together with the aggregated scenario values (whole project scenario NPVs). Descriptive numbers together with the graphical presentation of the pay-off distribution give much more to think about than only one single descriptive number, such as the most expected scenario value (that is often the only number used in supporting decision-making. By analyzing the descriptive numbers shortly, it becomes apparent that the mean NPV of the investment closely aligns with the estimated most expected NPV, while the ROV falls below the mean NPV. This typically indicates an opportune time to invest as the investment is considered “in the money”, with no value in waiting. Additionally, the success factor demonstrates a 100% result, indicating highly favorable prospects for the project to generate profits for the company.

Comparing the automation potential of different processes

This part demonstrates the use of the framework in comparing the value of RPA in different processes, allowing the identification of the most profitable processes for automation. The pay-off distributions of the three processes with numerical information and calculated descriptive numbers are visible in Figure 12 below. Process 1 is the same process that was already examined above. The same steps as those for Process 1 were followed to evaluate the pay-off distributions for Process 2 and Process 3. The only variation was made in the input values used to generate different scenarios for comparison purposes.

PROCESS 1 | **PROCESS 2** | **PROCESS 3**



Maximum NPV	2 435 305	Maximum NPV	2 582 129	Maximum NPV	2 875 778
Best guess NPV	1 287 875	Best guess NPV	1 404 530	Best guess NPV	1 346 202
Minimum NPV	26 931	Minimum NPV	-268 729	Minimum NPV	-158 912
Success ratio	100 %	Success ratio	98 %	Success ratio	99 %
Mean NPV	1 268 956	Mean NPV	1 323 075	Mean NPV	1 350 574
ROV	1 268 956	ROV	1 303 045	ROV	1 343 107

Figure 12. Pay-off distributions for three processes with descriptive numbers.

Based on the information presented above, it can be stated that all of the processes seem to be quite good options. Process 1 is the least risky choice, with a success ratio of 100/100 and a pay-off distribution that is entirely above zero. However, this process has the lowest potential, as indicated by its lowest ROV and lowest best guess (most likely) outcome. Each alternative has its strengths, and the selection process should be based on the decision-maker's priorities and preferences. Process 2 has the lowest success ratio and the lowest minimum possible NPV, but it has the highest best guess (most likely) outcome. Process 3 has simply the highest potential with the highest ROV, the highest mean NPV, and the highest maximum possible NPV. Each alternative has its strengths, and the selection process should be based on the decision-maker's priorities and preferences. The preferences can be obviously also codified into a "system," and multiple criteria decision-making tools can be utilized to rank and choose from the various alternatives. Such a tool may become handy when there are many alternatives to rank and choose from.

Comparing two implementation strategies

In this numerical example, two alternative strategies are used to illustrate the point of comparing different implementation strategies with the use of the framework developed. However, in a more realistic setting, there might be a number of sensible realistic starting times for the second phase implementation, and these can all be compared as alternatives. The cumulative NPV cash flow scenarios for both strategies are visible in Figure 13 (Strategy 1: one phase) and Figure 14 (Strategy 2: two phases).

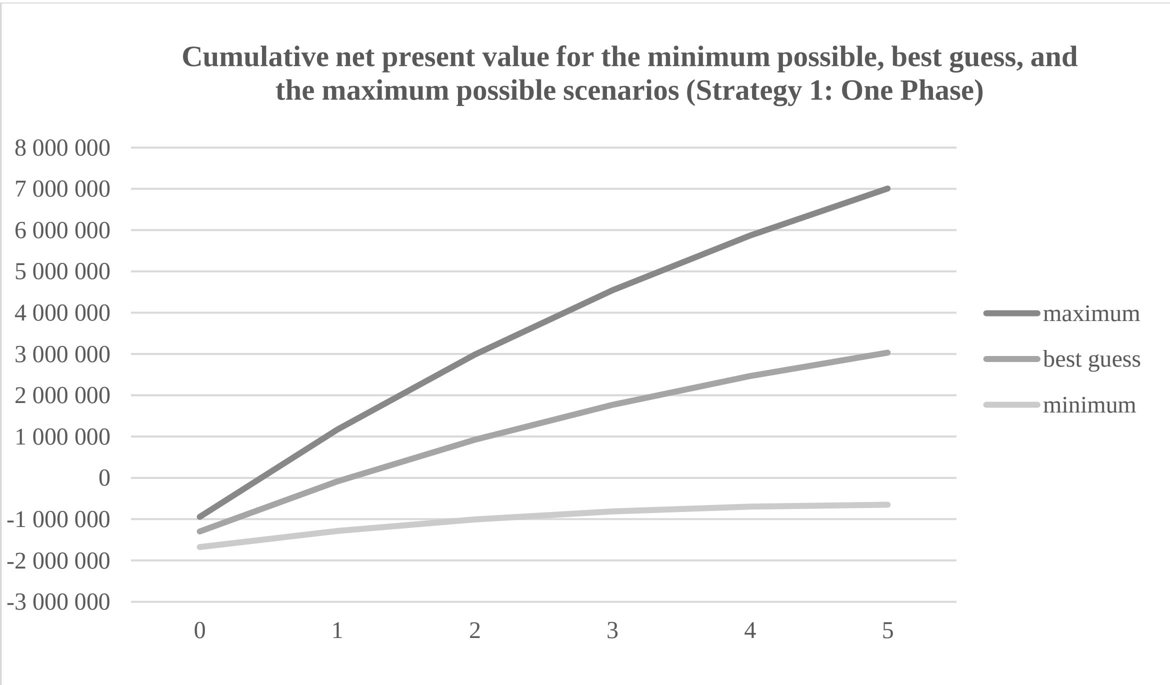


Figure 13. Cumulative net present values for the minimum possible, best guess, and the maximum possible scenarios of Strategy 1.

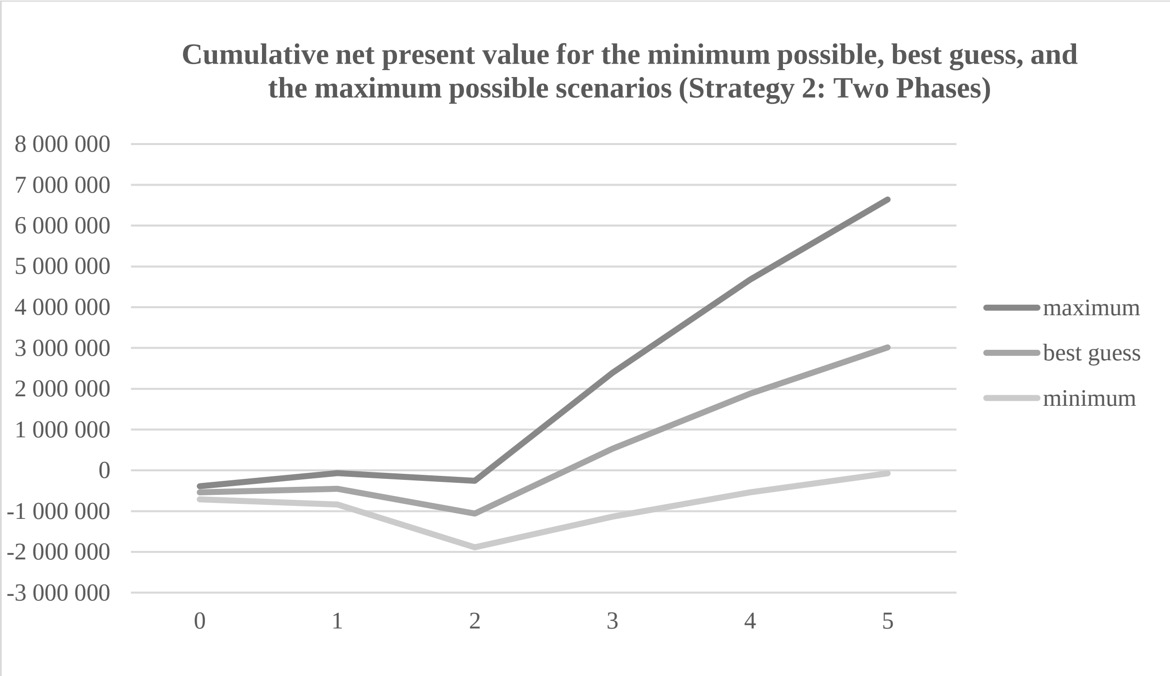
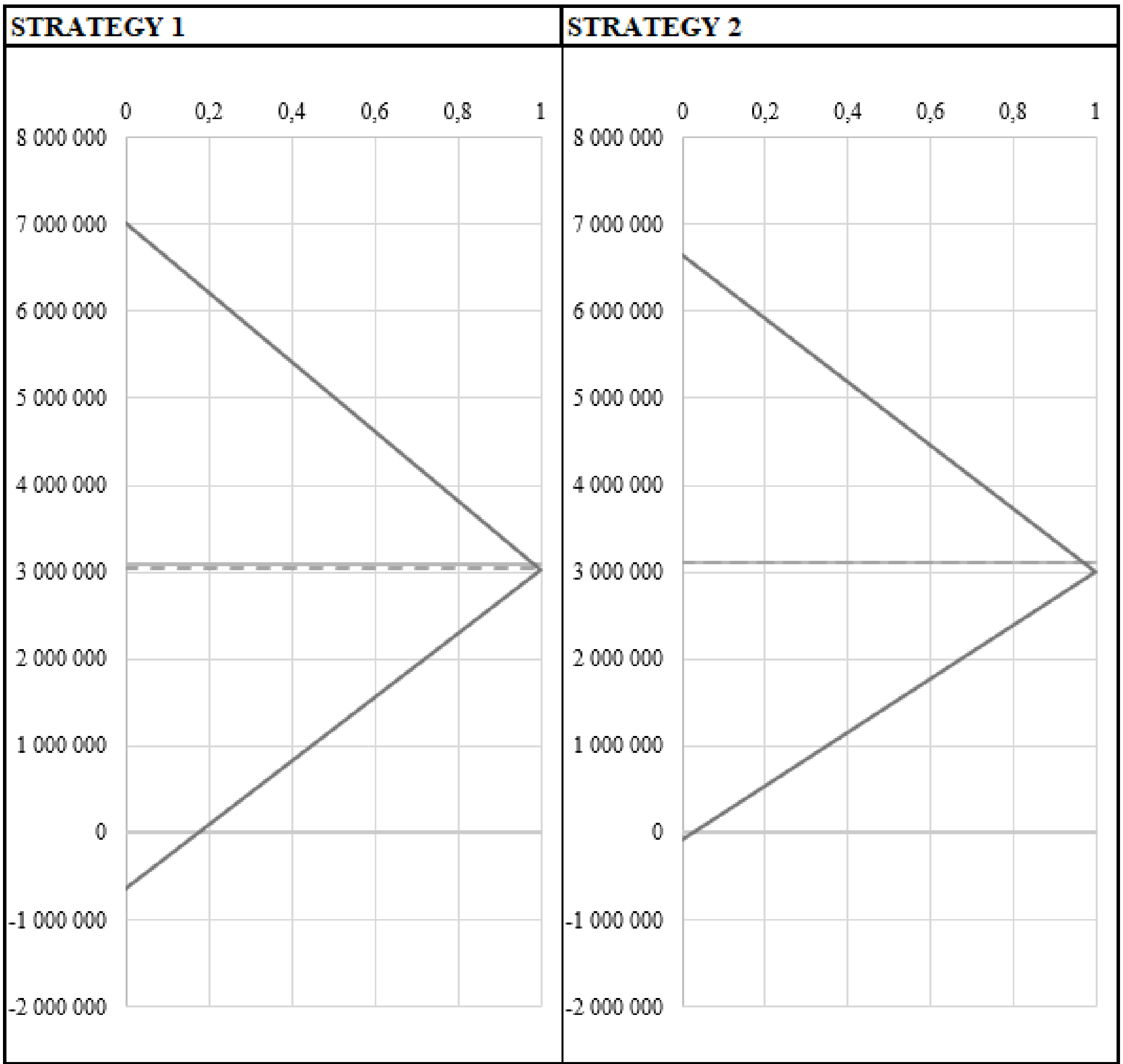


Figure 14. Cumulative net present values for the minimum possible, best guess, and the maximum possible scenarios of Strategy 2.

The distance between the optimistic and pessimistic scenarios is an indication of the level of inaccuracy of the estimation and it is easy to see that in the "implement all at once" strategy (Strategy1) the inaccuracy is at a higher level. This means also that the inaccuracy about the estimated range of the pay-back time is wider. Furthermore, in the 5 years period of estimation, the pessimistic scenario of both strategies is still under zero, meaning that the investment has not yet been paid back.

The pay-off distributions of the two strategies are visible in Figure 15. They show what was already discussed above. Strategy 1 NPV seems more difficult to accurately estimate than Strategy 2. In this case, the risk reduction aspect of phasing is quite evident. The worth of the lower risk is seen from the fact that even if the optimistic and best guess scenario NPV for Strategy 1 are higher, the mean NPV and the ROV for Strategy 2 are both higher. This is caused by the "weight" of the possible downside that Strategy 1 has. The pessimistic scenario NPV for Strategy 1 is $-648,710 while for Strategy 2 it is $-74,425 with a difference of $574,286 in favor of Strategy 2. The smaller downside is also reflected by the better "success factor" of Strategy 2.



STRATEGY 1		STRATEGY 2	
Maximum NPV	7 009 292	Maximum NPV	6 640 275
Best guess NPV	3 034 180	Best guess NPV	3 013 812
Minimum NPV	-648 710	Minimum NPV	-74 425
Success ratio	98.5 %	Success ratio	99.9 %
Mean NPV	3 086 238	Mean NPV	3 103 523
ROV	3 040 189	ROV	3 102 694

Figure 15. Pay-off distributions for Strategy 1 and Strategy 2 with descriptive numbers.

This is still not a clear case. What it boils down to is the risk profile of the decision-maker. If the decision-maker is ready to take a higher risk and believes that the market will act according to the best guess scenario or even fare better, then Strategy 1 is the right choice. On the other hand, if the decision-maker wants to play it safer and take the lower-risk alternative the decision will be Strategy 2. The point here is that phasing offers an alternative investment strategy in the context of implementing RPA solutions and the framework can be used in assessing the merits of the alternative.

Feedback Generated Based on Validation

Next, in this section, feedback generated based on the validation of the proposed four-step framework will be discussed regarding its suitability for evaluating RPA investments. Due to the limitations of this study, it has not been possible to investigate how the potential customer organization views the ex-ante evaluation of the profitability of RPA investment using the framework. Therefore, the suitability of the framework will be assessed based on feedback formed by the author of this study. The feedback has been generated based on the numerical examples presented above and analyzed using the Grounded Theory method chosen for this research, using all the main categories previously selected for the study: (1) Evaluation Challenges, (2) Evaluation Requirements, and (3) Need for A New Method.

1) The four-step framework was specifically designed to address the challenge of evaluating RPA investments in a way that takes into account the uncertainty and inaccuracy (especially on the benefits side) and potential risks involved. By applying the pay-off method and utilizing three value scenarios, the framework offers an intuitive way to generate value distributions and construct pay-off distributions. By using these scenarios, the pay-off method can account for a range of less probable variables that would not be included in a single scenario analysis. As a result, investment analysis using the pay-off method provides a wealth of information that goes beyond what is available from models based on only one scenario.

2) It can be said that the information supporting the creation of the scenarios can come directly from experts, such as the organization itself, system vendors, or external consultants. Therefore, based on the validation results, the framework is well-suited for ex-ante investment evaluations where organizations need to take into account their readiness and maturity level for adoption. It also became clear that the framework can be used to calculate the value of RPA in a single process or multiple processes together. The framework also allows a comparison of the pay-off distributions of different processes and implementation strategies in an intuitive way. Graphical presentations of the pay-off distributions make it easy for managers to understand the potential and risk associated with RPA investments. By comparing these distributions, managers can select the most profitable processes to automate and make informed decisions about different implementation strategies based on the value of time. The framework employs fuzzy logic to generate straightforward

results, including a graphical presentation of the pay-off distribution for the RPA investment, as well as a single number ROV and the NPV. Changes in the pay-off distribution reflect changed information in the value scenarios, updated by the experts during the recurring analysis sessions. Each change in the scenario values has a direct effect on the shape and the size of the pay-off distribution and the end results. When the discounted cash flow method is used, a change in a single expected cash flow causes a change in the pay-off distribution. Such transparency is something that managers are likely to appreciate.

3) Using the four-step framework introduces guidance on top of the moral valuation procedures. It considers the unique characteristics of RPA, such as its potential strategic effects, providing more reliable results than traditional approaches. The simple framework allows decision-makers to make better-informed decisions by enhancing decision support for complex investment decisions under vague and imprecise information coming from multiple sources. The framework is simple and does not add to the complexity of the problem of evaluating RPA ex-ante. However, these may prove to be difficult for some as fuzzy logic is not well known by all. The framework is admittedly a rather simplified picture of reality, and if a more complex representation is needed, then perhaps the pay-off method should not be used as the final tool in the framework.

In summary, the four-step framework presented in this study offers a new approach to valuing RPA investments by taking into account uncertainty and providing intuitive graphical presentations of pay-off distributions. The framework and the applied pay-off method are not in conflict with any of the earlier methods presented in the literature but can complement them, and on many occasions is able to utilize directly the inputs already available in companies using other discounted cash flow-based methods. Therefore, the framework is seen to provide valuable support to managers when evaluating RPA investments.

4 Summary and Conclusions

The next step is to proceed with discussing the summary and conclusions of this study. This chapter is organized into three sub-sections. The first sub-section focuses on the results obtained during the research and provides a concise summary of these results. The second sub-section focuses on drawing conclusions based on the results presented in the first sub-section. In the final sub-section, the contribution of this research to the existing body of knowledge is evaluated, along with its limitations. The contribution of the research is discussed in terms of its potential impact on theory, practice, and policy. The limitations of the study are also discussed in this section, along with potential avenues for future research.

4.1 Summary of the Research

The goal of this research was to create a new framework for evaluating RPA profitability ex-ante. To solve the main research problem, this study addressed its sub-questions first. Next, the main results of this research will be discussed by answering the sub-questions set for the study.

What are the challenges of evaluating RPA profitability ex-ante?

Based on both the literature review and the first interview, the challenges of evaluating RPA profitability ex-ante are seen to be: (1) measuring the potential benefits of RPA and (2) the limitations of traditional approaches to RPA.

1) RPA brings numerous benefits some of which are difficult to measure or even unmeasurable, as well as some unpredictable benefits that may be revealed only after a certain period of use of the technology. This uncertainty surrounding benefits coupled with other issues, such as the challenges in quantifying less tangible benefits, can make ex-ante estimates of cost savings and benefits quite imprecise. Therefore, all methods used in RPA profitability analysis ex-ante must consider the (sometimes significant) estimation inaccuracy.

2) Traditional evaluation metrics often focus on tangible benefits, such as cost savings, rather than less tangible benefits, such as improved customer and employee

satisfaction, and are insufficient in addressing the challenges resulting from the complexity of measuring RPA benefits. Instead, more comprehensive metrics that account for the imprecision in cost-benefit estimates and the broader implications of RPA, including its intangible benefits, are necessary.

What requirements can be found for a successful ex-ante evaluation of RPA profitability?

To effectively evaluate the profitability of RPA investment, it is crucial to identify and understand the critical factors that contribute to the success of this kind of investment. The advice and recommendations found in the literature came from 4 different dimensions (aligning Syed et al. (2020)), namely (1) organizational readiness assessment, (2) RPA task selection (3) stakeholders buy-in, and (4) active development and management of benefits. Based on these dimensions, the author formed the following requirements for the ex-ante evaluation of RPA:

1) It was found from the literature that the organizational environment and maturity level of the company plays a significant role in determining the success of RPA implementation. Proper implementation of RPA requires identifying inefficiencies in the organization's operations and selecting the most appropriate processes for automation. Therefore, organizations require RPA readiness and maturity assessment frameworks. Utilizing the services of an external consultant to assess RPA readiness in organizations is recommended. Each organization should be able to incorporate data, evaluation techniques, personal experience, personal knowledge, corporate or departmental politics, personal desires, and intuition in its evaluation process, for the fact that these are a range of input information required for the ex-ante RPA evaluating process.

2) It was also understood that organizations must have a comprehensive understanding of the processes and tasks that are needed to be automated. This requires a detailed analysis of the tasks and processes, as well as an understanding of how they fit into the larger organizational context. Not all tasks and processes are suitable for automation. Organizations must be able to evaluate the suitability of each process for automation based on factors such as complexity, volume, and frequency. This assessment must take into account both the potential benefits and the risks associated with automation. The evaluation of RPA profitability should allow for comparing the

automation potential of different processes to help organizations select suitable processes for automation. This requires the ability to evaluate the costs and benefits of automation, including the potential for cost savings and increased efficiency. To maximize the benefits of RPA, organizations must prioritize the implementation of RPA in areas where it will have the greatest impact and be able to compare and prioritize different implementation plans based on their potential value.

3) In terms of project success, it is essential to have the support and commitment of key stakeholders. This includes securing the necessary funding and resources for the RPA project and ensuring the cooperation of stakeholders during the implementation process. RPA is no longer just about automating internal processes, but also at the core of delivering products and services. Therefore, it is crucial to focus on the benefits of RPA for customers and stakeholders and how it will improve the organization's overall performance. To gain the buy-in of executives and stakeholders, it may be necessary to demonstrate the transformative impact of RPA on the organization. Therefore, the evaluation of RPA profitability should emphasize the importance of stakeholder involvement throughout the RPA implementation process to ensure their support and cooperation.

4) The ability to monitor and evaluate the results of RPA projects on an ongoing basis is important to ensure the benefits are measured and managed in a systematic way. Additionally, successful implementation of RPA projects requires careful planning, execution, and monitoring, as well as the involvement of stakeholders throughout the process. Hence, the evaluation of RPA profitability should emphasize the importance of monitoring and evaluating the results of RPA projects on an ongoing basis to ensure they continue to provide value and support the organization's strategic objectives. To properly evaluate the profitability of implementing RPA, it is important to have access to up-to-date information on the processes to be automated and the potential benefits of doing so. This information should be regularly updated to reflect any changes in the organization and its processes.

By incorporating the above requirements into the framework, organizations can ensure that the framework adequately captures the critical factors that impact RPA success and provides a comprehensive approach to evaluating the value of RPA investments. This can help organizations maximize the benefits of RPA, such as cost savings and increased efficiency while minimizing the costs, and ultimately supporting the organization's strategic objectives.

What makes the pay-off method suitable for an ex-ante evaluation of RPA profitability?

In this study, the formation of the four-step framework for ex-ante evaluation of RPA profitability using the pay-off method is discussed in more detail in sub-section 3.3.2. In that particular section, the focus is on evaluating how the method can support the implementation of profitability estimation of RPA projects based on the established starting points identified earlier in the study. It becomes clear during the section that the method is suitable as a basis for the presented framework. It can support the estimation process by taking into account factors that have previously complicated or even prevented such an estimation. In this summary section, the results presented earlier are not revisited. Instead, the essential research results for solving the sub-question concerned are presented by discussing how the framework can respond to the actual challenges of estimating the profitability of RPA using the pay-off method.

Profitability analysis with regards to RPA is not a simple task as **the benefit side of the equation cannot be well and precisely known ex-ante**, leading to imprecision in estimates. The pay-off method can overcome this challenge of uncertainty by accounting for the inaccuracy and still providing adequate decision support. **Unlike traditional evaluation metrics**, the method does not rely on a single number or a single average scenario, which is not sufficient in capturing the vagueness that is present in a realistic way. Instead, it considers a range of scenarios and estimates the expected value of the project. This makes it a suitable approach for evaluating RPA investments, as it can account for the complexity of these investments and provide decision-makers with a more comprehensive evaluation of their potential profitability.

By using a comprehensive approach that takes into account **organizational readiness and maturity**, the pay-off method can provide decision-makers with adequate decision support in the face of uncertainty and complexity. The information to support drafting the scenarios can come directly from experts, most often from within the firm itself, from system vendors (with regards to the costs), or from external consultants. Therefore, the pay-off method is particularly well-suited for ex-ante investment evaluations where organizations need to take into account their readiness and maturity level for the adoption. Moreover, the assessment using the pay-off method can be done by external consultants who evaluate RPA readiness and provide input information required for the RPA evaluation process, such as data, evaluation techniques, personal experience, personal knowledge, corporate or departmental politics, personal desires, and intuition.

The selection of initial tasks for RPA is found to be an important aspect of the implementation process. Using the pay-off method in the analysis, organizations **can compare the potential profitability of different processes** and prioritize the implementation of RPA in areas where it will have the greatest impact. To evaluate the suitability of each process for automation, it takes into account the potential benefits and risks associated with automation. This enables organizations to make informed decisions about which processes to automate and which ones to leave as they are. The pay-off method can also help organizations evaluate the profitability of RPA implementation by comparing the potential cost savings and increased efficiency of automation against the costs of implementation. This way organizations can identify areas where cost savings and efficiency gains are most likely to be achieved. Furthermore, the pay-off method can be used to prioritize different implementation plans based on their potential value.

One of the main advantages of the pay-off method is its simplicity and ease of use. The results of the method are straightforward and easy to understand, making it **accessible to all stakeholders** regardless of their financial background. This is particularly important in the case of RPA investments, where all stakeholders need to understand the evaluation results and what RPA represents for the organization Additionally, the pay-off method is a resource-efficient evaluation technique that requires minimal effort and time to perform. The simplicity of the method allows for quick and easy calculations, which saves valuable time and resources. This is a significant advantage over other evaluation methods that can be complex and time-consuming. Ultimately, this method provides organizations with a reliable and straightforward approach to assessing RPA profitability, ensuring that they can make informed investment decisions with confidence.

In order to properly evaluate the profitability of RPA, it is important to have access to up-to-date information on the processes to be automated and the potential benefits of doing so. To ensure that **the benefits of RPA projects are measured and managed** in a systematic way, the pay-off method emphasizes the importance of careful planning, execution, and monitoring, as well as the involvement of stakeholders throughout the process. This enables organizations to identify any issues or areas for improvement and take corrective action as needed. Furthermore, the pay-off method emphasizes the importance of regularly updating information on the processes to be automated and the potential benefits of doing so. This ensures that the information used to evaluate the profitability of RPA implementation is up-to-date and reflects any changes in the organization and its processes.

The evaluation criteria and methodology outlined in this research suggested that the pay-off method is well-suited as the basis for a framework for ex-ante evaluation of RPA profitability. Instead of developing a completely new method, this research focused on adapting the original pay-off method into a new framework for conducting the evaluation. The incorporation of real option valuation methods into the method developed is considered to improve the reliability and comprehensiveness of the evaluation. However, this research did not address the real option valuation part of the pay-off method. The choice of the pay-off method as the basis for the framework was also supported by observations in the literature review, which indicated that new methods are needed for evaluating the profitability of RPA ex-ante.

4.2 Conclusions of the Results

The four-step framework was designed based on the information gathered from the literature and existing case studies. Its applicability in evaluating the profitability of RPA ex-ante was evaluated through a validation process that was conducted as part of the study. The author drew conclusions based on the validation process, which will be discussed in the first section of this sub-chapter. In the second part, the final conclusions drawn from the overall study will be presented. This includes an evaluation of the effectiveness of the framework developed and its potential implications for the field of RPA.

Conclusions made by the author

Profitability analysis with regards to RPA is not a simple task as the benefit side of the equation cannot be well and precisely known ex-ante, leading to imprecision in estimates. The difficulty lies in quantifying the intangible benefits, including quality improvement and flexibility enhancement. To overcome this challenge of uncertainty, decision-makers must use tools that can account for inaccuracy and still provide adequate decision support. It is clear that methods that use single numbers or a single average scenario for the project are not sufficient in capturing the vagueness that is present, in a realistic way. Therefore, it is essential to adopt more comprehensive approaches that can effectively capture the complexity of RPA investments.

To address the research problem of evaluating the profitability of RPA investments, a framework was proposed in four straightforward steps, utilizing scenarios, fuzzy logic, and the pay-off method, with a graphical presentation of the results. With the simple four-step process, it was straightforward to estimate the costs and the benefits of an RPA investment, aggregate them and draw intuitively understandable results. The simple framework was suggested to allow decision-makers to make better-informed decisions by enhancing decision support for complex investment decisions under vague and imprecise information coming from multiple sources. The framework presented and illustrated in the empirical part of the study is simple and does not add to the complexity of the problem. To the best of the author's knowledge, this is the first time such a framework has been suggested for evaluating the profitability of RPA investments ex-ante.

Scenarios are a familiar tool to managers and typically require little explanation or persuasion. The creation of the pay-off method is a simplification of reality – it is observed that under vague information a triangular distribution is often a good-enough first representation of reality. As more information becomes available, the situation can be adjusted to reflect a more accurate picture. Compared to using single numbers, which are the most common in investment analysis, the use of a triangular distribution is much more effective in any case. The graphical representation of results is useful in drawing attention to potential downsides and prompting relevant questions regarding risk management. Using graphical presentations in the comparison of different process or implementation strategy alternatives together with tables of descriptive numbers that explain the perceived profitability of the investment in more detail allows the decision-makers to reach a holistic picture of the alternatives and of their decision. The author has provided three numerical examples to illustrate the four-step framework.

The four-step framework introduced in the study offers decision-makers a valuable tool to assess the perceived imprecision in their analysis of costs and benefits associated with RPA investments. This is a significant contribution, as the literature often separates cost and benefit analyses, with surprisingly little attention paid to profitability. Moreover, the expected NPV provides decision-makers with the "best" managerial expectation, while the mean NPV reflects the center point of the range of possibilities. The straightforward graphical presentation of the pay-off method allows decision-makers to understand the associated level of imprecision in profitability and provides them with flexible tools to evaluate different options and underlying assumptions. These contributions are important because they empower decision-makers to take real action in making decisions, rather than simply accepting proposals from experts and shifting responsibility to them.

One primary objective of the study was to develop a generalizable approach that could be applied to any organization or industry seeking to automate its processes. The pay-off method was identified as a suitable tool due to its successful track record in evaluating similar projects. This method has been utilized to evaluate a variety of initiatives, such as intangible rights and product development projects, where future evaluations need to be made based on limited and imprecise information. The pay-off method is a flexible tool that can be tailored to an organization's specific circumstances and objectives. It can be used to evaluate the potential profitability of implementing RPA for a specific business process or a broader organizational initiative. In doing so, it can take into account a wide range of factors that may impact the returns of RPA, such as cost savings, productivity improvements, and enhanced customer satisfaction. By using the pay-off method, organizations can gain a more accurate and comprehensive understanding of the potential returns of RPA

The framework and its development should be further evaluated and challenged by other academic studies, in order to ensure its functionality and further improvement. It is also important to gather significant practical experience from consulting companies and real customer cases to verify its functionality and suitability in its intended environment.

<u>The overall conclusions of the entire study</u>

The study was motivated by the need to provide a more thorough understanding of RPA investments and to make well-informed decisions concerning the implementation of RPA projects. The recognition, that despite the potential benefits promised by RPA, numerous organizations have encountered significant difficulties in its implementation, particularly due to the absence of objective methods to evaluate RPA profitability ex-ante, fuelled the need for this research. The research was conducted to reduce the gap in academic research on ex-ante evaluation of RPA profitability.

To solve the main research problem, a new four-step framework was developed for the ex-ante evaluation of RPA profitability. Special interest was put in taking into account the profound uncertainty and imprecision of different forecasts used when evaluating RPA investments, and therefore the existing investment analysis method, the pay-off method was chosen for the analysis. The primary objective of the framework was to address the challenges faced during the evaluation of RPA and to support the success of RPA projects. To support the resolution of the main research problem, the following sub-questions were established: (1) What are the challenges of evaluating RPA profitability ex-ante? (2) What requirements can be found for a successful ex-ante evaluation of RPA profitability? (3) What makes the pay-off method suitable for an ex-ante evaluation of RPA profitability?

The methodology employed in this study was the Design Science Research (DSR) methodology. The selected methodology effectively supported the resolution of the research problem addressed in this study. It also allowed for the creation of a logically sequenced description of the research process, from which a comprehensive and holistic understanding of the previously unexamined subject was successfully derived. The method chosen for data collection was a qualitative case study. The case study method was chosen as the research strategy because it was seen as the best way to support the resolution of the research problem due to its revealing nature. The Grounded Theory (Glaser & Strauss 1967) method was chosen as the data analysis method for this qualitative research because it has been proven to support the methodology's aim of understanding and deepening the understanding of the problem and the previously unexplored factors behind it.

Considering the limitations of the qualitative case study, it can be concluded that the theoretical saturation point within the scope of this study has been reached at an adequate level. The solution for addressing the main research problem was successfully developed, validated, and found to be suitable for its intended purpose. Based on these findings, it can be concluded that the results of the study provide valuable insights into the research problem and contribute to the advancement of the field by reducing the existing research gap. However, it cannot be seen as a direct solution to the whole problem, as it remains to be seen how reliable the evaluations made with the framework are and whether it will be implemented in practice for the ex-ante evaluation of RPA investments.

Overall, this study aimed to provide a comprehensive evaluation of the challenges and requirements for the ex-ante evaluation of RPA profitability, as well as explore the factors that make the pay-off method suitable for the evaluation. Through the use of the DSR methodology and qualitative case study approach, the study aimed to contribute to the academic literature and advance the understanding of pre-evaluating RPA profitability. The summary of the research results highlights the comprehensive nature of the study in addressing the sub-problems associated with the main research issue. Furthermore, the study provides a deeper understanding of the previously identified research gap in the field and the contributing factors that have led to its existence. Given these observations, the study can be deemed successful in its goal of reducing the research gap and, thus, achieving its set objectives. It is, therefore, reasonable to conclude that this study has met its goals.

4.3 Contribution, Limitations, and Further Research

Finally, in this research, it is important to examine its contribution. In this context, contribution refers to the benefit and value of the research for its different readers. The contribution of this research has been evaluated from four different perspectives, which are: (1) the contribution of the research to academic research, (2) the contribution of the research to RPA users, (3) the limitations of the research, and (4) the research's potential areas for future research. These will be discussed in detail in this sub-section.

<u>Contribution to Academic Literature</u>

RPA has gained significant attention as a promising technology for organizations seeking to improve their efficiency and productivity. However, despite this increased interest, there remains a gap in the academic literature on evaluating the profitability of RPA ex-ante. This gap in knowledge is problematic as it limits organizations' ability to make informed decisions about the implementation of RPA. Therefore, this study aimed to address the gap by systematically focusing on increasing understanding of this issue and examining the suitability of the pay-off method for implementing ex-ante evaluation of RPA profitability. This study represents an important contribution to the academic literature on RPA as it is the first study to systematically focus on this research gap. Additionally, the study's examination of the pay-off method as a suitable tool for pre-valuating the profitability of RPA is a novel contribution as previous academic studies have identified the need for ex-ante evaluation of the financial impacts of RPA but have not examined this specific method for achieving it.

Previous academic studies conducted around the identified research gap have strongly focused on increasing understanding of identifying and evaluating the effects of RPA-related actions after the solution has been implemented. Additionally, these previous studies have aimed to define RPA and its related concepts. This research contributed to this academic field by providing a novel theoretical framework that focuses on comprehensively addressing the ex-ante evaluation of the profitability of RPA. This theoretical framework was developed by identifying the research gap and conducting a literature review, which provides a broad theoretical overview of relevant previous academic literature on this type of research. However, the previous literature on the topic is highly limited. Thus, this theoretical framework on the challenges and requirements of ex-ante evaluation of RPA profitability provides benefits for future academic research.

Additionally, the results and conclusions of the empirical research provide value to academic research by further increasing understanding of the research gap and the underlying factors in this field. During the empirical research, understanding has been increased particularly in the main categories according to the data analysis method: (1) the challenges of the ex-ante evaluation of RPA profitability, (2) requirements found for successful ex-ante evaluation of RPA profitability, (3) need for a new method for ex-ante evaluation of RPA profitability.

<u>Contribution to RPA Users</u>

In this research, a four-step framework was developed with the main objective to address the challenges faced in the ex-ante evaluation of RPA and to support the success of RPA projects. This framework can support the success of any company's RPA project. The utilization of this framework increases understanding of the factors critical for the success of an RPA project and its evaluation. It allows organizations to identify and evaluate the tasks that are well-suited for automation in order to prioritize the implementation of RPA in areas where it will have the greatest financial impact. Additionally, it can be used to evaluate the profitability of different implementation strategies, such as implementing RPA in one phase versus two different phases. This helps organizations determine the most cost-effective and efficient approach to implement the RPA.

In addition to RPA projects, the framework may also be used in other investments with similar characteristics. Utilizing the framework increases understanding of considering strategic impacts at the decision-making stage. This allows organizations to make informed decisions about the best way to implement the technology and consider the long-term impact on the organization. The author hopes that the increased understanding of the factors critical for the success of an RPA project, based on this research, will raise discussion, especially on the basis of which decisions to invest in this kind of project are made. This research contributes to the field by providing organizations with the evaluation framework that can support the success of any company's RPA project and by increasing the understanding of strategic factors that are critical for realizing the full potential of such technology.

Limitations of the Research

The limitations of the study can be attributed to several factors. Firstly, the analysis of the literature on RPA did not aim to create an exhaustive collection of indicators, but rather to gain an understanding of the main challenges associated with its evaluation. This implies that some valuable insights that could have provided additional perspectives and requirements may have been neglected. Secondly, the qualitative analysis conducted in this study was based on a small number of cases, which may limit the generalizability of the results to a larger population. Furthermore, the researcher's personal biases may also have influenced the interpretation of data, affecting the reliability and validity of the findings. Additionally, the findings of the qualitative case study are contextually bound and may not be generalizable to other situations. Finally, the assumptions of the possible RPA costs and benefits in the numerical examples used in the validation of the framework are made for simplification purposes only. In reality, organizations must conduct a thorough analysis of the RPA market and gather information from RPA vendors and consultants to obtain more precise values. It is important to note that the assumptions made in this research do not accurately reflect the costs and benefits of RPA in a real-world scenario.

Further Research

This study has contributed to the field of RPA project evaluation by identifying a research gap and creating a new framework for the ex-ante evaluation of the profitability of RPA investments. This framework serves as a foundation for future academic research in the field. In order to address the limitations, it is important to critically evaluate and challenge the framework and its development through further academic research. This could include gathering practical experience from real customer cases in consulting companies to verify its functionality and suitability. Additionally, research on the accuracy and suitability of the framework for evaluating the profitability of RPA projects by external advisors would be useful in confirming its viability. It would also be valuable to investigate the applicability of the framework to other types of projects and to determine the contribution of research from other scientific fields to reducing the research gap identified in this study. Overall, the results of this study provide a foundation for further academic research in the field, highlighting the need for diverse, both quantitative and qualitative, research to fully understand the ex-ante evaluation of RPA project profitability.

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Appendices

Appendix 1

Table 1. Summary of the research literature sources for Chapter 2.1 of the literature review.

Reference	Title	The goal of the paper
Aguirre & Rodriguez (2018)	Automation of a Business Process Using Robotic Process Automation (RPA): A Case Study	A case study was conducted on a BPO provider to verify the benefits and results of applying RPA to a service business process with front and back-office activities
Anagnoste (2017)	Robotic Automation Process - The next major revolution in terms of back-office operations improvement	The paper will analyze also the most important vendor providers of RPA solutions on the market and will provide specific case studies from different industries, thus helping future leaders and organizations taking better decisions.
Cooper, Holderness, Sorensen & Wood (2019)	Robotic Process Automation in Public Accounting	This study is the first to discuss the benefits, opportunities, and challenges to implementing RPA in accounting and serves as a catalyst for future research.
Dey & Das (2019)	Robotic process automation: assessment of the technology for transformation of business processes	We examine how robotic process automation (RPA) can be deployed as a technology solution in business processes and services as a transformation lever beyond traditional business process management and outsourcing.
Doguc (2020)	Robot Process Automation (RPA) and Its Future. Handbook of Research on Strategic Fit and Design in Business Ecosystems	This chapter will introduce the technologies used in RPA applications and discuss the future of RPA.
Fung (2014)	Criteria, use cases and effects of information technology process automation	The objective of this study is to shed some lights on ITPA criteria, use cases as well as the effects ITPA brings. The effects include the benefits as well as negative effects of ITPA.
Geyer-Klingeberg, Nakladal, Baldayf & Veit (2018)	Process Mining and Robotic Process Automation: A Perfect Match	Within this paper, we illustrate how process mining supports organizations throughout the lifecycle of RPA initiatives.
Hallikainen, Bekkhus & Pan (2018)	How OpusCapita used internal RPA capabilities to offer services to clients. MIS Quarterly Executive	This article describes the RPA journey of OpusCapita, a BPO provider that first created a strong internal RPA capability and then extended its operations to providing RPA services to clients.
Hindel, Cabrera & Stierle (2020)	Robotic Process Automation: Hype or Hope?	To objectively discuss the strengths and weaknesses of this technology, we conduct a literature review, a practical implementation of an RPA solution, and an interview with an industry expert. We reveal that the current literature primarily focuses on economic factors. This paper, therefore, adds various social and technical aspects to the discussion.
Hughes & Scott-Morton (2006)	The transforming power of complementary assets. MIT Sloan Management Review	The article discusses changes in information technology and the ability of businesses to exploit investments in complementary assets.
Kim & sanders (2002)	Strategic actions in information technology investment based on real option theory	This paper develops a framework of strategic actions based on real option theory.
Koi-Akrofi (2017)	Evaluation methods, frameworks, and models	This works aims to review a number of these frameworks/models and methods to see the way forward in this business of IT investments justification.

Lacity & Willcocks (2016a)	A new approach to automating services	This article focuses on robotic process automation (RPA)-- the tools and platforms that deal with structured data, rules-based processes, and deterministic outcomes.
Lacity & Willcocks (2016b)	Robotic process automation at Telefonica O2	The academic researchers at the Outsourcing Unit (OU) aim to assess the current and long-term effects of business services automation on client organizations.
Lacity, Willcocks & Craig (2015)	Robotic process automation: mature capabilities in the energy sector	The academic researchers at the Outsourcing Unit (OU) aim to assess the current and long-term effects of business services automation on client organizations.
Luehrman (1997)	What’s it worth? A general manager’s guide to valuation	A general manager's guide to valuation. Timothy Luehrman presents an overview of the three tools, explaining how they work and when to use them.
Meironke & Kühnel (2022)	How to Measure RPA's Benefits? A Review of Metrics, Indicators, and Evaluation Methods of RPA Benefit Assessment	In this paper, we identify 62 distinct metrics/indicators and ten evaluation methods used for assessing RPA benefits.
Mills, Rowbotham & Robertson (1998)	Using economic profit in assessing business performance	The paper uses economic profit to assess performance: A metric for modern firms
Myers (1974)	Interactions of corporate financing and investment decisions: implications for capital budgeting	The purpose of this paper is to present general approach for analysis of interactions of corporate financing and investment decisions, and to derive the approach's implications for capital investment decisions.
Peppard & Ward (2005)	Unlocking sustained business value from IT investments	Unlocking Sustained Business Value from IT Investments: Balancing Problem-Based and Innovation Based Implementations
Radke, Dang & Tan (2020)	Using Robotic Process Automation (RPA) to Enhance Item Master Data Maintenance Process	This research demonstrates the potential benefits of applying robotic process automation (RPA) technology in master data management based on two companies in the manufacturing industry.
Shank & Govindarajan (1992)	Strategic cost analysis of technological investments	The authors discuss the limitations of four current approaches and show how their own framework - Strategic Cost Management - applies to a large forest products company that is making a decision on a major technological innovation.
Siderska (2020)	Robotic Process Automation — a driver of digital transformation?	The paper introduces Robotic Process Automation (RPA), which is an emerging and cutting-edge conception of business processes automation, based on the notion of software robots or artificial intelligence workers. The paper is conceptual as it discusses the fundamentals behind this idea, synthesizes the knowledge of technology, and presents it in a new context.
Syed, Suriadi, Adams, Bandara, Leemans, Ouyang, ter Hofstede, van de Weerd, Wynn & Reijers (2020)	Robotic Process Automation: Contemporary themes and challenges	This paper presents a structured literature review that identifies a number of contemporary, RPA related themes and challenges for future research.
Viehhauser & Doerr (2021)	Digging for Gold in RPA Projects – A Quantifiable Method to Identify and Prioritize Suitable RPA Process Candidates	The goal of this paper is to develop a generalizable method to detect, prioritize, and select process candidates for the automation with RPA.
Vitharanage, Bandara, Syed & Toman (2020)	An Empirically Supported Conceptualisation of Robotic Process Automation (RPA) Benefits	This paper presents the findings of an exploratory case study that investigates the benefits of RPA at an Australian University.
Wewerka & Reichert (2020)	Robotic Process Automation - A Systematic Literature Review and Assessment Framework	This paper presents the state-of-the-art in the RPA field by means of a Systematic Literature Review (SLR).
Willcocks, Lacity & Craig (2015a)	The IT Function and Robotic Process Automation	The academic researchers at the Outsourcing Unit (OU) aim to assess the current and long-term effects of business services automation on client organizations.
William & William (2019)	Improving Corporate Secretary Productivity using Robotic Process Automation	We aim to develop an RPA system that supports Corporate Service Providers (CSP) in Singapore with their annual compliance processes for its clients and their ad-hoc requests or inquiries from its clients.

Appendix 2. GitHub repository link to Excel template of the numerical example calculations (Chapter 3.3.4)

This appendix provides a link to a GitHub repository that contains an Excel template. The Excel template includes all the necessary calculations for the numerical examples used to validate the framework developed in the thesis. The repository serves as a valuable resource for readers interested in replicating or further exploring the results presented in Chapter 3.3.4. The repository is available here.