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Business process improvement opportunities: a framework to support business process redesign

Master's Thesis (30 ECTS)

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Business process improvement opportunities: a framework to support business process redesign

Abstract:

Business processes are a key asset of the organization that largely determines its efficiency. Organizations interested in an efficient performance constantly look for improvement opportunities in their processes. While there might be various improvement opportunities in the business process, it is not always possible to detect them based on the best practices, previous experience, or assumptions. This research aims at collecting and structuring existing knowledge about business process improvement opportunities. The research is performed by the means of systematic literature review and focuses to discover how improvement opportunities can be identified in the business process and how the process can be improved. Based on the results, a framework of improvement opportunities is developed to support the practitioners in business process redesign.

Keywords:

Business process improvement, business process redesign, improvement opportunity, framework, systematic literature review.

CERCS: P170 Computer science, numerical analysis, systems, control

Äriprotsessi arendamise võimalused: raamistik toetamaks äriprotsesside ümberkujundamist

Lühikokkuvõte:

Äriprotsess on ettevõtte võtmetähtsusega vara, mis suuresti määrab ettevõtte efektiivsuse. Ettevõtted, mis soovivad efektiivset tootlust, otsivad pidevalt võimalusi oma äriprotsesside täiustamiseks. Olgugi, et võib leiduda mitmeid võimalusi äriprotsesside arendamiseks, ei ole neid alati võimalik tuvastada heade tavade, varasemate kogemuste või oletuste abil. Käesoleva uurimistöö eesmärk on koguda ja struktureerida varasemaid teadmisi äriprotsesside arendamise võimaluste valdkonnas. Uurimistöö raames tehakse süstemaatiline kirjanduslik ülevaade, leidmaks viise kuidas äriprotsessis täiustamise võimalusi tuvastada ja protsessi paremaks teha. Tulemuste põhjal koostatakse arendamisvõimaluste raamistik toetamaks äriprotsessi ümberkujundajate tööd.

Võtmesõnad:

Äriprotsessi arendamine, äriprotsessi ümberkujundamine, arenemisvõimalus, raamistik, süstemaatiline kirjanduse ülevaade.

CERCS: P170 Arvutiteadus, arvanalüüs, süsteemid, kontroll

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1 Introduction

Organizations, concerned about their efficiency, constantly look for the improvement opportunities. Improvements can be approached from different perspectives: a company may focus on enhancing its business strategy, exploiting new opportunities identified on the market, fostering the corporate culture and employee motivation, adapting its organizational structure, cooperating with key market players or improving the quality of the product. Another way implies focusing on the business processes of the company. Business processes form the foundation of each organization's operation. The way the processes are established and managed determines the effectiveness of the production, the ability of the company to adjust its performance to the changing environment, the cost and revenue structure of the company, the potential for further development and improvement [1].

Being a primary asset of the organization, processes should be carefully managed. Business process management is a discipline that focuses on management and improvement of processes in the organization. It embraces process identification, discovery, analysis, redesign, implementation, and process monitoring and controlling. Improving the business processes refers to finding the most efficient way of how the sequences of events, activities and decisions are structured and executed [1]. Thus, it is essential to understand what problems can be found in the process, which parts and components of the process can contain issues to be improved. Moreover, even if no immediate issues are detected, the process can have some hidden potential for improvement. Improvement opportunities refer to the weaknesses of the process and areas of potential improvement. They can be identified by revealing certain patterns that indicate the presence of improvement opportunity. By detecting the improvement opportunities in the process, the company gets the possibility to understand which parts of the process can be modified so that to achieve process improvements. Business process redesign focuses on addressing the improvement opportunities and enhancing the process with the application of numerous redesign principles. The redesign can be a one-time activity to fix some process issues and reduce wastes. However, constant process improvement can bring more value for the organization proposing a permanent aspiration towards the efficient process performance. In order to improve the business process efficiently, certain redesign patterns can be applied. Redesign patterns are established guidelines or rules describing how an opportunity can be addressed to make the process more efficient.

There are numerous studies in the process improvement area, describing the identification of improvement opportunities and the application of process redesign. However, there is no systematic review of the possible improvement opportunities. Although the identification of improvement opportunities is described in different studies, the case studies on process redesign imply finding the opportunities for improvement, it might be problematic for redesign practitioners to cover all the existing publications in search of the necessary information. Thus, in attempts to identify the improvement opportunities, the practitioners rely mainly on best practices, their previous experience, creativity, and assumptions. This can limit the possibility to identify all possible improvement opportunities and achieve the most efficient result from the process redesign.

The primary research objective of this thesis is to discover how business processes can be improved. The main research questions are targeted to identify how improvement opportunities can be detected in the business processes and how these opportunities can be addressed. Moreover, the thesis aims to answer the questions of which levels and aspects of the process can be examined to identify the improvement opportunities. The contribution of this thesis is a list of improvement opportunities and corresponding redesign patterns which

can give a practitioner a clear overview of a range of opportunities for improvement that can be detected from the process, and methods which can be used to improve the process performance. Based on the research results, the framework is proposed that summarizes and categorizes the business process improvements against the level of the process, aspect of the process and improvement opportunity similarity. The framework would serve as a structured "catalogue" for the business process managers to support their efforts in detecting improvement opportunities as well as would provide ideas of how the identified opportunities can be addressed. Researchers in the field of business process management and engineers can further elaborate the framework to enrich it with the improvement opportunity identification rules and evaluation techniques which can be applied in process mining purposes. In order to answer the research questions, first, a systematic literature review will be performed so that to extract all the data relevant to the aim of the study. Then the gathered data will be structured and analysed to identify and map improvement opportunities with related aspects. Finally, the framework will be developed to demonstrate the results of the research.

The rest of the thesis is structured as follows. In Section 2 the concepts of business process management, process improvement and redesign are introduced, the notions of improvement opportunity and redesign pattern are explained. Section 3 embraces the related work and depicts the research gap this paper aims to cover. Section 4 describes the strategy and procedure of the systematic literature review. In Section 5 the results of the systematic literature review are provided. In Section 6 the framework is presented and discussed, covering the motivation of improvement opportunity categorization, definitions of improvement opportunities and redesign patterns, as well as framework application ideas. Section 7 describes the threats to the validity of this research, and Section 8 concludes the paper with a research summary.

2 Background

In this section, the relevant background is presented so that to introduce key concepts and notions used in the research. The section covers the definition of a business process, continues with the description of the business process management field, describes the business process improvement area, and introduces the terms of business process improvement opportunity and redesign pattern.

2.1 Business processes

In defining the notion of the business process, authors most commonly refer to the transformation of inputs into outputs through the execution of a set of activities. Thus, according to Hammer and Champy [2], a business process is "a collection of activities that takes one or more inputs and creates an output that is of value to the customer". Davenport [3] defines the business process as "structured, measured set of activities designed to produce a specified output for a particular customer or market". It is also highlighted that the main emphasis is on how the work is done rather than what output is produced by this work. Dumas et al. [1] detailed the definition and stated that business process is "the chain of *activities*, *events*, and *decisions* which are performed by the organization to deliver *value* to its *customers*". Based on the given definitions, the process is supposed to have a clear structure and contain an input, a set of activities, events and decisions, execution of which produce a certain *outcome* that delivers value to the customer. The notion of business process possesses a value-adding perspective [4] meaning that any process has to provide value to the customer as a result of its execution, where customer can be either an organization's client, another company, industrial unit, department, worker, or another process. A business process has also several aspects such as *actors*, referring to process participants including humans, organizations and systems, and *objects*, referring to material and immaterial objects involved in the process execution. Altogether these process components form a structure of a business process. Figure 1 presents the components of a business process and their relations.

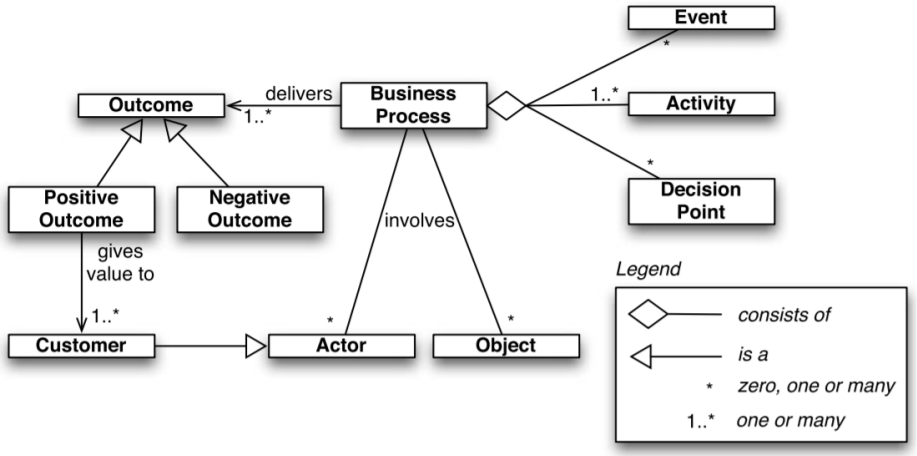

Figure 1. Components of a business process [1].

Business processes have been continuously studying from different perspectives to learn how the business process can be efficiently managed. The efficiency of the processes can be evaluated by the quality of the service it provides and the efficiency of the process itself. The more customers are satisfied with the process outputs and the more efficient are the internal processes of the company, the greater the profit the company will yield. Business processes define the performance of the entire organization, which make it essential for organizations to monitor the performance of the processes and work on their improvement [1].

2.2 Business process management

Since processes are focal assets of organizations on which the performance of the organization is dependent, it is essential to manage the processes properly so that support and improve the efficiency of the company. The body of knowledge which specializes in dealing with the processes is known as business process management. Business process management (BPM) is the field of study which aims at analysing, designing and evaluating the business processes in order to improve their efficiency [1]. Taking its origins from statistical process control [5] and later having a dramatic increase in popularity due to introduction of business process reengineering concepts by Hammer and Champy [2], nowadays business process management is a mature discipline that embraces various knowledge areas such as information technology, management sciences, industrial engineering, software programming, data mining and others. It has established principles, methods, tools, techniques and frameworks, which are used to improve the processes [6].

The entire discipline of BPM can be decomposed in 6 major phases which depict the application of the BPM process: process identification, process discovery, process analysis, process redesign, process implementation, and process monitoring and controlling. In order to demonstrate how the phases are connected and which order they follow, the model was developed which is called a BPM lifecycle (Figure 2).

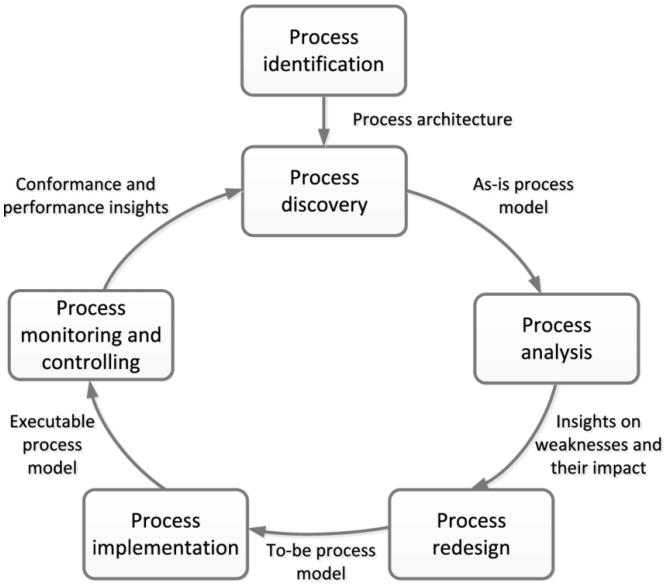

Figure 2. BPM Lifecycle [1]

Process identification is the starting phase of BPM that is focused on the overall process architecture investigation, which includes the enumeration of main processes in a company. The next step, the process discovery, is centred on the current state of a company's business processes. An outcome of this phase is a set of the as-is process models. Subsequently, during the process analysis phase, the "as-is" process models are investigated to identify sources of waste, process weaknesses and flaws, and define the prioritized list of process issues. These identified issues are considered during the process redesign phase when changes are introduced to the business process to eliminate or mitigate existing problems. The goal of the process implementation phase is to establish the updated "to-be" process. Finally, the process monitoring and controlling phase is used to assess the redesigned process performance by collecting and analysing the relevant process performance data. At this stage, new process issues can be found, which might require repeating the BPM cycle [1].

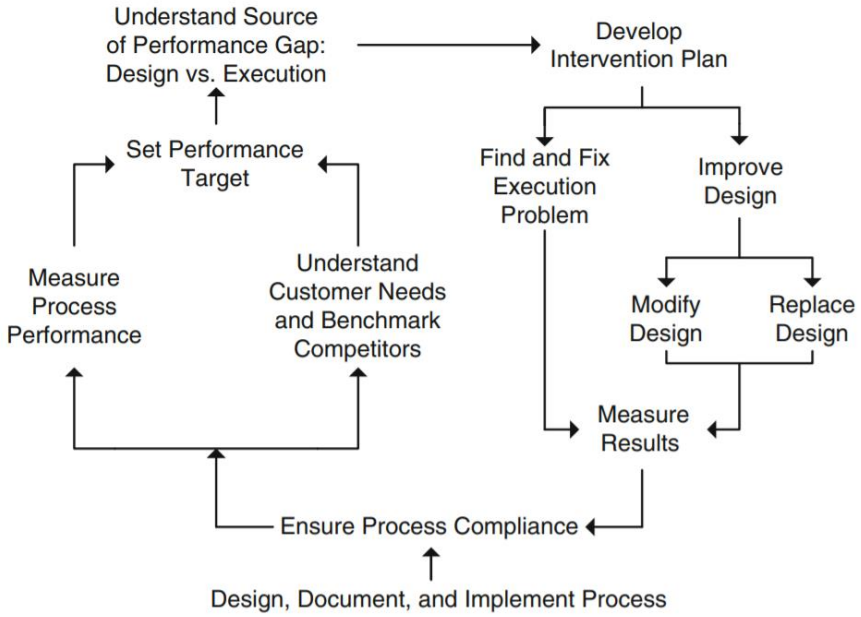

Figure 3. The essential process management cycle [5]

A more detailed view of how business process management functions in practice can be demonstrated by the process management cycle (Figure 3). The process starts from the bottom, where the process is designed, documented, and implemented. This stage comprises the initial process creation from scratch when no process is in place so far. The second stage relates to ensuring that the implemented process meets the process design developed in the first stage, i.e. is built as it was supposed to look like. While developing the process, certain process metrics should be established, based on which the process performance is evaluated once the process is implemented. Therefore, the following stages placed on the left focus on constant process monitoring for the process to meet the aims established by the organization and needs of the customer. The process performance metrics, thus, should be controlled as well as the analysis of the customer needs and benchmarking activities should be conducted. If some process issues are identified, for instance, inconsistency with the process goals, performance problems, or ignorance of the market demands, the performance target is set. With understanding how ideally the process should be performed, the next step is to identify what is lacking that prevents the process to perform according to the established targets. The key idea at this stage is to understand the source of the problem or gap, find the root-cause issue. Once the problem is identified, the strategy for problem elimination is developed. Then, if the problem is relatively small and does not imply sophisticated changes to the process, it is fixed, and the improved process compliance is ensured. However, if the issue is more complex, it might require process modification, or, in a more dramatic case, replacement of the whole process design. The entire cycle is linked in the form of a circle, as this process is a continuous one, i.e. once a new modified process is in place, the whole cycle starts again. Such a process management cycle is currently adopted by most organizations that aim to manage their processes efficiently [5].

2.3 Business process improvement

According to the process management cycle, business process improvement is a significant part of process management in case the organization wants its processes to perform efficiently. This statement can be proved by observing the level of the process performance along the time that is depicted in Figure 4. It can be observed that the performance level of most processes demonstrates a tendency to decrease. Thus, it is impossible to introduce an

efficient process that would keep its performance level without process management. If no improvement efforts are taken the process performance will gradually decrease. However, if the process is carefully maintained, the process performance can be also kept up. When process improvement activity is an on-going process in an organization and efficiently conducted, the process performance level is expected to grow. Process performance breakthrough can be also achieved by introducing a process design or design modification that implies substantial process optimization. However, breakthroughs cannot be achieved in separation from continuous process improvement, since a breakthrough in a natural consequence of constant process improvement and seeking creative ways for making processes better [7].

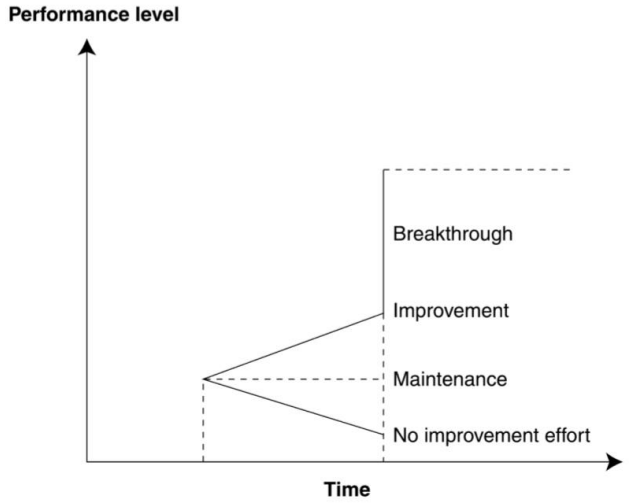

Figure 4. Process performance level over time [7].

First steps towards process improvement lie in process analysis. There are various techniques used for analysing the processes: problem analysis, root cause analysis, activity-based costing, benchmarking, outcome analysis, technology analysis, business process analysis and activity elimination are among them [8]. Moreover, different methods can be applied for process analysis, such as process modelling and model analysis, performance metrics analysis, process simulation and process mining. All these methods are constructed to find the points of where the process can be improved, i.e. identify improvement opportunities. In studies opportunities for process improvement are also referred to as process weaknesses and items with improvement potential. In order to be considered and identified as a weakness or item with a potential for improvement, a certain distinguishable pattern should be observed that is called a weakness pattern [9]. Based on the definitions of the related notions, a business process **improvement opportunity** can be described as a pattern in the process execution that demonstrates weakness or has potential for improvement. An example of improvement opportunity can be *Verification causing document requests*. This improvement opportunity relates to the situation when the data verification activity reveals a significant number of errors and inconsistencies, hence, additional documents are requested to obtain correct data. As a result, the process disruptions occur, as well as extra efforts are applied to request the documents and conduct the verification again [9]. Therefore, the process can be potentially improved by addressing this process weakness.

Business process redesign is the phase of the BPM lifecycle which implies an active process restructuring to address the identified process weaknesses and constantly improve the process performance. The key aspects of the redesign process can be expressed with 3 questions: what, how and by whom, that altogether constitute a framework for business process

redesign. It is graphically presented in Figure 5. The framework starts with the "What?" aspect that reflects what are the key objectives a company have in a desire to redesign the process, i.e. what problems it wants to solve. For instance, a company might have too many employees involved in the process causing high process costs. Thus, the company is interested in why there are so many staff and do they need such amount of workforce. This framework aspect could be associated with the improvement opportunities identification. Within the second area, "How?", the company determines how the process restructuring will be approached in terms of modifying tasks and procedures. Aspect "By whom?" in its turn focuses on the question of how to distribute resources within the process and in what order activities should be executed [10]. These sectors include various redesign options that can be taken to improve the inefficiencies, for examples, in Hammer and Champy's study [2] a set of guidelines are presented that can be followed, amongst which are *Reduce checks and controls as much as possible, Make process generic, i.e. use multiple version of the same process, Execute tasks in parallel whenever possible*. For instance, to reduce the number of staff a company might consider automating the process instead of using human resources for its execution.

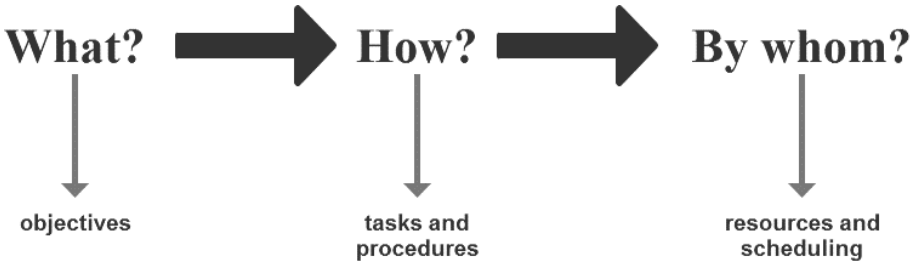

Figure 5. Business process redesign framework [10]

The process redesign can be enabled through the numerous redesign heuristics. Heuristic itself is a rule of a thumb for the process execution. Some of the heuristics give clear instruction of what changes should be adopted in the process to fix the identified flaws, others rather provide a guideline of which direction to take [1]. The BPR heuristics, which can be also referred as **redesign patterns** [11], is a set of principles that are used as guidelines for the practitioners in an attempt of the process improvement, as above-mentioned guidelines proposed by Hammer and Champy [2]. Redesign pattern can be also described as "a three-part rule, which expresses a relation between a certain context, a problem, and a solution". The key aim of the redesign pattern is to transform a business process from an "as-is" state to a desired "to-be" state, i.e. enable the act of process improvement [11].

A redesign pattern can be explained with the metamodel, that is depicted in Figure 6, where a redesign pattern is referred to as a BPI pattern. This model helps to highlight which attributes a redesign pattern has and the nature of links with other objects. A *pattern* has a single *problem, context,* and *solution*, i.e. a certain redesign pattern is aimed at solving a certain problem in a context, providing a solution to it. The *solution* implies having a *mechanism* of redesign introduction and might have one or more *building blocks*. By mechanism, a specific procedure is meant by which the solution is implemented, for instance, if the redesign solution implies task elimination, then the mechanism is "elimination", i.e. removing it from the process. Thus, the mechanism alone does not represent the pattern but rather demonstrates the proceeding. Building blocks refer to the pre-build models for implementation that can be directly applied to the process model. As a result of the application of a redesign pattern a certain *effect* is expected, that relates to a certain improvement in process

performance. *Performance indicator* demonstrates, then, which performance measures and to which extent are improved [11].

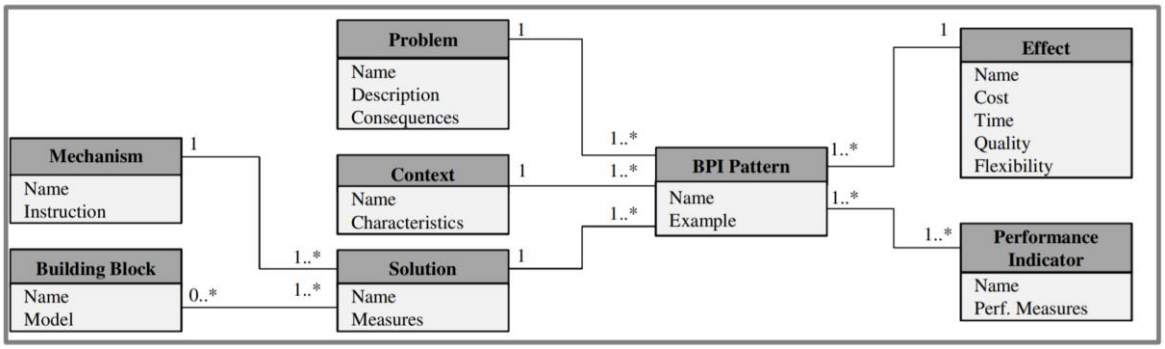

Figure 6. Redesign pattern metamodel [11].

Redesign patterns are targeted at improving different process areas. Thus, the following pattern categories are distinguished based on which component of the process the redesign pattern is applied to fix. Among these categories are *customer* (focusing on customer interaction), *business process operation* (focusing on how the workflow is executed), *business process behaviour* (focusing on when the workflow is executed), *organization* (considering mostly resource allocation and usage), *information* (considering data used in the process), *technology* (focusing on applied technologies), and *external environment* (considering company interaction with the third parties). An example of redesign pattern from the customer interaction category can be "control relocation" pattern that proposes to move control activities close to the customer interaction. For instance, when applications or other documents are received from the customer and document verification is needed, this control activity should be placed right after the document is provided by the customer. Thus, in case an error or missing data is detected, the customer can immediately fix the issue which prevents long waiting times and reworks [12].

The nature and influence of various redesign patterns provide practitioners with broad opportunities in process redesign. The process improvements can be introduced in a transactional manner, implying only minor changes to some specific process entities. Radical changes of the process, also referred to as transformational, imply renouncement of the initial process and designing a new one from scratch. Transformational process redesign has formed a separate sub-field of the business process redesign called business process reengineering. Such process transformations are usually a long, challenging and costly activity for the organization and not always bring the result the practitioners expect it to deliver due to various reasons, starting from the inefficient redesign decisions to unpredicted changes in the environment. Thus, it is of the increasing importance of constant process improvement using methods and tools of monitoring and adjusting the processes in real-time. Redesign methods can be creative, requiring creative thinking from the redesign practitioners, and of more analytical, or mechanic, nature, implying the application of precise rules and procedures [13].

Once the redesign is introduced, the process performance is evaluated to measure the degree of improvement. Typically, when measuring the improved process performance, the framework called "The Devil's Quadrangle" is reminded. This framework introduces the four major dimensions in which the process performance can be improved, that are time, cost, flexibility, and quality. The main objectives that are set in front of the process redesign are to reduce the time of the process execution, decrease the costs associated with the process handling, increase the flexibility of the process that is represented in the ability of the

process react to changes, and enhance the quality of the process. The revealed regularity in process improvement formulated the rule which grounded the name of the framework: once improving one of the process dimensions, the weakening of other dimensions may occur. Hence, it becomes problematic to come up with such a redesign formula, that will "cure" the process regarding time, cost, flexibility, and quality parameters simultaneously. For instance, when the process cycle time is rather long and needs to be decreased, one of the redesign options can be to add more resources to the process, so that there will be more capacities in the process, such as additional workers, who will take a certain part of the responsibilities, thereby speeding up the process. However, while the process cycle time will decrease, the costs spent on the additional resource involvement will become higher at the same time [1]. Figure 7 depicts a visual representation of the framework "The Devil's Quadrangle".

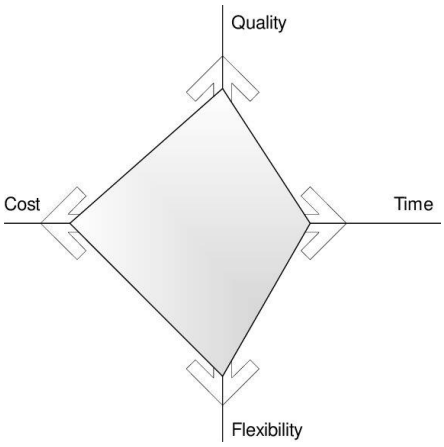

Figure 7. The Devil's Quadrangle [14]

In conclusion, processes lie in the foundation of every organization. For the processes to perform efficiently, they should be properly managed. Business process management is a field of study that focuses on process management and improvement. It is a broad field covering such phrases as process identification, discovery, analysis, redesign, implementation, monitoring and controlling. For the process to perform efficiently, continuous process improvement is necessary. By identifying process improvement opportunities, lying in various aspects and parts of the processes, and addressing these opportunities by suitable redesign patterns, process improvements can be achieved. The perspectives of time, cost, quality, and flexibility are used to measure the business process performance.

3 Related Work

In this section, an overview of the related work is described concerning studies on business process improvement opportunities, papers conducting systematic literature reviews of works in the business process improvement field, and studies aimed at developing frameworks structuring and systemizing knowledge in business process improvement.

Improvement opportunities are not thoroughly investigated and described in the current literature as far as improvement opportunities themselves were commonly not the key subject of the conducted research but rather stayed out of the focus of business process improvement studies. However, works conducted in broader or contiguous areas to the field of identification of the business process improvement opportunities can be considered as related since they incorporate identification of the improvement opportunities, apply similar research approaches in the business process improvement field and/or attempt to develop frameworks to support the business process redesign practitioners in applying process changes.

Anand and Gnanzou [15] researched the question of the current level of development of business process management, business process reengineering, and business process innovation. By the means of a literature review, 116 articles were examined. The perspective of the paper implies studying the position, state of development and level of application of these fields of knowledge in practice. Moreover, the study attempts to predict potential future research directions. Hence, it provides a higher view on how the business process management areas were developing concerning the geographical areas of the conducted researches, the publication resources (libraries) used, the research approaches applied, the components, topics and application areas they targeted. For instance, it was revealed that all the examined business process areas demonstrated a high number of studies regarding customer management and resource management, hence it can be expected that in this thesis improvement opportunities can be largely discovered in the process parts where customers are involved or concerning the resource usage. Although the paper provides a structured view of the field development and studies saturation within the defined business process management areas, it does not provide a sufficient level of detail to examine the certain parts of the business process improvement. This thesis has a different scope and aims to discover the business process improvement at a lower level of detail, focusing on the identification of business process improvement opportunities and redesign patterns.

Kettinger and Teng [16] in their work study how the process of the business process redesign (BPR) is conducted, namely which stages it is comprised of, which activities are performed, which techniques and tools are applied. The profound study uses various methods of research and is based on the results of a systematic literature review, market assessment, and semi-structures interviews. The research aimed to develop an understanding of the BPR process and introduce a framework that can support the practitioners in selecting techniques that can be used throughout this process. First, they introduced a Stage-Activity framework where the stages of the BPR process were mapped with the activities conducted at each of the defined stages. Then, with the means of a comprehensive survey of commonly used BPR techniques and tools, the framework was enriched with the description and mapping of each activity with relevant techniques and tools. The research resulted in a framework with detailed descriptions of each stage of the BPR process, depicting how the BPR process can be conducted. However, the exact results that can be achieved by the application of the described techniques are out of the scope of this paper, hence the paper does not speculate on the possible improvement opportunities that can be identified. Thus, the focus of this paper is the BPR techniques and how they can be selected, when this thesis is to cover the results of the application of specific redesign techniques.

The most recent related work dated by the year 2019 by Gross et.al. [3] presents a systematic literature review of 98 relevant papers performed to identify the redesign methods. Based on the obtained results a framework was developed to support business process redesign practitioners in selecting suitable redesign methods concerning the needs of the process change. The framework comprises 98 redesign methods and categorizes them according to 6 parameters: analytical and creative, inward-looking and outward-looking, transactional and transformational. Although the mapping of the redesign methods provides us with a broad general overview of the redesign method categorisation, the paper leaves out of the scope the description of method application. Thus, while this paper aims to support the redesign practitioners in selecting the suitable methods for process change, this thesis is to contribute providing describing how to detect the parts to be changed and what are the ways to change them.

Majority of the identified related work is concentrated in the business process redesign area with a focus on redesign patterns used for process improvement. One of such papers is Reijers and Mansar's study [12] that overviews the collection of the best practices in business process redesign which the authors derived from the literature survey and their own experience in business process redesign. It presents a detailed description of a successful business process redesign patterns that were proved to be efficiently applied by practitioners in the business process redesign attempts. Altogether the authors identified and described 29 best practices. The paper also introduces a framework that structures the gathered relevant data on them. The following aspects of the redesign patterns are covered in the framework: (1) definition of the redesign pattern; (2) impact of the redesign pattern application along the dimensions of cost, flexibility, time, and quality of the process; (3) identified limits of the redesign pattern; (4) references to the studies the redesign pattern was derived from; (5) applied techniques to implement the redesign; (6) tools which can be used to support the pattern application; (6) application examples from the referenced studies. Although the paper provides an overview of a broad variety of patterns, the study does not state that the list of patterns is complete. The focus of the paper is to provide the collection of the best, meaning the most used and resulting, patterns which proved to be efficient based on the examined studies and the practical experience of the authors. Moreover, after the paper publication process mining was introduced which brought broader opportunities of process examination and hence, might contribute to the identification of other approaches of process redesign. Thus, the thesis is to enlarge the collection of the describes redesign patterns and, in addition to that, match well-known and newly described redesign patterns with the improvement opportunities they can address.

Another paper presenting a systematic literature review on the business process redesign patterns is the work by Leggat et.al. [17] It reflects on the redesign heuristics applicable for the redesign of hospital care provision processes. The paper reviews 41 case studies in healthcare institutions, identifies applicable redesign techniques and describes their influence on the process performance. Similar research is performed by Curatolo and Huet [18] where the literature review was performed to identify the lean methods for the hospital process improvement. With their scope narrowed down to one industry, selected process types and approaches these papers leave the opportunity to broaden the study by including other industries and process types in the research. Within this thesis the scope is not connected to any selected industry, thus, might contribute by identifying additional patterns.

Concerning the related work in process analysis area, and specifically works examining the identification of business process improvement opportunities, there is a relatively low number of papers in this field, however, several related studies were identified. One of them is research by Ghidini et.al. [19] where a systematic literature review of the existing methods

in predictive process monitoring was performed. Their research resulted in developing a value-driven framework for selecting a predictive monitoring algorithm that would provide a company with an efficient means for analysing their business processes. The focus of the work was toward how the improvement opportunities can be identified with the application of process mining instruments and how to choose the best-suiting predictive monitoring algorithm concerning the process characteristics and organization needs, rather than what are the possible improvement opportunity that can be identified. Hence, the study under discussion and this thesis differ in the scope of the research.

The topic of identification of the improvement opportunities from the process models was closely examined in a work by Becker et.al. [20] In this paper, different types of weaknesses were examined utilizing automatic semantic analysis of business processes. By weaknesses, they understood the flaws in the process that could be potentially improved. In order to detect theses weaknesses, semantically analysable business process models from the banking sector were used. Thus, they managed to identify and describe 19 weakness patterns from the analysed business process models. Another study, that elaborates the findings of the previously mentioned paper, is the research conducted by Delfmann and Höhenberger [21], where they attempt to collect the process weakness patterns and introduce automatic model query approaches for these patterns identification. The conducted empirical study comprised of an analysis of several hundreds of weakness-afflicted process models from the business domain of public administration. As a result, 280 weakness patterns were identified and then categorised based on the issue similarity. Although the topic of these research papers highly correlates with this thesis's theme, their scopes differ, as far as these papers limit their scopes of the research towards a particular sector and derive the weaknesses based exclusively on the process model analysis. Moreover, they claim that the limited amount of process models was examined, thus the weakness collection could be incomplete. Hence, potentially other improvement opportunities could be identified that are not common for the selected business sectors and/or are not reflected in the provided business models.

Although the related work papers used similar approaches for the research and had complementary aims, none of these studies comprises the collection of the improvement opportunities derived from the existing research and case studies in the business process improvement field. The thesis contributes to the research with the systematic literature review of relevant publications and development of the list of business process improvement opportunities. The framework is proposed where the identified improvement opportunities are categorised against the criteria of level of the process, aspect of the process and opportunity similarity. This framework can be used by the business process redesign practitioners to navigate through the variety of possible opportunities for process improvement and provide the ideas how these opportunities can be addressed, thus, the process can be improved.

4 Systematic Literature Review

4.1 Planning and Motivation

This section presents the methods and procedure of systematic literature review (SLR). The SLR was executed in compliance with the guidelines proposed by Kitchenham [22]. The stages of SLR comprise three main phases that are planning, conducting, and reporting the review. The planning phase includes identification of the need for a review and formulation of the motivation, specification of the research questions, developing and evaluating the review protocol. The conducting of the review phase considers the studies identification, selection of primary studies, study quality assessment, data extraction and data synthesis. Finally, the reporting phase comprises the specification of the dissemination mechanisms as well as formulation and evaluation of the final report [22].

The objective of the SLR is to identify how business processes can be improved. Three main focus areas of the SLR comprise 1) the identification of the improvement opportunities in the business processes, 2) identification of the redesign patterns applied for the business process improvement, and 3) the link between the improvement opportunities and the redesign patterns, i.e. with which redesign patterns the defined improvement opportunities are addressed. The means of SLR is applied to obtain a complete notion in this research topic as far as SLR allows to summarise the relevant existing findings using a well-defined structured methodology that ensures the results of the reviews to be less likely biased compared to the ad hoc reviews [22].

4.2 Research Questions

This SLR is aimed at identifying and examining the relevant publications on business process improvement. The objective of the research is reflected in a series of more concrete research questions. Based on defined objective and focus areas, the following research questions (RQ) are formulated:

(1) **RQ1: How improvement opportunities are identified in business processes?** This research question refers to the identification of patterns within the process or process characteristics that indicate the opportunity for improvement.

(2) **RQ2: At what level of the process are improvement opportunities identified?** Improvement opportunity can be located at the level of the whole process, parts within a process, or at the level of activities. This research question aims to address the level of process hierarchy where the improvement opportunities are identified.

(3) **RQ3: What process aspects are considered for identifying improvement opportunities?** Business processes have different aspects such as, amongst others, activities, events, decision points, resources, or objects. This research question aims at discovering which aspects are examined to detect improvement opportunities.

(4) **RQ4: How are the identified improvement opportunities addressed (redesigned)?** This research question aims to discover what changes were proposed and/or applied in the process for each identified improvement opportunity to improve the process performance.

4.3 Search Strategy

The search strategy used in this SLR is based on the recommendations provided in studies and guidelines on conducting the SLRs [23], [24], [25]. In order to ensure that all the relevant studies are included in the research, the search strategy was developed. The search

strategy comprised the development of the search string and its application to several electronic databases.

The aim was to perform a comprehensive search and identify the initial list of primary studies. In order to develop the search string, the guidelines suggested by Kitchenham [22] were followed. The range of terms used for the search included the following:

(1) "business process" – the term is the key term of the research and describes the foundation of the study.
(2) "process improvement" – the term is derived from the research questions. Due to the fact, that there is no standard notion expressing the given term definition and different sources tend to use term variants, the following terms were also included in the search string:
    a. Process Reengineering
    b. Process Redesign
    c. Process Change
    d. Process Optimization
    e. Process Innovation
(3) "method" – the term is also derived from the research questions and represents the redesign methods applied to the identified improvement opportunities to improve the process performance. Apart from this term, its synonyms can be used in the literature, hence these synonyms are also included in the search string:
    a. Procedure
    b. Technique
    c. Approach
(4) "framework" – the term that covers a structured system of approaches rather than single techniques. By including this term in the search, we aimed to identify and examine the existing frameworks developed in the process improvement field that represent the collection of methods and techniques in business process improvement identification and/or business process redesign.
(5) "case study" – the term demonstrates the empirical interest of this research. As far as the study is also focused on examining the practical cases of how the process improvement opportunities were identified and redesign patterns were applied, the term "case study" is added to the search.

Based on the search terms, the following search string was defined:

(("business process") AND

("process improvement" OR "process reengineering" OR "process redesign" OR "process change" OR "process optimization" OR "process innovation") AND

(method OR procedure OR technique OR approach OR framework OR "case study"))

The search string was applied in several electronic databases. The databases were selected based on the coverage of journal papers in the field of computer science where research on business process improvement is mostly published. The databases were also required to be freely accessed with the university domain. Hence, the following databases were used:

(1) ACM Digital Library,
(2) IEEE Xplore,
(3) Scopus (includes SpringerLink),
(4) Web of Science.

The review was performed by two reviewers, where the workload on research search, selection, and data extraction is equally shared.

Table 1. The total number of papers identified per source.

Source	Total number of papers identified
ACMDigital	2033
IEEE Explore	720
Scopus	1942
WoS	1668
Total	**6363**

The developed search string was applied to each of the selected databases. The search results per source are shown in Table 1. The search result lists from all databases were downloaded and compounded in a single list that composed a total of 6363 publications.

4.4 Paper Selection Criteria

The paper selection aims to identify the papers relevant to the research that provide enough information to address the research questions. The paper selection criteria comprise of inclusion and exclusion criteria:

(1) Inclusion criteria (IC):
   a. **IC1: Is the paper relevant to the domain of business process improvement?** This criterion is aimed at filtering out the papers that the research objective and research field are outside of the scope of the business process improvement domain.
   b. **IC2: Does the paper present, review, discuss, or demonstrate a method or a case for business process improvement?** Based on this selection criterion the studies that represent any theoretical discussion and/or practical application in the field of business process improvement are identified.
   c. **IC3: Does the study describe at least one way of identifying an improvement opportunity or business process improvement/redesign?** This selection criterion is focused on identifying papers containing actual identification of improvement opportunities or redesign of a business process, for instance, in the form of a case study. With this selection criterion, we can ensure that the study contains enough information to address the determined research questions.

(2) Exclusion criteria (EC):
   a. **EC1: Is the full-text version digitally accessible? (I)** Papers accessible via digital libraries subscribed to by the University or available on the Internet in free access are considered as accessible. Papers provided for the payment and not available via mentioned channels, are considered as inaccessible.
   b. **EC2: Is the study written in English? (I)** Papers that are not available in English are considered as unavailable for the review as far as it is impossible to understand them for both reviewers at the same time.
   c. EC3: Does the study format satisfy the scientific paper format? (I) Papers that are journal publications, workshop proceedings, conference proceedings, book chapters are included in the review as far as they have satisfied the recognized well-defined requirements to a scientific publication.

Publications of other types, amongst which are book reviews, proceeding volumes, meeting preprints, are considered as irrelevant for this review.

d. **EC4: Is the paper a duplicate? (E)** Duplicate papers are those where papers with the same title from the same authors published the same year appear in different digital libraries (exact duplicate). Duplicates are also those studies that are published by the same authors with approximately the same topic (version duplicate). In the case of an exact duplicate, only one is included and in the case of version duplicates, the most recent version is included. In case there are duplicates that are conference version and journal version, the journal version is included as far as it contains more data on the research.
e. **EC5: Is the study less than 6 pages? (E)** Papers that are less than 6 pages are excluded from the review as they will not have enough depth to develop the research theme. They are unlikely to describe the identification of the business process improvements and business process redesign to the level of details required by this research.

4.5 Paper Selection Procedure

Based on the defined paper selection criteria, the selection procedure was executed as follows: first, filtering by paper format was conducted, then duplicates and papers containing fewer than 6 pages were removed, filtering by paper title and paper abstract was performed, and finally, fingering by reading the full paper was executed. Further, this section describes each of the filtering stages. Table 2 summarizes the data on the number of papers that were processed and filtered, Figure 8 depicts a visual representation of the paper filtering process results.

Table 2. The results of the application of selection criteria per paper filtering stage.

Filtering stage	**Number of identified papers**	**Total number of papers left**
Primary search results	6363	
Filtering by paper format	145	6218
Filtering out duplicates	1082	5136
Filtering by number of pages	1139	3997
Filtering by paper title	2850	1147
Filtering by paper abstract	529	618
Filtering by reading the full paper	468	**150**

(1) **Filtering by paper format.** On this stage, the publications that are not papers are excluded from the review based on the criteria EC3. Thus, such publications as volume proceedings were filtered out. For instance, the 2008 IEEE Symposium on Advanced Management of Information for Globalized Enterprises, AMIGE 2008 Proceedings dated year 2009 and similar publications were removed from the review publication list. As such, out of a total number of 6363 papers, 145 papers that are non-papers were removed and 6218 papers entered the next round of filtering.

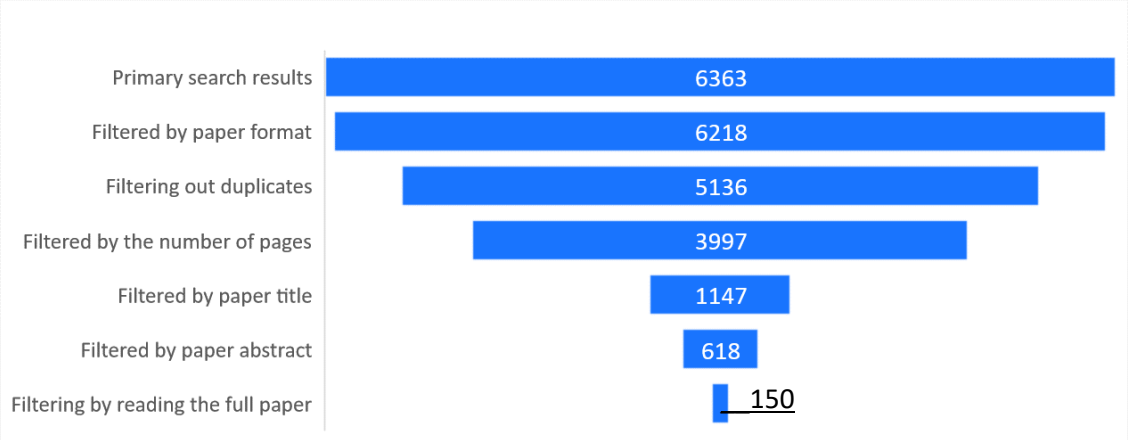

Figure 8. The number of papers per filtering stage.

(2) **Filtering out duplicates.** Since there are 4 resources of paper search, some papers can inevitably occur in several resources, thus creating duplicates in the list of research papers for data extraction. Hence, the next step was to remove the duplicates from the list. 1082 duplicated were identified and removed, leaving 5136 papers for the further filtering stage.

(3) **Filtering by the number of pages.** Based on the exclusion criteria EC5, 145 papers that are less than 6 papers are removed and 6218 papers entered the next round of filtering.

(4) **Filtering by paper title.** The rest of the papers are filtered by the title matching the research topic and question driven by the selection criteria IC1 and IC2. If from the title it is evident that the paper does not relate to the research, such paper is removed from the list. In case it is not clear and/or confusion occurs, the paper is left for the next filtering stage. In the result of filtering the paper title, 2950 papers were considered irrelevant for this research and removed from the list. 1147 papers entered the last round of filtering that is filtering by the abstract.

(5) **Filtering by paper abstract.** Similarly to the filtering by title, this kind of filtering considers paper relevance to the research topic based on selection criteria IC1 and IC2 but this time we examined paper abstracts. When paper abstract gave a clear understanding that the paper is focused on different research questions not connected with this research, such paper was excluded from the list. During this filtering stage, 529 papers were identified as those examining different research questions and removed from the list. As a result, 618 papers formed the final list of papers relevant to the research study and are eligible for the data extraction session.

(6) **Filtering by reading the full paper.** During the data extraction procedure (See Section 4.6) additional 468 of papers were filtered out from the list of relevant studies based on the selection criteria IC1, IC2, IC3, EC1, and EC2 as far as the grounding for paper exclusion can be achieved only when the paper is attempted to be fully reviewed. Thus, out 618 papers resulted from the filtering, 468 paper were removed based on the above-mentioned criteria, resulting in 150 papers included in the data extraction stage.

As a result of the filtering process, conducted based on determined inclusion/exclusion criteria, out of 6363 papers obtained from the primary search, 150 papers were selected as eligible for this SLR.

4.6 Data Extraction Strategy

In order to proceed further with the data extraction stage, the data extraction form was developed. According to [24],[26], and [27] data form allows collecting data in a structured, unbiased and consistent way. The data form is used to map the obtained insights from the paper review during the screening stage. Based on the formulated research questions, the designed data form includes 3 categories of data:

(1) **Identification Data.** Data that helps to identify the paper: paper title and authors, publication year and the number of citations. Moreover, a unique identifier was assigned to each paper to facilitate the paper referencing further in the data analysis stage.

(2) **Context of Study**. This data provides the reader with the context of the study, describing the settings where the study was conducted (industry, the processes that were examined and/or improved).

(3) Process Improvement Method. This block of data describes the method applied in the paper and the aspects this method targeted, including the description of the identified improvement opportunities and the redesign with which these opportunities were addressed.

The data extraction form with the definition of each parameter is presented in Table 3.

Table 3. Data extraction form.

Identification Data	
Id	Unique identifier of the paper
Title	Title of the paper
Authors	Authors of the paper
Publication year	Year of publication of the paper
Citations	Number of citations of the paper
Context of the Study	
Industry	The industry where the case study was performed, the method applied, or the example provided.
Targeted process	The process(es) under examination and/or improvement.
Type of process	Categorization of the process regarding process boundaries of the company: internal, supplier, customer or inter-organizational.
Process Improvement Method	
Hierarchy level targeted	The level of the process where the improvement opportunity is identified: activity, fragment, or process level.
Aspect of the process targeted	The aspect of the process affected by the identified improvement opportunity: activity, resource, data, order, etc.
Improvement opportunities identified	Name of the identified improvement opportunities.

Improvement opportunities description	Description of the identified improvement opportunities, their definitions and examples from the study.
Redesign patterns applied	The improvement methods used to address the identified opportunities.
Redesign patterns description	Descriptions of the redesign patterns used in detail, including how the process is changed and the examples from the study.

Having the primary list of papers filtered and obtaining the list of 150 relevant papers, the data was extracted from them using the designed data extraction form. Papers were equally shared between the reviewers. The data was extracted iteratively. First, a test portion of papers was extracted by both reviewers together. Once the strategy, approach and terminology were agreed on, the reviewers proceed individually. Random checks were also performed. The extracted data was randomly reviewed by a second reviewer and in cases of questions, uncertainty, ambiguity, or differing views, both reviewers examined the paper and used a consensus approach to resolve discrepancies.

4.7 Data Analysis Strategy

The data analysis phase started once the data was extracted from all the papers that met the defined inclusion and exclusion requirement. Following the research questions, the focus on the analysis was to aggregate and summarize the data revealing the improvement opportunities, redesign patterns and the link between them. Based on the natural flow of the business process improvement procedure, where first the improvement opportunities are identified and then the process is redesigned with the appropriate redesign patterns, the data is summarized by the identified improvement opportunities. In order to do so, the data extraction table was examined to distinguish all unique improvement opportunities that were identified from the papers. The data was aggregated based on each improvement opportunity. As the next step of the analysis the improvement opportunities were studied to figure out:

(1) At which level of the process the improvement opportunities are identified,
(2) In which aspect of the process the improvement opportunities lie,
(3) Which redesign patterns are applied to address the identified improvement opportunities?

4.8 Papers Overview

In this section an overview of the papers included in this research will be presented. Based on the set inclusion and exclusion criteria, the total amount of 150 papers were considered eligible for the data extraction. The distribution of the papers over the years of publication is depicted in Figure 9. Few studies were found before the year 2008, where no more than 5 papers were published per year and in some years no studies are present. The main massive of papers examined in this SLR, 78% from all the papers, were published in 2008-2019.

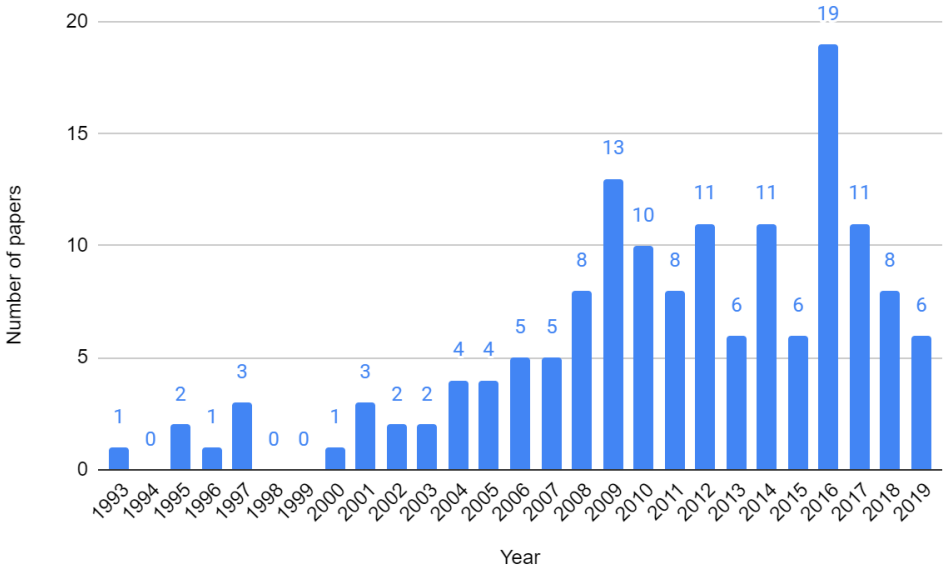

Figure 9. Distribution of papers over the publication year.

The processes under examination and/or improvement described in the SLR papers were categorized regarding process boundaries of the company:

(1) **Internal process**: process within the company boundaries. Examples of such process can be manufacturing process [28], [29], sales forecasting process [30], insurance claim check process [10] and other processes that are performed within the limits of one company and without the involvement of external parties.

(2) **Supplier process**: process that is performed by the company and the supplier, for instance, order fulfilment process in manufacturing [31] that includes process parts executed by the material suppliers.

(3) **Customer process**: process that is performed by the company and the customer, for instance, payment process [32], reservation change process in travel industry [32] or document request process in the public sector [33] that include process parts executed by the customer.

(4) **Inter-organizational process**: process that is performed by several companies mutually involved in delivering the output and/or imply both supplier and customer involvement. For instance, order to cash process [34] that is conducted by two parties, manufacturer and supplier, both of which participate in process execution.

Based on the SLR results, it was identified that a prevailing number of studies is focused on examination and/or improvement of internal processes – 92% of all papers cover the research methods applicable for the internal processes and/or demonstrate their methods on the processes executed within the company boundaries. The complete distribution of the processes over the process type is depicted in Figure 10. It should be noted that the percentages do not summarize to 100% as far as some papers study more than one type of processes.

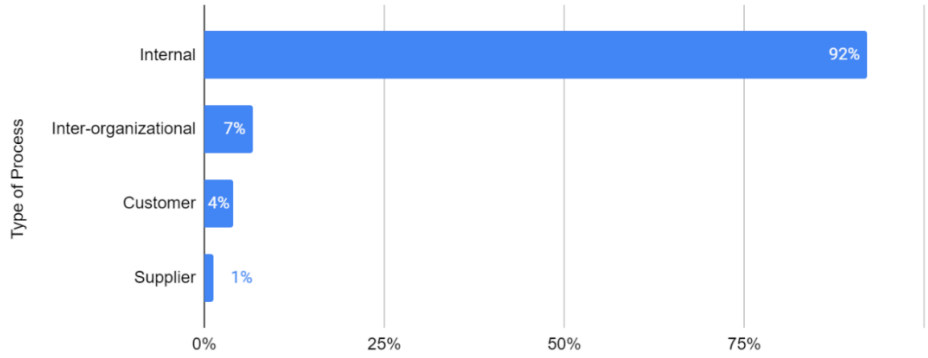

Figure 10. Distribution of papers over the process types.

As a result of the paper overview, the key characteristics can be denoted: (1) the total number of 150 papers met the determined inclusion and exclusion criteria and were included in this SLR; (2) the vast majority of papers (78% of all the papers) were published in 2008-2019 where the whole period of paper coverage comprised 1993-2019; (3) the main focus of the papers (92% of all the papers) is dedicated to the study of the internal processes of the company.

To sum up, the main research aim is to identify how business processes can be improved. The research questions are focused on discovering how the improvement opportunities are identified, what levels and aspects of the process are considered, and what redesign patterns are applied to address the identified improvement opportunities. The means of the systematic literature review is applied to obtain a complete notion in this research topic. The search strategy was developed, according to which 6363 papers were found in the digital libraries. The selection criteria were defined, based on which the papers were filtered. It resulted in 150 papers that are considered eligible for the research. Then, the data extraction and data analysis strategies were developed. Finally, the paper overview was conducted which demonstrated that the interest in business improvement theme increased in 2008-2019. It resulted in a greater number of publications where most of the studies are focused on the internal processes of the organizations.

5 SLR Results

In this section, the results of the SLR are presented. The results description follows the order of the research questions defined in Section 4.2 of this thesis. First, the identified improvement opportunities will be presented. Second, the description of the levels and the aspects of the process where improvement opportunities can be identified is provided. Finally, the results of the redesign patterns examination are described.

5.1 Improvement Opportunities

In this section, the results of the identification of improvement opportunities will be described. With the first research question (RQ1) the aim of identifying the possible improvement opportunities was set. The total amount of 376 descriptions of improvement opportunities were identified within reviewed 150 papers. The data on these improvement opportunities was aggregated and analysed allowing to distinguish and define 101 unique improvement opportunities. The full list of improvement opportunities arranged in alphabetical order is available in Appendix I.

In order to obtain a general view of the identified improvement opportunities, they were analysed so that to determine some similar characteristics the opportunities share and to see if there are some explicit common areas where these opportunities are concentrated. Thus, it became possible to define several vivid types of improvement opportunities.

The first type of improvement opportunities is **Waste**. This type was formulated based on the concept of wastes coming from the Lean process improvement methodology. The notion of wastes implied process components that produce inefficiencies in the process. These improvement opportunities can be associated with the 8 sources of waste: overproduction, overprocessing, waiting, motion, transportation, inventory, defects and behavioural waste (underutilized employees) [35]. 17 identified improvement opportunities can be associated with wastes, amongst which are reworks of a single activity and a section of activities due to errors, production of a defective output that cannot be used, holding a large inventory causing additional costs, product transportations between the processes and motion of employees within the process. For instance, in a manufacturing process where the production line is supported with machinery, defects in the machinery can be identified. Due to these defects, the machines can frequently go out of order. Therefore, the process execution is negatively affected by disruptions in the machines and the process stops until the machine is fixed. These process disruptions and waiting time coming from machine defects produce waste for the process performance and the company in general [36].

Another group of improvement opportunities is named **Non-valuable work** and includes opportunities that do not add much value to the process or do not add value at all. In contrary to the wastes, the nature of the executed work is not always harmful and brings inefficiencies, rather in certain context this work is limited in value and undesirable to have. 10 improvement opportunities were identified which are associated with non-valuable work and included activities that add no value, activities that are necessary for the business execution but not necessary for the customer, that add value but partially overlap each other, unnecessary handovers, and duplicate work. For example, duplicate work relates to the completely identical work in the process/-es. Hence, the emphasis is on the fact that such work is already executed, has the same inputs and outputs, thus the duplication occurs. For instance, in a university faculty processes, the collection of identical information was noticed. On the faculty, two separate timetable databases are maintaining the same data, each of them requires

the corresponding data entries and updates. Here, a duplicate data object is one of the identical timetable databases, when data entries and updates are the duplicate activities [37].

10 improvement opportunities were identified as ones focused on the manual type of work, therefore a **Manual work** category is formulated. Manual work refers to the type of work that is performed by process participants without the aid of any software or technology [1], thus involves direct involvement of the human resource in the execution of this work. An example of such improvement can be a manual data entry, that is the activity implying the process participant manually entering data into the system or a database. For instance, in a university registrar office, there is a matriculation process, part of which implies student registration in the university system. Thus, to register a student, a university employee manually enters students' data into the system. This manual data entry can be considered as an improvement opportunity due to the manual nature of the performed work [11].

Other identified improvement opportunities types were defined such as **Unavailability** (absence of process components necessary for efficient process execution, for instance, unavailability of input in time, **Expensive components** (process components that imply high costs, such as activities that require a high amount of costly resource), **Variants** (variation in process component execution), etc. Some of the improvement opportunities can enter several types, for instance, *"Manual data entries"* can be treated as manual work, however, when manual work is performed by a costly resource, it becomes very expensive and can be seen as the expensive component. Other improvement opportunities standalone out of all the types, as do not demonstrate any explicit similarities with the rest of the improvement opportunities. For instance, "Workarounds" can be defined as temporary process paths taken to reduce known issues or achieve an unsupported objective. Such kind of improvement opportunities can hardly be included in some of the defined types.

In conclusion, data extraction from 150 papers resulted in the identification of 101 unique improvement opportunities. The identified improvement opportunities appeared to demonstrate similarities between each other, meaning focusing on similar issues or areas of the process performance, hence, it became possible to define several improvement opportunities types. Among the most explicit ones are wastes, non-valuable work, manual work, that included the largest number of improvement opportunities within the type. Some of the improvement opportunities, however, appeared to stay outside of any type as does not show sufficient similarity with the defined types.

5.2 Levels of the Process

This section addresses the second research question (RQ2) aiming at identifying the levels of the process where improvement opportunities can be identified. Level of the process defines the level of process granularity where the improvement opportunity can be identified. It was noticed that in attempts to detect the improvement opportunities, some papers tend to examine the process as a whole and/or the relationship between several processes, other papers describe the improvement opportunities identification on a lower level of granularity, considering certain parts of the process rather than the entire process. The rest of the papers focused on the lowest level of detail and inspected the activities and their attributes to find the opportunities to make the process better. Hence, the extracted data shows that improvement opportunities can be identified at the following levels of the process: process level, fragment level and activity level.

Improvement opportunities at the **process level** tend to demonstrate the involvement of the whole process and/or the impact on the entire process. Thus, when the process is examined for the improvement opportunity identification, the practitioners do not examine each

activity, event or decision point, neither do they investigate the groups of activities, or other components of the process involved in the activity or fragment execution. Here, they rather focus on the key performance metrics of the entire process, such as process cycle time, process case costs, process resource utilization, etc. Moreover, they consider characteristics intrinsic to the entire process, such as the level of process complexity [11], the level of automation [38], the value the process delivers [39]. In order to address the improvement opportunities, the redesign guidelines were commonly applied, bringing transformational changes to the process. For instance, in the case study of a car manufacturing company, the cross-docking process was under the examination. The process analysis included the process performance data analysis, and process modelling using the SCOR model (Supply Chain Operation Reference Model). The process was characterized as low performing in terms of time and costs. The analysis revealed weaknesses in the management of this business process, notably on the synchronization of the physical and information flows. The redesign practitioners noted that the advantages of the tracking technology can be applied to improve the management of the process flows and, in addition to that, decrease the time and cost of the process. Thus, technology was introduced to support the whole process [40].

Another perspective at which the processes were approached is the examination of the relationship between several processes. Here the focus is shifted from the process itself to the connections which the process has with other processes. Thus, in this area, at least two processes are involved. In this context, they can be separate processes such as production and delivery processes, and sub-processes of a larger process, such as stages of manufacturing, painting, and varnishing in a production process. The relationship between the processes can consider the level of automation of the link between the processes or reflect in the waiting times between the processes. For instance, an insurance claim process comprises several sub-processes. Considering the sub-process of claim registration and sub-process of claim revision, it was revealed that since the revision process takes a long time, the bidding process cannot start if the revision has not been finalized. Hence, a long waiting time occurs between the claim registration and claim revision, causing all other processes to wait [41].

Improvement opportunities can be also found in a section of activities forming a part of the process but not including the whole process, i.e. at the **fragment level**. Since a sub-process can be also called a section of activities being a part of the larger process, the distinction between the fragment and a sub-process lie in the value-adding perspective. A set of activities alone does not add value to the customer or the contiguous process, whereas a sub-process value reflects in the input produced for the connected sub-process. In order to identify improvement opportunities of this level, the practitioners tend to examine and commonly compare the performance of sections of activities. Therefore, a more detailed look into the process components performance is done. The practitioners examine the performance parameters of the activities and decision points, and then the parts of the process with the greatest performance issues can be identified. These very parts are then examined for the improvement opportunities identification. To address the improvement opportunities at this level, both redesign guidelines and more mechanic redesign patterns are applied. For instance, in an e-government service organisation, a process of Virtual Private Network (VPN) connection request was examined. From the cost analysis of the process, it was identified that the parts of the process which imply connection testing appear to be the most expensive parts of the process. Thus, the improvement opportunity is in certain process

fragments that included activities on testing. This improvement opportunity is addressed by the introduction of a test-robot that allows testing the connection in an automated way. Thus, a technology solution is used to improve the fragments of the process [42].

Similar to the process level, another perspective is the relationship between the fragments. Several fragments should be included in the analysis where the link between them is the focus of the examination. Such connections refer to the presence of the necessary links between the fragments and to the waiting time between them. For instance, in out-patient process, there are several stations where the activities are performed: reception desk, pharmacy, examination room, etc. Activities performed under each of the stations can be considered as process fragments. From the performance evaluation, delay times at the internal medicine department and the pharmacy are observed and are longer than those at other stations. Hence, the improvement opportunity lies in the link between these fragments. One of the proposed solutions was to change the customers' arrival pattern, i.e. make customers arrive at a stable rate so that to reduce the waiting times [43].

Another category of improvement opportunities relates to the **activity level** of the process. Improvement opportunities here are expected to be found in the activity itself and/or in the resources, objects and tools used for the activity execution. These improvement opportunities can be detected by analysis of the activity and its attributes. In order to do so, practitioners tend to use process modelling and process mining tools, so that to get a detailed description of the process performance as well as the performance of each process component. In redesign attempts, a prevailing number of patterns are analytical, leading to transactional changes in the process. For instance, in a company accounting department, the process of payment processing is examined. As a result of process analysis, the manual checks were identified, that are activities requiring manual checks and/or control actions. When the accounting specialists receive bank statements of incoming payments, they manually match them against invoices issued to customers. This is the activity that has an opportunity for improvement that lies in the activity characteristics. In order to address this opportunity, the manual check is automated, which means that the process is not changed, the fragments stay the same, however, a certain activity is modified [44].

In order to understand which level of the process contains the greatest variety of the potential improvement opportunities, the comparison of the number of improvement opportunities by each of the defined level of the process was conducted. Figure 11 depicts the results of this comparison. According to these results, out of the total of 101 identified improvement opportunities:

(1) 33 improvement opportunities are associated with the process as an integral component to detect it,
(2) 30 improvement opportunities are derived from the fragment analysis,
(3) 38 improvement opportunities are identified at the activity level.

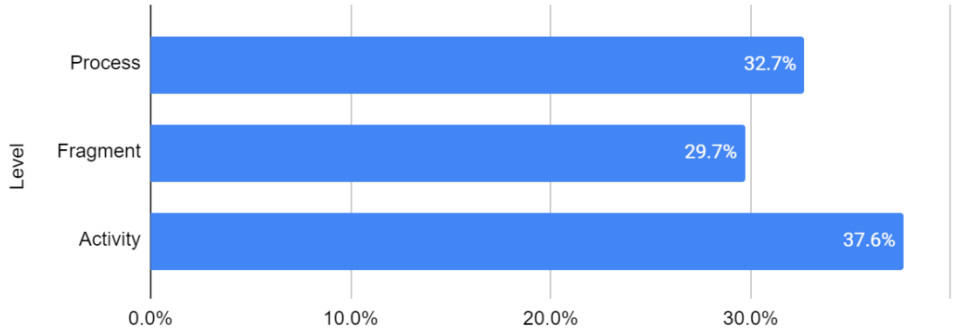

Figure 11. Percentage of improvement opportunities per level of the process.

Thus, most of the improvement opportunities were detected at the activity level, comprising a 38% portion of all the identified improvement opportunities. Approximately 33% of the improvement opportunities were located at the process level, and finally around 30% of them – at the fragment level. Is can be seen that each level of the process has approximately the same number of unique improvement opportunities that can be detected there.

To sum up, the improvement opportunities at the process level consider two perspectives: the entire process and the connections between the processes. The identification of this improvement opportunities is performed via examination of the process performance metrics, such as process cycle time and costs, and process characteristics, as the level of automation of the process. The improvement opportunities are commonly addressed with redesign guidelines focused on changing the entire process. Improvement opportunities at the fragments level also refer to two perspectives: the fragment, as a set of activities not delivering value on its own, and relationship between several fragments. Improvement opportunities are identified by a more detailed analysis of the process components, and commonly involve the comparison of the process fragments in terms of performance and characteristics. Both redesign guidelines and more analytical redesign methods are applied to improvement opportunities at the fragment level. The improvement opportunities at the activity level can be found in the activity and its attributes. They can be identified by analysis of the activity performance and its attributes. At this level, the redesign is commonly made by mechanic redesign and brings transactional changes to the process. Most of the examined papers focused on the identification of improvement opportunities at the activity level.

5.3 Aspects of the Process

In this section, the results answering the third research question (RQ3) are described that is set to identify the aspects of the process where the improvement opportunities can be detected. The notion “aspect” implies any process component participating and/or used in the process. The extracted data revealed that there is a range of aspects which demonstrated the existence of the improvement opportunities. From the extracted data analysis, the total number of 10 different aspects were identified, among which are the following: activity, fragment, process, order, resource, data, time, scheduling, output, and connection.

Activity, fragment, and process aspects refer to a single activity, a part of the process or the entire process respectively as a component where improvement opportunities can be identified. These aspects are derived naturally from the level of the process under examination. The focus is logically on the performance and characteristics of the components under examination: activity at the activity level, a section of activities at a fragment level and an entire process as a whole at the process level. The practitioners inspected the value these components bring, the characteristics such as the level of automation, the deviations in

performance such as deviations in size or cost of execution. For example, the quality of an activity, fragment or process can be examined to detect the improvement opportunities. Thus, at the activity level, activity errors can be considered an improvement opportunity, that are activities that have a higher correlation with quality issues. In addition to that, activity rework can be observed, that are the cases when activities are repeated due to errors. At the fragment level, improvement opportunity of quality type can be seen in a fragment that is inaccurately performed, resulting in errors and fragment rework. Finally, at the process level process can be considered too rigid and difficult to manage due to the sophisticated process structure, thus, the improvement opportunity is process complexity.

Order aspect describes the opportunities of improvement that were identified by inspecting the order in which the process components are executed. Since process fragments and processes themselves are a set of smaller elements, the structure of fragments and processes should be considered. In the examined studies the order of the components was investigated to find the opportunities to improve the process by changing the position of the components. Thus, within a fragment, the order of activities, events and decision points is examined, within a process – the order of the fragments, or less frequently the order of the elements of smaller granularity. Moreover, the order of the processes might be considered, however, such examples are scares. For instance, the order of the activities is inspected in a knock-out process. It is identified that expensive activity is placed earlier, while cheap activity is located later in the knock-out process. It means, that these two activities in a knock-out process are not ordered according to the cost of execution: most costly placed first, hence, their order can be subjected for change [45].

Resource aspect group includes improvement opportunities that lie in the resources participating and used for the process execution. These improvement opportunities are related to the resources and how these resources are utilized in the process. For instance, if the resource utilisation is compared to available resource capacity, it can be found out that the resource demonstrates high or low resource utilisation. In the university registrar office example, in process of matriculation renewal, it was revealed that personnel resources work to capacity having a high workload causing other issues in the process as frequent errors, delays, and overtime work [11]. Another example of inefficient resource utilization is the usage of a scanner in a computed tomography scan process in a hospital. Computed tomography scanner, being a rather expensive resource in the process, is fairly used as far as the contiguous procedures, such as patient registration and observation, took the largest part of the process [46].

Data aspect refers to information objects and flows that can also contain improvement opportunities. Under this aspect, the improvement opportunities were collected where the key focus is on the data used and/or allocated for the process execution. Thus, such characteristics as the value of the data, the quality of the data, data availability, and level of automation of the data flow and data management were considered. For instance, data storage can be organized on paper and managed by the process employees manually. In a government administration process, some activities require looking up legal information available only on paper. This causes problems with the topicality of the information and the time needed to find it, as well as adds costs related to documents storing [9].

Time aspect refers to the waiting times at different levels of the process. This type of improvement opportunities deals with the waiting times occurring within the process or between several processes. Waiting time refers to the time that a case spends in an idle mode, which means that the case is already released from the process component, but for some reason, the sequential component is not ready to take the case into processing. For instance, very often in a health service process, a problem of the so-called "three longs and one short" can be observed. The "three longs" represent the long waiting time for registration, the long waiting time before seeing a doctor, and the long waiting time for buying drugs. Contrary to the "three longs" that may add up to two hours, "one short" indicates that the consult time with physicians is very short, usually around 3 to 5 minutes [47]. Thus, these "three longs" indicate that the case waits for further processing and stays in an idle mode. This aspect appeared to be rather narrow, as it includes only the waiting time, however, potentially other improvement opportunities concerning time aspect can be identified enlarging the variety of this aspect.

Scheduling aspect relates to the activities which execution is based on scheduled condition. In the reviewed publications, the improvement opportunities suitable for this aspect were observed in the context of activity scheduling and its efficiency. For instance, an activity can be scheduled indefinitely when there is a long waiting time before the activity execution can be started. As described in [48], in a patient intake process, when a new case has arrived and registered for the observation by a doctor, a meeting is scheduled and once the time comes, the case continues to be processed. However, it was proposed that instead of a scheduled meeting, a team-leader can the start processing the case once it arrives.

Output aspect relates to the outcomes of the component execution. In other words, the output is the result of the execution of an activity, fragment, or process. Here practitioners tend to examine output value and output quality. For example, an improvement opportunity can be found by examining the quality of the final product. If the produced output is of low quality, contains defects or errors, such a product can be called defective and considered as an improvement opportunity. For instance, in a manufacturing company, a process of creating sales forecasting was conducted to predict the sales dynamics and arrange the production accordingly. However, the process resulted in non-accurate forecasts which impacted the production schedules and caused mismatch of production schedules with inventories to demand [49]. Thus, the product of the process, inaccurate forecasts, are defective and attempted to be improved.

Connection aspect represents the links between the activities, fragments, and processes. Regarding the connection aspect, the characteristics of link availability and the level of automation of the link were considered. For instance, the level of automation considers if the link is performed automatically, by human resources with the aid of some technology or completely manually. In an order-to-delivery process, the process comprises several subprocesses which are linked to each other and have connection points – that are the points where the output of one process becomes an input to another one. Examining such process in an engineering company, it was found out that the software is restricted to the order fulfilment process, without having any connection to the up-(Customer service) and downstream processes (Product management, Sales). Each process uses different tools, such as Excel sheets or proprietary tools without dedicated interfaces. Hence, the data needs to be transferred manually from one process to the other indicating a manual connection [50].

The comparison of the number of improvement opportunities per aspect of the process was conducted and visualized in Figure 12. The results revealed that that the most improvement opportunities are located within the following aspects: resource, activity, fragment, data and process; that altogether comprise approximately 85% of all identified improvement opportunities. Resource aspect took the leading position holding around 27% of the improvement opportunities which is 27 unique improvement opportunities related to the resources at the different process levels.

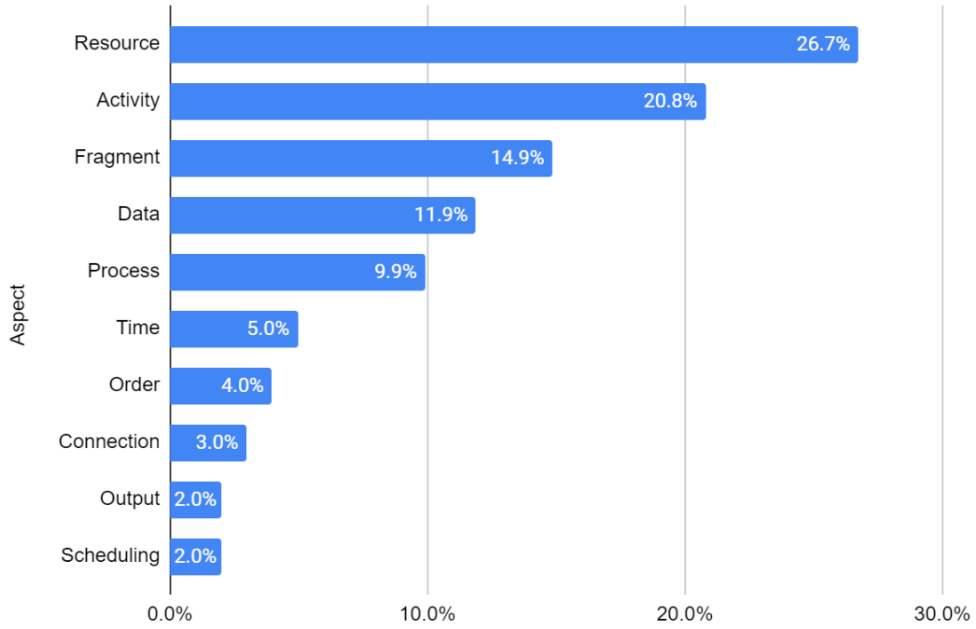

Figure 12. Percentage of improvement opportunities per aspect of the process.

As a result, the identified improvement opportunities are associated with 10 aspects of the process: activity, fragment, process, order, resource, data, time, scheduling, output, and connection. The major number of improvement opportunities are related to the resource, activity, fragment, data, and process aspects.

5.4 Redesign Patterns

Following the fourth research question (RQ4), in this section, the results are reported on identified redesign patterns that are applied to address the improvement opportunities. The notion “pattern”, also known as heuristics [12], presents a technique of the process improvement. In conducting the redesign, the reviewed papers described various techniques utilizing which the process can be improved. The total amount of 201 redesign pattern applications was described, however, some of the redesigns tended to demonstrate similar approaches. Thus, it became possible to distinguish several redesign patterns types, such as, amongst other, work automation, technology application, work elimination, and resource management.

One of the redesign approaches, that commonly occurs in attempts to improve the business process can be associated with automation of work, thus compounds a **Work automation** category. In that way, the work in no longer performed by human resources, but rather executed automatically, thus the work executed faster, with less cost, and with a better result [12]. Work automation is performed at different levels of the process, from single activity automation to automation of the entire process. For instance, in case a notification is sent

manually by the employee to inform customer, such activity is proposed to get automated [38]. Another example can be a process that is labour-intensive and time-consuming since it is performed manually, hence it can also be automated. Apart from automating the work, papers also describe the cases of data flow automation. For instance, in the case of a ministry their payment execution process was run with the paper-based document flow, where documentation was in paper form and transported physically between process participants. Then, the redesign implied application of technology to automate the data flow in the process [51].

Another approach, which is commonly adopted by the redesign practitioner is the introduction of technology to support the work execution. This group is called **Technology application**. The key difference from automation here is that the work still needs a human resource to be performed, however, technology facilitates work execution and improves the results of the work [12]. Thus, technology is introduced to support certain activities and the entire process. For instance, not all manual activities and processes are possible to automate since human work is an essential input there. In a manufacturing company, a manual forecasting process was redesign with the application of the technology, that not entirely automated the process, but rather facilitated it and provided additional opportunities for the employees to perform the work faster, easier and delivering more accurate results [49].

Numerous redesigns considered the process improvement through **Work elimination** approaches, which means removing some part of the work from the process. The reviewed papers described the elimination of certain activities, sections of activities, and even entire processes. For instance, the duplicate process was identified in [52], which was entirely overlapping with another process, and produced outputs that are duplicates and not needed. Hence, such processes are eliminated. Another example is activities that do not add value to the process or represent wastes, such as motion. When people move from one place to another which divert them from actual work processes, elimination of such activities is proposed [29].

Another category is **Resource management**. Apart from redesigning the activity, fragment and process components, many papers are focused on resource optimization issues. Thus, the redesign patterns are targeted at improving resource utilization and allocation within the process. Among the key redesign directions is the reallocation of resources (e.g. changing the activity-resource assignment), adding extra resources and improving the quality of the resources. For instance, if a high rate of defects is observed in the process and the final product is of low quality, the initiative of employing more professional staff is proposed [53]. Alternatively, the reason for a high number of mistakes can be that resources are overwhelmed, hence the redesign is performed by adding more resources can improve the performance of the error-prone activities [54].

Apart from the above-mentioned types, several other types were also identified such as **Reordering** (changing the position of the process components within the process), **Composition** (merging and decomposing process components), **Standardization** (removing the variations of the process components), etc. However, the major number of redesign attempts was done by automation and technology application, work elimination and resource management.

According to the results of the extracted data analysis, the total amount of 201 redesign pattern applications was identified, out of which 90 unique redesign patterns were determined. It should be noted that if the redesign pattern is applied at a different level and/or to a different aspect of the process, they are considered as separate redesign patterns. For instance, the patterns aimed at process component elimination can include the following:

“Activity elimination”, “Fragment elimination”, “Process elimination”, “Data object elimination”, “Tool elimination”, etc. Then we inspected the number of unique redesign patterns associated with levels of the process. The comparison results are depicted in Figure 13. It can be seen that the number of unique redesign patterns is approximately equal at the activity (25 patterns) and fragment (29 patterns) levels, and a bit higher number of patterns is identified at the process level (36 patterns). Hence, the greatest variety of redesign patterns is proposed for the process redesign at the level of the entire process.

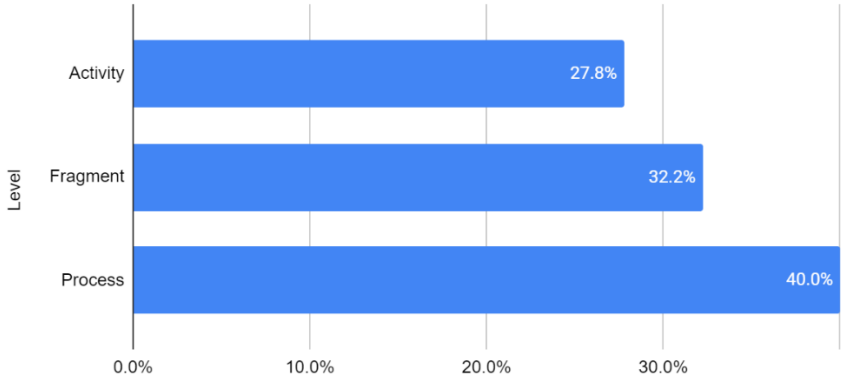

Figure 13. Percentage of redesign patterns per level of the process.

In the conclusion of the analysis of the redesign patterns, the following main findings can be formulated: (1) redesign patterns are mainly associated with work automation, technology application to facilitate the work, work elimination and resource management; (2) the total amount of 201 redesign pattern applications was identified, out of which 90 unique redesign patterns were determined; (3) the greatest variety of unique redesign patterns can be found at the process level.

To sum up, in this SLR the total number of 150 papers were examined which allowed us to identify 101 improvement opportunities and 90 redesign patterns. The improvement opportunities are addressed at the activity, fragment, and process levels. Most of the examined papers focus on the activity level in attempts to find opportunities for improvement. It was determined that the identified improvement opportunities relate to certain process aspects: activity, fragment, process, order, resource, data, time, scheduling, output, and connection. The major number of improvement opportunities relates to the resource, activity, fragment, data, and process aspects. In order to address the identified improvement opportunities, various redesigns were applied, most commonly related to work automation, technology application, work elimination and resource management implying changes of the entire process.

6 Improvement Opportunity Framework

The results of the SLR revealed that the number of studies in business process improvement field has been increasing in the last decade (Figure 9). Both researchers and practitioners attempt to find the optimal way of improving the processes, identifying, and reporting about various improvement opportunities they detect. However, in practice, they can rely on the best practices established in the field, their prior experience, creativity, and assumptions in finding the opportunities for process improvement. Therefore, business process improvement identification becomes a time-consuming procedure, often involving teams of practitioners who can provide professional input based on their expertise in certain sectors and gained practical experience. Moreover, some of the improvement opportunities that have not been examined by these practitioners before and/or improvement opportunities that are less evident or more sophisticated in their identification, might be left unnoticed. Hence, the process potential for the improvement might not be fully revealed. Considering these obstacles, the developed framework aims at supporting process improvement practitioner in finding the improvement opportunities that the processes contain. The framework serves as a structured "catalogue" of the known improvement opportunities and gives ideas to the practitioners on how these improvement opportunities can be addressed. As such, the framework contains a list of improvement opportunities, their definitions, and examples from the examined studies. In addition, for each improvement opportunity, the redesign patterns are provided describing how the redesign was conducted in different cases with examples. As a result, a redesign practitioner obtains a guide providing data on what improvement opportunities can be identified in the process and how they can be addressed. In this section, the framework is discussed, including the following: first, the structure of the framework is described, and a high-level view on the framework is presented, then the motivation of applied categorization is described. Further, the actual framework of improvement opportunities is demonstrated, following by a discussion of ideas on how the framework can be applied and a description of identified redesign patterns.

6.1 Framework Structure

In this section, the framework structure will be presented.

Using the results of extracted data analysis, improvement opportunity definition and categorization, mapping them with the relevant redesign patterns, the framework of improvement opportunities was developed. Due to the large size of the developed framework and the amount of data provided in it, it might be difficult to navigate easily from the beginning. In order to overcome this difficulty, a high-level view on the framework was developed which can be used as a supplementary tool in finding the necessary information. The high-level framework presents the improvement opportunity categories mapped with the aspect of the process and the level of the process where improvement opportunities of these categories can be identified. Thus, this high-level view of the framework will help to focus on a selected section of improvement opportunities, that can be them easily found in the detailed framework. The high-level framework is presented in Table 4.

	Level		
Aspect	**Activity**	**Fragment**	**Process**
Activity	Activity Value Manual Activities Deviating Activity Performance Activity Quality		
Fragment		Fragment Value Manual Fragments Deviating Fragment Performance	
Process			Process Value Manual Processes Deviating Process Performance Process Quality Inventory
Order		Activity Order Decision Point Order	
Resource	Resource Utilization Resource Allocation	Resource Utilization Resource Allocation Job Handovers	Resource Utilization Resource Allocation Resource Unavailability Resource Quality
Data	Data Value Manual Data Management Data Quality Data Unavailability		Data Value Manual Data Management
Time		Waiting Time	Waiting Time
Scheduling	Inefficient Scheduling		
Output			Output Value Output Quality
Connec-tion		Deviating Connections	Manual Connections

Table 4. The high-level framework of improvement opportunities

The columns of the framework indicate the level of the process, the rows define the aspects of the process, in the table cells at the intersection of level and aspect the improvement opportunity categories are listed that can be identified. For instance, considering the output aspect at the process level, two categories of improvement opportunities can be identified: opportunities related to output value and output quality. However, no improvement opportunities can be found in the output aspect at the activity and fragment levels of the process, thus, these cells are left empty.

6.2 Improvement Opportunity Categorization

In this section, the motivation for improvement opportunity categorization will be described. The improvement opportunity categorization derives naturally from the SLR results obtained in addressing research questions on identification the levels of the process and aspects of the process where the improvement opportunities can be detected. Hence, for the framework development the improvement opportunities were grouped against the following criteria:

(1) Level of the process (described in Section 6.2.1),
(2) Aspect of the process (described in Section 6.2.2),
(3) Similar characteristics, i.e. characteristics the improvement opportunities share (described in Section 6.2.3).

6.2.1. Improvement Opportunity Categorization by the Process Level

Although the notions of process, fragment and activity levels were already introduced in Section 5.3, in the context of the proposed framework these notions are refined to formulate explicit rules of improvement opportunity categorization. Hence, the levels of the process are defined as follows.

A **process** is a set of activities, events and decisions that collectively produce output and deliver value to the customer. Referring to the business process modelling notation, a process must have a start event and at least one end event. Thereby, the **process level** includes improvement opportunities that concern the whole process and the relationship between several processes. For instance, from the process analysis it can be noted that the process is performed completely manually which can lead to long cycle time and high defect rates, hence the improvement opportunity "*Manual process"* can be considered which describes the characteristic of the entire process.

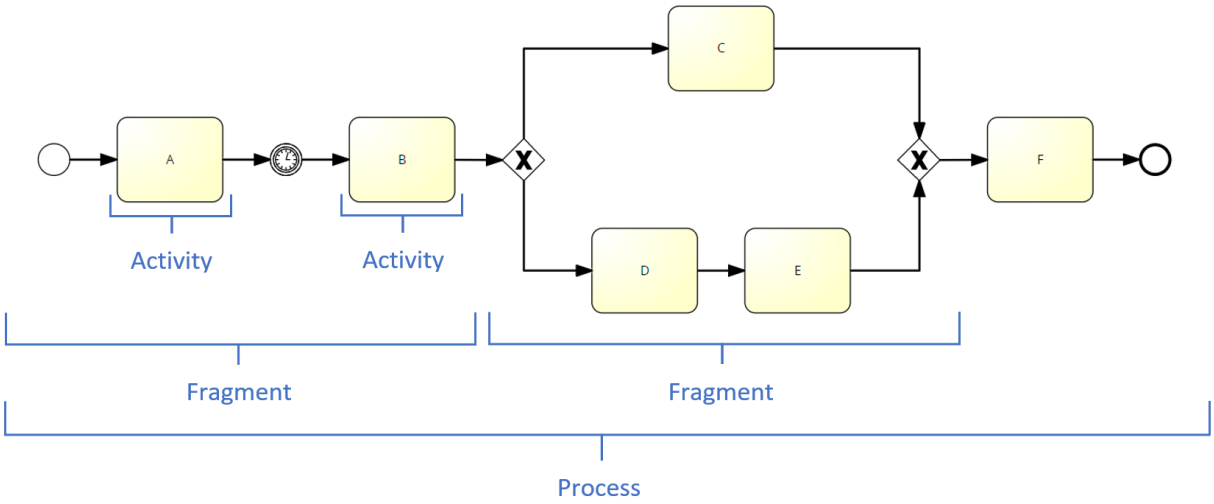

Figure 14. Process model demonstrating the levels of the process.

A **fragment** is a set of activities that involves at least two activities but not the entire process, thus do not deliver value to the customer as it is. A fragment cannot contain both start and end event/-s but can contain either a start event or end event/-s. Then, **fragment level** comprises improvement opportunities that lie in the section of activities and the relationship between a pair of fragments. For instance, during the process analysis practitioners can identify that some fragments are automated, other process parts are conducted manually. These manual fragments can be considered as an improvement opportunity, called *"Manual fragment"*, that is found not in the entire process but a certain process part.

Activity is the single unit of work and represents the lowest level of detail used for process categorization in this framework. Activity level includes those improvement opportunities that are contained in a single activity and/or its attributes (resource, data or scheduling). For instance, by inspecting the characteristics and performance of activities, a manual time-consuming activity can be identified that can be considered an improvement opportunity, determined as *"Manual activity"*. Based on the presented definitions, a simple business process model is built using the BPMN-notation to graphically demonstrate the defined levels of the process (Figure 14).

6.2.2 Improvement Opportunity Categorization by the Process Aspect

The notion "aspect" implies any process component executed within the process, such as activity, or process component participating and/or used in the process, such as resource or data. From the SLR a range of aspects of the process was identified that can contain the improvement opportunity at different levels. For the improvement opportunity framework development, the following aspect definitions were used as categorization criteria: activity, fragment, process, order, resource, data, time, scheduling, connection, and output.

Improvement opportunity of the **activity aspect** is in the activity itself and can be detected by examining the activity performance and activity distinctive characteristic. For instance, by examining the value of the activity, *Non-value-added activities* can be identified that are activities consuming time, resources and/or facilities but adding no value to the customer [1].

Like the activity aspect, the improvement opportunity of a **fragment aspect** lies in a set of activities itself. By examining the fragment performance and its characteristics, the improvement opportunities can be identified. For instance, by examining the value of the fragment, *Non-value-added fragments* can be identified that are fragments consuming time, resources and/or facilities but adding no value to the customer [55].

Process aspect considers the process as a subject of the examination where the improvement opportunity is located. Thus, the entire process performance is inspected, and its characteristics are examined. For instance, by examining the value of the entire processes, *Duplicate processes* can be identified that are two or more processes that are identical to each other [52].

Order aspect considers the order of the components of the process, i.e. in which sequence the components are executed. For example, an improvement opportunity can be seen in independent sequential activities when activities that do not depend on each other for inputs, outputs and resources and are executed sequentially. This improvement opportunity is called *Independent sequential activities*. The focus in this improvement opportunity is on the order of the activities, i.e. if the activities do not depend on each other for inputs/outputs and executed by different resources, what is the reason behind their sequential execution [53], [56], [45].

Resource aspect includes any type of resources that are involved in activity, fragment, or process execution. These resources can be human, i.e. workers and employees, and non-human, that are machines, equipment, facilities, technologies. Here, the improvement opportunities associated with resource utilization, resource allocation, work assignment, resource availability and quality are located. For instance, improvement opportunity can be identified by examining the resource utilization, detecting *Low or high resource utilization* involved in the execution of an activity [46], [11]. Another example in the context of the process level: tool allocated for the process execution is characterized by a high number of tool defects, i.e. the process execution is negatively affected by disruptions in the tool supporting the execution of the process. These include examples of frequent machine breakdowns when the process execution cannot be continued until the defect is fixed. Hence, *Tool defects* is a potential improvement opportunity in this process [36].

Data aspect comprises of any data, data objects and data flows used within the process. Within this aspect, data is inspected regarding data value, level of data management automation, data quality and availability. *Incomplete data* is an example of the improvement opportunity related to the data aspect of the process. Incomplete data means that the data was not fully captured, resulting in an increased effort to manage the data. For instance, when a company receives an incomplete application from the client and needs to perform additional activities to get the rest of the data from the client [51].

Time aspect relates to the component performance in terms of time. This aspect considers waiting times between the process components: between activities, fragments and processes. For example, *Waiting time between activities* can be considered that is the time a case spends in an idle mode when one activity released the output, but the sequential activity is not ready to process it [1].

Scheduling aspect relates to the efficiency of scheduling process components. Thus, execution of activities and processes can be scheduled by a certain condition. If it is performed inadequately, *Inefficient scheduling* is an improvement opportunity.

Connection aspect refers to the links between the process components, for example, the link between a couple of fragments in the process. This aspect is considered in terms of the presence of the necessary connections and the level of their automation. The *Missing link between fragments* of the process can lead to process disruptions and lost semi-finished cases and presents an improvement opportunity to be addressed [57].

Output aspect refers to the results of the activity, fragment, or process execution in the form of a physical item or service. For instance, in a manufacturing process, a finished product is the output of the process, but at the activity level, the output of the activity is the semi-finished item. The perspective of output value and quality can be considered. An example of the improvement opportunity in this aspect can be a *Defective product* that is the process output of low quality, containing defects and/or errors [49].

6.2.3 Improvement Opportunities Categorization by Similarity

As far as the framework contains many improvement opportunities and comprises of several pages, the necessity of further categorization was seen to facilitate the navigation on the framework. During the analysis of the identified improvement opportunities, it was noted that these opportunities tend to possess certain similarities with each other within their level and aspect categories. Hence, categorization based on the characteristic the improvement opportunities share was conducted. Table 5 presents the categories of improvement opportunities and their definitions.

Table 5. Improvement opportunity categories with definitions.

Aspect	Category	Definition
Activity Level		
Activity	Activity Value	Activities that consume time, resources and/or facilities but add little or no value.
	Manual Activities	Activities that are performed manually.
	Deviating Activity Performance	Activities that deviate, i.e. exhibit abnormal behaviour, as compared with other activities

Aspect	Category	Definition
		in the process or this activity performance on average.
	Activity Quality	Activities that demonstrate quality issues.
Resource	Resource Utilization	Resources that are inefficiently utilised.
	Resource Allocation	Resources that are inefficiently allocated.
Data	Data Value	Data that is allocated and/or used in the process but adds little or no value.
	Manual Data Management	Data that is managed manually.
	Data Quality	Data that demonstrates quality issues.
	Data Unavailability	Data that is needed but not available in the process.
Scheduling	Inefficient Scheduling	Activities and events that are inefficiently scheduled.
Fragment Level		
Fragment	Fragment Value	Fragments that consume time, resources and/or facilities but add little or no value.
	Manual Fragments	Fragments that are performed manually.
	Deviating Fragment Performance	Fragments that deviate, i.e. exhibit abnormal behaviour, as compared with other fragments in the process or this fragment performance on average.
Order	Activity Order	Activities that are inefficiently ordered.
	Decision Point Order	Decision points that are inefficiently ordered or placed in the process.
Resource	Resource Utilization	Resources that are inefficiently utilised.
	Resource Allocation	Resources that are inefficiently allocated.
	Job Handovers	Resource switches in a case processing that are inefficient or not necessary.
Time	Waiting Time	Time that a case spends in an idle mode.
Connection	Deviating Connections	Connections that demonstrate performance issues.
Process Level		
Process	Process Value	Processes that consume time, resources and/or facilities but add little or no value.
	Manual Processes	Processes that are performed manually.
	Deviating Process Performance	Processes that deviate, i.e. exhibit abnormal behaviour, as compared with other processes or this process performance on average.
	Process Quality	Processes that demonstrate quality issues.
Resource	Resource Utilization	Resources that are inefficiently utilised.
	Resource Allocation	Resources that are inefficiently allocated.
	Resource Unavailability	Resource that is needed for process execution but not available in the process.
	Resource Quality	Resources that demonstrate quality issues.
	Inventory	Inventory that is inefficiently managed.
Data	Data Value	Data that is allocated and/or used in the process but adds little or no value.

Aspect	Category	Definition
	Manual Data Management	Data that is managed manually.
Time	Waiting Time	Time that a case spends in an idle mode.
Connection	Manual Connections	Connections that are managed manually.
Output	Output Value	Output that is produced but adds little or no value.
	Output Quality	Output that demonstrates quality issues.

In conclusion, the framework is categorized against the criteria naturally derived from the results of the extracted data analysis: (1) by the level of the process, where process, fragment and activity levels are defined; (2) by the aspect of the process, where 10 aspects are identified: activity, fragment, process, order, resource, time, data, scheduling, and output; (3) by improvement opportunity similarities within the level and aspect of the process they belong to, where 36 categories are distinguished.

6.3 Improvement Opportunity Framework

In this section, the improvement opportunity framework is demonstrated. The excerpt from the framework is presented in Table 6. The excerpt demonstrates the improvement opportunities at the activity level of the process related to the "Activity Value" category within the activity aspect of the process. Full framework is not included in the thesis due to its space limitation, therefore the link is provided where the framework can be viewed as a Google Sheet table[1].

By reading the framework from left to right, the first column comprises the aspect of the process where the improvement opportunity is contained. The second column indicates the category, to which the improvement opportunity belongs. Then the improvement opportunity name and definition are presented following by the example/-s derived from one or several publications included in this SLR. The next block of the framework describes the redesign method: first, the redesign patterns with which the improvement opportunity can be addressed, then example/-s of redesign application from the reviewed studies. The framework also includes the indication of the level of the process which is placed as a separation header. The improvement opportunity category and its definition are presented at the beginning of each category.

In addition to the data presented in the excerpt, the framework available in the Google Sheet table includes the following columns which were excluded from the excerpt due to space limitation: (1) reference/-s of the improvement opportunity definition; (2) reference/-s of the improvement opportunity example; (3) reference/-s of the redesign pattern example; (4) reference/-s of the papers from which the data presented in each row was derived. The references are presented in the form of the assigned indicators. A full list of references for SLR papers with indicators is presented in a separate tab called "References".

[1] https://bit.ly/35PA0Pn

Table 6. Excerpt from the framework of improvement opportunities.

Aspect	**Category**	**Improvement opportunity**			**Redesign**	
		Name	Definition	Example	Patterns	Example
Activity						
Activity	**Activity Value**	Activities that consume time, resources and/or facilities but add little or no value.				
Activity	Activity Value	Non-value-added (NVA) activities	Activities that consume time, resources and/or facilities but add no value to the customer.	In a healthcare recovery ward process, the surgery ward makes calls to check if the care unit has a room available and a patient can be transported to them. On average, it is necessary to call at least four times from the surgery ward to the care unit until there is a free place and the time of the patient's transportation can be planned. Calling back and forth several times are non-value-added activities.	Task elimination	NVA tasks are eliminated. In the case of the healthcare recovery ward, the care unit is to call to the surgery ward once the place is available.
Activity	Activity Value	Duplicate activities	Two or more activates that are identical to each other.	Activities of collecting of identical information. On the faculty, there were two separate timetable databases maintained the same data, each of them required the corresponding data entries and updates. Data entries and updates are duplicate activities.	Task elimination	Duplicate activities are eliminated.
Activity	Activity Value	Motion	Movement of people which divert them from actual processing work.	In a chocolate manufacturing process, several unnecessary worker movements can be observed such as Transfer to the production line with an operator, Shift supervisor back to the office. These activities do not add value from the perspective of the customer.	Task elimination	Motion activities are eliminated.

Aspect	Category	Improvement opportunity			Redesign	
		Name	Definition	Example	Patterns	Example
Activity	Activity Value	Business value-added (BVA) activities	Activities that are required for business but do not add value to the customer.	In a help desk service process, after the request is received, the operator registers the request in the system. The activity "Register request" does not add value to the customer but is required by the process standards and is necessary for further request processing.	Task automation, Parallelism	Some BVA activities, such as sending notifications, can be automated, i.e. notifications are produced and sent automatically. BVA activities can be also executed in parallel with value-added activities.
Activity	Activity Value	Business value-added (BVA) activities with limited value	Activities that are useful for business but deliver less value than the required effort to execute it.	Review activity if the average number of mistakes found by this review is low.	Task elimination	According to [K077] and [Dumas] if the BVA activities add little value and/or the estimated cost is below a certain threshold, such BVA activities can be eliminated. [Dumas] also notes that this option should be weighed against the possible consequences of having fewer control steps in place.
Activity	Activity Value	Partially overlapping activities	A pair of activities sharing a common part, i.e. partially overlapping each other.	NA	Task composition, Task elimination	A common part of the overlapping activities is identified. The common part of the specific remaining task is kept while the other remaining parts are eliminated.

For instance, improvement opportunity *Business value added (BVA) activities with limited value* can be detected by inspecting the activity aspect considering the activity value. This improvement opportunity can be defined as “activities that are useful for business but deliver less value than the required effort to execute it”. An example of such activity is a review activity, i.e. the activity of execution verification if the average number of mistakes found by this review is low. In order to address this improvement opportunity, “Task elimination” pattern can be applied. An example of the redesign is provided in the last column.

This framework was designed to facilitate the business process redesign conducted by redesign practitioners. The framework can be used to streamline the process examination for the identification of the described improvement opportunities based on certain demands. These demands are reflected in the framework structure in the form of the improvement opportunity categorization. For instance, redesign practitioners might be interested in the improvement of an activity which demonstrates low performance compared to the other activities creating a bottleneck in the process. Thus, the focus will on the improvement opportunities that are located at the activity level. Then, inspecting this activity against the improvement opportunities presented in the framework might reveal the problem causing the bottleneck, i.e. the improvement opportunity. The framework, further, provides concrete redesign

patterns that can be undertaken to improve the process. With the availability of the real-world examples and references to the publications, the practitioners can more deeply examine selected improvement opportunity and the ways it was addressed in practice by other researchers. Besides, this framework can be used by students who study business process management and related disciplines. With the help of this framework, students lacking domain experience can at once get an overview of the possible opportunities and redesigns, that can facilitate the learning process.

As a result, this improvement opportunity framework covers the path from the identification of the improvement opportunity to its solution providing improvement opportunity definitions and examples from the case studies. Besides, it includes a categorization by the level of the process, aspect of the process and opportunity similarity. The framework can be used by redesign practitioners to facilitate the business process redesign.

6.4 Redesign Pattern Definitions

In this section, the definitions of the identified redesign patterns will be provided.

Once the improvement opportunities are identified, the question of how they can be addressed arises. In order to provide an answer to this question, the redesign patterns that were proposed to apply in the reviewed studies were collected and mapped to the relevant improvement opportunities. The Reijers and Mansar's work [12] was taken as a basis in defining the redesign patterns. This research paper contains the descriptions of the best practices in process redesign with redesign pattern definitions and examples. Hence, in order to get the definitions of redesign patterns related to the best practices, the reader is referred to Reijers and Mansar's study [12]. Most of the redesign patterns applied in the studies used for this SLR are already examined and described in detail by this author. However, not all identified redesign patterns are described in this study, hence, it is also essential to provide the definitions to them. In that way, the practitioners can get an understanding of what authors meant by these redesign patterns. Hence, in this section, the redesign patterns collected from the SLR and not defined in the above-mentioned publication will be presented.

From the results of this SLR, 27 additional redesign patterns are collected and described. For each redesign pattern, a definition, and the list of opportunities it can address are also provided which were derived from the literature. In Table 7 the excerpt from the list of defined redesign pattern is presented. The full list of redesign patterns is available in Appendix II. The first column includes the names of the redesign patterns, the second presents the definitions explaining the patterns, and finally, the third column contains improvement opportunities addressed by these patterns, including the indication at which level and aspect of the process the improvement opportunities are identified.

Table 7. Selected redesign patterns related to data management.

Redesign Pattern	**Definition**	**Addressed Improvement Opportunities**
Data addition [58]	Add data that will help the participant in process execution.	• Incomplete data *Level: Activity* *Aspect: Data* • Defective product *Level: Process* *Aspect: Output*

Redesign Pattern	Definition	Addressed Improvement Opportunities
Data flow composition [59]	Combine several data flows in a single flow.	• Duplicate data flows *Level: Process* *Aspect: Data*
Data handover elimination [29]	Eliminate unnecessary handovers of data objects.	• Unnecessary data transportation *Level: Activity* *Aspect: Data*
Data object composition [60]	Use one composite data object instead of several overlapping data objects.	• Partially overlapping data objects *Level: Activity* *Aspect: Data*
Data object elimination [61]	Eliminate unnecessary data objects from a business process.	• Duplicate data objects *Level: Activity* *Aspect: Data*
Data standardization [62]	Establish a clear structure of the data objects and data stores used in the process.	• Unstructured data *Level: Activity* *Aspect: Data*

To sum up, the redesign patterns used to address the identified improvement opportunities were collected and added to the framework. In defining the redesign patterns the framework comprising the best redesign heuristics proposed by Reijers and Mansar [12] was used. Besides, 27 additional redesign patterns not described in this study were identified, defined, and mapped with the improvement opportunities they can address.

In conclusion, the framework is primarily designed to support the redesign practitioners in process redesign. It structures the existing knowledge in identification of improvement opportunities and process redesign, thus presents a "catalogue" of opportunities that can be used as a supporting tool in process redesign. It can be used to facilitate the process of identification of improvement opportunities in the process and in finding ways of how the identified improvement opportunities can be addressed. Additionally, the framework is proposed to be used as a supplementary tool in the learning process for students of business process management related courses.

7 Threats to validity

In this section, the threats to validity are presented that were identified for this SLR research. In formulating threats to validity, the guidelines for identifying, categorizing, and mitigating threats to validity in software engineering secondary studies suggested by Ampatzoglou [63] were followed. Based on these guidelines, the following types of threats will be discussed: threats related to the validity of the study selection, threats related to data validity, and threats related to research validity.

7.1 Study selection validity

This category refers to issues that threaten the validity of searching and including primary studies in the examined set during the search process and study filtering phase [63]. Within this category, several threats are applicable for this SLR. First, the threat of *inadequate identification of the relevant publications,* i.e. not including all the relevant studies in the SLR. This threat was mitigated by determining the structured procedure of paper searching and filtering, reflected in the SLR strategies that was prepared based on the recognized guidelines [22]. Another mitigation method was applied in the form of performing the search in several digital libraries which contain well-recognized publications in the business process improvement field. The developed search string was developed to cover an as much broader range of publications by including several synonyms to the terms of "process improvement" and "method" so that to alleviate the absence of the standard terminology. At the data filtering stage, the threat of *inefficient handling of duplicate articles* was prevented by removing duplicates from the analysis. Continuing with the data filtering, the threat of *exclusion of relevant publication*s existed, that was mitigated by following the well-defined inclusion and exclusion criteria stated in the selection strategy and participation of two reviewers, who performed random cross-check of the filtering results and discussed the conflicts. However, some of the relevant papers might have been missed as we had to exclude: (1) *non-English papers*; (2) *papers we did not have access to* (papers have fee-based access not provided by our institution). Due to the fact, that the number of non-English papers is relatively small (3 papers) compared to papers not accessible (120 papers), the latter has a more significant effect and can potentially compromise the results.

7.2 Data validity

Threats in this category relate to the validity of the extracted dataset and its analysis occurring in the data extraction and analysis phases [63]. As far as the data was extracted manually by two reviewers, the major threat in this category is *data extraction bias* due to some level of subjectivity in this process. In order to mitigate this threat, the reviewers adopted the following procedure: (1) the first block of papers (5 papers) was extracted by both reviewers, and the results were compared and validated; (2) then reviewers extracted the data separately; (3) validation checks of random papers by a co-author was conducted; (4) in case of confusion and/or conflicts the discussions were initiated. Besides, the *threat of researchers' bias in data interpretation and analysis* was mitigated by (1) conducting a pilot data analysis and interpretation by both reviewers together; (2) prior agreement on terms, methods and procedure definitions and ensuring their common understanding; (3) regular meetings for result discussion (once a week). Finally, other threats to data validity (such as *small sample size, papers cannot answer the research questions, the obtained dataset lacks*

relationships, low validity of primary studies no statistical analysis of the dataset, etc. [63]) were considered irrelevant for this SLR.

7.3 Research validity

Threats grouped under this category refer to the overall research design issues that might occur during the whole SLR process, including search, filtering, data extraction and analysis phases [63]. Since the SLR was performed involving a student, the threat of *unfamiliarity to the research filed* should be considered that can lead to the omission of relevant studies and/or limited synthesis capacity because of the lack of knowledge in the domain. However, this threat was mitigated by regular validation of the student's results by the supervisor who is experienced in the field and is familiar with secondary studies since was involved in several of them as an author and reviewer. Moreover, the study allows replicating the SLR process by following the SLR protocol defined in detail in order to repeat all the steps performed by the reviewers and compare the results that exclude the threat of *lack of repeatability*. The reviewers were also managed to ensure that a *research method fitting to the research goal was selected* following the guidelines for performing SLRs [22], discussion and validation with the experts. The research questions were formulated in such a way that *answering these research questions can fulfil the goal* that was achieved by matching the research questions to the research goal described in Section 4.1-4.2. However, the threat of *lack of comparable studies* might still exist as far as the identified related works cannot be fully used for comparison the results since this SLR attempts to cover the gap where studies have not been present.

In conclusion, although there are several threats to validity identified as potentially relevant for this SLR, most of them were mitigated and/or excluded, hence do not hinder the research results. However, the major threat to validity that might influence the research was identified as the exclusion of relevant publications due to papers not accessible in a digital library. Nevertheless, the research is claimed to meet the requirements of the study selection, data, and research validity to a sufficient extent to be considered valid.

8 Conclusion

This thesis presents a systematic literature review of the publications concerning business process improvement. The focus of the research is on collecting and systemizing existing knowledge on the improvement opportunities that can be identified in the process. The research covers the questions of how improvement opportunities can be identified, what levels and aspects of the process are considered for their identification, and what are the redesign patterns that are used to address these improvement opportunities. A systematic literature review was conducted in accordance with the guidelines proposed for the SLRs and in compliance with a well-defined strategy.

For the SLR 150 papers were selected based on the established inclusion/exclusion criteria, from which data was extracted and analysed. The total number of 101 improvement opportunities and 90 redesign patterns were identified. Improvement opportunities are identified at activity, fragment, and process levels, and within the following aspects: activity, fragment, process, order, resource, time, data, scheduling, connection and output. Considering improvement opportunity similarities within the level and aspect of the process they belong to, 36 categories of improvement opportunities are distinguished. The redesign patterns that are used to address the identified improvement opportunities were identified and mapped with the improvement opportunities they target. In addition to redesign patterns, described as best practices, 27 additional redesign patterns were identified, defined, and mapped with the improvement opportunities they can address. Based on the improvement opportunity categorization, that is naturally derived from the obtained results, the framework was developed which presents the results of the analysis in a structured way. The framework can be used as a tool to support redesign practitioners in business process improvement.

From the analysis of the developed framework, several perspectives for future work were identified. First, the study can be elaborated by adding an evaluation perspective to the framework. By outlining how the improved process performance is measured and which metrics are used for each of the identified redesign patterns, we can extend the framework by providing support for the evaluation part of the redesign process. Second, the framework will be examined for identification of potential gaps in the current research, i.e. identification of the levels and aspects of the process which potentially could contain improvement opportunities, however, the current studies do not attempt to examine them.

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Appendix

I. List of identified improvement opportunities

The table presents the full list of identified improvement opportunities arranged in alphabetical order.

Table 8. List of identified improvement opportunities.

	Improvement opportunity
1	Activities sharing resources
2	Activity errors
3	Activity resource bottlenecks
4	Activity rework
5	Activity variants
6	Business value-added (BVA) activities
7	Business value-added (BVA) activities with limited value
8	Centralized decision-making
9	Complex customer interaction
10	Cross-functional boundaries
11	Data errors
12	Defective activities sharing resources
13	Defective product
14	Different processes sharing the same customer
15	Disconnected fragments
16	Duplicate activities
17	Duplicate data flows
18	Duplicate data objects
19	Duplicate processes
20	Duplicate processes in different facilities
21	Event-driven fragments
22	Expensive activities
23	Expensive activities placed first
24	Expensive exceptions
25	Expensive fragments
26	Fragment resource bottlenecks
27	Fragment rework
28	Fragment variants
29	Frequently rejected activities placed first
30	High resource utilization in an activity
31	High resource utilization in a fragment
32	High resource utilization in a process
33	High risk processes
34	Incomplete data
35	Independent sequential activities

36	Inefficient batching
37	Inefficient case assignment
38	Inefficient event scheduling
39	Inefficient resource allocation
40	Infrequent fragment variants
41	Irreversible case assignments
42	Lack of expertise
43	Lack of resources
44	Lack of transparency
45	Large activities
46	Large fragment
47	Large inventory
48	Late knock-out check
49	Less frequent process variants
50	Low resource capacity
51	Low resource utilization in an activity
52	Low resource utilization in a fragment
53	Low throughput
54	Manual activities
55	Manual checks
56	Manual data entries
57	Manual data movement
58	Manual data processing
59	Manual data transfers
60	Manual fragments
61	Manual notifications
62	Manual process connections
63	Manual processes
64	Motions
65	Non-value-added (NVA) activities
66	Non-value-added (NVA) fragments
67	Order queues
68	Overload resources during peak times
69	Overproduction
70	Paper data storage
71	Paper-based document flow
72	Partially overlapping activities
73	Partially overlapping data objects
74	Partially overlapping fragments
75	Process complexity
76	Process variants
77	Product-dependent fragment variants

78	Product-dependent process variants
79	Product/material transportations
80	Resource-intensive process
81	Routine data exchange
82	Rule-based customer interaction
83	Several tools involved
84	Similar activities
85	Simple rule-based activities
86	Small activities
87	Tool defects
88	Tool output errors
89	Unavailability of input in time
90	Unavailability of knowledge documentation
91	Unavailability of real-time data
92	Uneven resource utilization
93	Unnecessary data transportation
94	Unnecessary job handovers
95	Unstructured data
96	Unvalidated data
97	Waiting time between activities
98	Waiting time between fragments
99	Waiting time between processes
100	Waiting time variation
101	Workarounds

II. List of identified redesign patterns

The table presents the list of identified redesign patterns that are not described in [12] arranged in alphabetical order.

Table 9. Identified redesign patterns.

Redesign Pattern	Definition	Addressed Improvement Opportunities
Activity addition [30]	Add activity to the process that can improve the quality of the output.	• Defective product *Level: Process* *Aspect: Output*
Arrival rate pattern change [43]	Change the customers' arrival pattern: provide incentives to move customers to light-load hours from peak-load hours.	• Waiting time between fragments *Level: Fragment* *Aspect: Time* • Overload resources during peak times *Level: Process* *Aspect: Resource*
Boundary spanner [64]	Add a new role to the process to support knowledge-intensive work that is located on the boundary of the process between the company and the customer, involving customer interaction.	• Process complexity *Level: Process* *Aspect: Order*
Change batching schedule [65]	Make batching more frequent to reduce waiting times.	• Inefficient batching *Level: Activity* *Aspect: Resource*
Cohesion [66]	Make roles loosely coupled, so that the number of interactions between them is reduced to a minimum.	• Cross-functional boundaries *Level: Process* *Aspect: Resource*
Connection addition [57]	Add missing connection between the process components.	• Disconnected fragments *Level: Fragment* *Aspect: Connection*
Data addition [58]	Add data that will help the participant in process execution.	• Incomplete data *Level: Activity* *Aspect: Data* • Defective product *Level: Process* *Aspect: Output*
Data flow composition [59]	Combine several data flows in a single flow.	• Duplicate data flows *Level: Process* *Aspect: Data*
Data handover elimination [29]	Eliminate unnecessary handover of data objects.	• Unnecessary data transportation *Level: Activity* *Aspect: Data*
Data object composition [60]	Use one composite data object instead of several overlapping data objects.	• Partially overlapping data objects *Level: Activity* *Aspect: Data*

Redesign Pattern	Definition	Addressed Improvement Opportunities
Data object elimination [61]	Eliminate unnecessary data objects from a business process.	• Duplicate data objects *Level: Activity* *Aspect: Data*
Data standardization [62]	Establish a clear structure of the data objects and data stores used in the process.	• Unstructured data *Level: Activity* *Aspect: Data*
Follow up [58]	Contact customer to provide additional information so that to improve the outcomes of work performed by the customer.	• Incomplete data *Level: Activity* *Aspect: Data*
Inventory buffering [67]	Reschedule input supply so that there is a buffer stock of input material that can mitigate the negative impacts of input shortage.	• Unavailability of input in time *Level: Process* *Aspect: Resource*
New method [68]	Design separate process flow for different types of cases considering the differences of cases in the development of process structure.	• Order queues *Level: Process* *Aspect: Time*
New tool [59]	Replace the current tool with a new tool with a higher capacity and/or with no defects.	• Low tool capacity *Level: Process* *Aspect: Tool* • Tool defects *Level: Process* *Aspect: Tool*
Relocation to one system [69]	Relocate operations and data to one system from other systems involved in the process.	• Several tools involved *Level: Process* *Aspect: Tool*
Replacement [55]	Replace obsolete process components with suitable ones.	• Non-value-added fragments *Level: Fragment* *Aspect: Fragment*
Scheduling [70]	Introduce scheduling so that cases arrive according to the established schedule rather than in free mode.	• Overload resources during peak times *Level: Process* *Aspect: Resource*
Staff change [53]	Replace inefficient staff members with new employees with a sufficient level of expertise and/or skills.	• Lack of expertise *Level: Process* *Aspect: Resource*
Staff training [54]	Train employees involved in activity, fragment and/or process execution to improve the quality of their work.	• Activity errors *Level: Activity* *Aspect: Activity*

Redesign Pattern	Definition	Addressed Improvement Opportunities
		• Fragment rework *Level: Fragment* *Aspect: Fragment* • Lack of expertise *Level: Process* *Aspect: Resource*
System integration [71]	Establish a connection between two systems used in one process to automate data transfer from one system to another.	• Manual data transfers *Level: Activity* *Aspect: Activity*
Tool composition [72]	Combine several systems involved in the process into one single system.	• Several tools involved *Level: Process* *Aspect: Tool*
Tool elimination [51]	Eliminate unnecessary tools from a business process.	• Several tools involved *Level: Process* *Aspect: Tool*
Variant elimination: Activity [73] Fragment [74] Process [75]	Eliminate the variants of the process component execution (activity, fragment, or process) and leave a single variant that demonstrates the best performance.	• Activity performance variation *Level: Activity* *Aspect: Activity* • Fragment variants *Level: Fragment* *Aspect: Fragment* • Process variants *Level: Process* *Aspect: Process* • Less frequent process variants *Level: Process* *Aspect: Process* • Product-dependent process variants *Level: Process* *Aspect: Process*
Waste elimination [76]	Eliminate wastes from the process: overproduction, defects, inventory, transportation, waiting, motion and overproduction.	• High defect rate *Level: Process* *Aspect: Process* • Large inventory *Level: Process* *Aspect: Resource*
Work shift change [70]	Reschedule work shifts of the employees so that there are more resources available during peak times and less during light-load periods.	• Overload resources during peak times *Level: Process* *Aspect: Resource*

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