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Presenting Business Process Improvement Changes – A Systematic Literature Review

Master's Thesis (30 ECTS)

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Presenting Business Process Improvement Changes – A Systematic Literature Review

Abstract:

Business Process Improvement (BPI) has a big potential by helping to improve end-user satisfaction, to reduce costs and throughput times. A lot of business process improvement techniques exist, but they lack the information about the presentation of the effects of business process change. In order to fill this gap, this thesis provides an overview of the ways that are used to present the effects of business process change in real-life business process scenarios. For that purpose, a systematic literature review is performed to identify papers that apply BPI on real-life cases from industry to see what means are used to capture and present those changes. The identified final papers are analysed in order to answer to Research Questions (RQ). The analysis reveals that as in any other scientific field where change is occurring the change could be presented either visually, or in a numerical way, or in a not structured (narrative) way using some presentation strategies. This knowledge that gives some hints on how changes are conveyed can be used to support people to better understand the changes which occur in a process after a BPI.

Keywords:

Business process improvement, process redesign, process optimisation, patterns, heuristics, process visualisation, best practices

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

Muutuste esitlemine äriprotsesside täiustamiseks - süstemaatiline kirjanduse ülevaade

Lühikokkuvõte:

Äriprotsessi täiustamine aitab parandada lõppkasutaja kogemust, vähendada kulutusi ja kiirendada tööd. Eksisteerib mitmeid äriprotsessi täiustamise tehnikaid. Olemasolevate protsesside juures ei ole aga demonstreeritud muutuste mõju. Et täita see lünk, pakub antud lõputöö ülevaadet viisidest kuidas demonstreerida äriprotesside muutuste mõju päris elu näidete põhjal. Sel eesmärgil on tehtud süstemaatiline kirjanduse ülevaade artiklitest, mis kasutavad äriprotsesside täiustamist päris elu näidetes, et näha kuidas need muutuseid on esitletud. Leitud artikkleid analüüsiti, ning leiti vastused uurimuse küsimustele. Analüüsi tulemusena leiti, et nagu igas teises teadusvaldkonnas, mis käsitleb muutusi, saab neid esitleda visuaalselt, numbriliselt või mitte struktureeritud viisil kasutates erinevaid esitlemise strateegiaid. Teadmine, kuidas antakse edasi asjade muutumist, aitab inimestel paremini aru saada nende sisust. Võimalik on paremini aru saada äriprotsesside muutustest.

Võtmesõnad:

Äriprotsessi täiustamine, protessi ümberkorraldus, protessi optimisatsioon, mustrid, heuristika, protessi visualisatsioon, parimad tavad

CERCS: P170 Arvutiteadus, arvutusmeetodid, süsteemid, juhtimine (automaatjuhtimisteooria)

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List of abbreviations and terms

AoURN	Aspect-oriented User Requirements Notation
ATD	Actor Transaction Diagram
BPA	Business Process Analysis
BPCIP	Business Process Continuous Improvement Process
BPEMM	Business Process Execution Measurement Model
BPI	Business Process Improvement
BPM	Business Process Management
BPMN	Business process modelling notation
CP-nets	Coloured Petri nets
ERP	Enterprise Resource Planning
GED	Goal, Exceptions and Dependency
GRAI	Graphs with Results and Actions Inter-related
GRL	Goal-oriented Requirement Language
IDEF0	Integration Definition for Function Modelling
OMG	Object Management Group
PIP	Process Improvement Patterns
RQ	Research Question
UCM	Use Case Maps
URN	User Requirements Notation

1 Introduction

Every organisation manages a lot of business processes, which are the important parts of it. A business process is a process which is used by a company to deliver a product or a service to the customers. More common types of processes that are used in organisations are order-to-cash, quote-to-order, procure-to-pay, issue-to-resolution and application-to-approval processes.

Business Process Management (BPM) is an approach that gives techniques, concepts, tools and methods to make the business process more effective and efficient. BPM is a mean with an aim to improve the performance of the process by optimising and remodelling company's business processes. BPM activities can be summarised in phases of BPM lifecycle (see Figure 1).

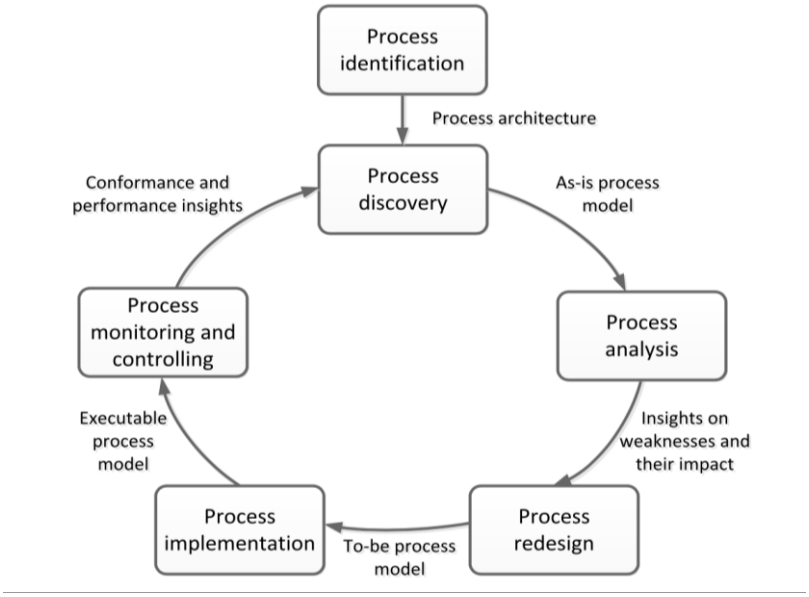

Figure 1. BPM lifecycle [8].

Firstly, a process is identified and described in a form of process models, which is called as-is process model. Then the process is analysed in order to find the issues associated with the process, which aims to reduce processes' throughput times, costs and to improve customer satisfaction. For this purpose, the initial process is analysed to point out its weaknesses and to produce ideas for improvement. Based on the identified issues and their prioritisation the changes are identified and performed and the to-be process is

modelled. At the last phase, the new to-be process is analysed to define its performance with respect to previously identified objectives and measures [8].

In process analysis phase, issues regarding as-is process are described and prioritised. Business Process Analysis (BPA) is a very valuable method for successful improvement of business processes. Analysis can be either qualitative, which identifies unnecessary or weak parts of the process; or quantitative, which assesses the process in terms of performance measures [8]. BPA aims to improve the time, cost, quality and flexibility of the business processes. Ideally, it aims to decrease the time which is needed to handle the order, lower business process execution cost, improve the quality of delivered service and ability of the business process to react to variation. The interesting behaviour is that improving one dimension might have a weakening effect on another. To point out this difficult trade-off the model that describes the relationship between time, cost, quality and the flexibility has a name Devil's Quadrangle, which is shown in Figure 2 [32].

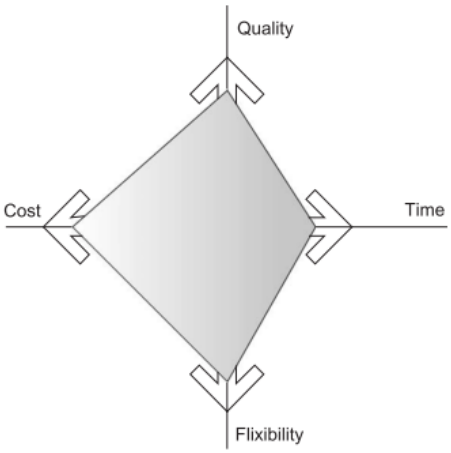

Figure 2. The Devil's Quadrangle [35].

BPA gives an insight into the current performance of the business processes. This information helps to understand the gap between practice and guidelines, which enables organisations to improve their processes regarding their objectives [32]. Process analysis enables understanding of current problems and this understanding helps to identify where the changes should be made in order to improve or redesign the process.

There are a lot of tools and techniques, such as process mapping/operational method study, change management, benchmarking which can be used to improve a business process [27]. However, regardless which tool or technique is used, sometimes it could be

hard to understand what were the results of the improvement. To make this process more understandable process visualisation in form of process models or diagrams is used, which is a mean that is used as a support for a better understanding of the results provided by the application of the process improvement tools and techniques.

Usually, ideas for process improvement are produced during the workshops, brainstorming or other creative sessions, during which process is analysed for identifying its weaknesses and generating ideas for improvement. These creative sessions are not conducted in a systematic way, which makes the generation and presentation of to-be process scenarios less thorough. As a result, there is a lack of information regarding the ways for presentability of the process changes. In other words, creativity sessions allow process designer to get some kind of a picture of the process issues, but not precisely describe the effects of the business process change [24].

In this setting, a systematic literature review was conducted in order to identify the ways of presentation of BPI changes. Literature review looks for papers that apply BPI on real-life cases from industry to see what means are used to capture and present these changes. A real-life case is intended as what was used in a paper to describe the application of a BPI techniques. The idea behind it is to have something which would be as close as possible to a situation occurring in a real company. It was decided to focus on the real-life cases because they help to understand both the nature and the extent of the change in order to address the following questions:

- RQ1: How are applied BPI changes presented in real-life cases?
- RQ1.1: Does the size of the project affect how BPI changes are presented?
- RQ1.2: Does the extent of the process change affect the way BPI changes are presented?
- RQ1.3: Does the industry domain matter in how BPI changes are presented?
- RQ1.4 Does the modelling language affect the way BPI changes are presented?

These research questions are relevant because they aim at investigating more how BPI changes are presented. This will help to improve the ways in which the presentation of improvements is done making the effects of the business process change both visible and easily comprehensible to the people who are affected by the change. Identification of the effects of the business process change also helps to see and estimate the newly designed

process performance that was previously identified based on improvement objectives and measures.

This thesis consists of 6 chapters. Following an Introduction part Conceptual foundation part is presented. In Chapter 3 the systematic literature review is presented, which gives a detailed description of the papers' selection process. After that, the selected papers are grouped on the base of the approaches they used for the BPI. Also, a short description of the papers is provided. Chapter 4 presents answers to RQs and it ends with a discussion of the results, which were obtained based on the answers to RQs. Chapter 5 presents the related work and the thesis ends with the conclusions and the list of references.

2 Conceptual foundation

In this chapter, the idea behind modelling languages is presented. Also, some common types of modelling languages are described, focusing on their advantages, disadvantages and areas of their use.

Modelling languages are used to present the business processes. In modelling languages, the process is represented as a sequence of activities and some agent performs each of those activities. Usually, in human interaction workflows the agent is an actor, who is able to do particular tasks using supporting systems infrastructure. A set of operations are performed by the actor over a supporting systems infrastructure during execution when the actor is assigned to a particular activity. These operations can include different things, such as manipulation of data and information, communication with other agents, etc. [42]. There are different types of modelling languages, for example, Business Process Modelling Notation (BPMN), Petri nets, Workflow nets, etc. that are used to present and analyse different aspects of business processes.

In recent years one of the most widely-used notations for modelling business processes is the **BPMN**, which is a standard defined by the Object Management Group (OMG). BPMN graphical notations are divided into four basic categories:

- Flow objects (for events, activities, and decision nodes)
- Connecting objects (for connecting flow objects)
- Swimlines (for representing process participants)
- Artefacts (for additional information) [20]

Flow objects consist of events, activities, and decision nodes. An event can signal the starting point of the process (start event), its end (end event) and arriving messages during the implementation of the process (intermediate event). Activities are tasks which should be performed in the process. Flow objects are connected with connecting objects. Swimlines are for representation of the process participants (agents) and artefacts stand for additional information. Decision nodes define how the sequence of objects can come together/apart in diverse sequences [22].

Integration Definition for Function Modelling (IDEF0) shows how activities flow by using square boxes (see Figure 3). Four types of arrows identify the control, input, output and mechanism of activities. Control-arrow is shown from above in the activity box and

stands for activities requirements. Input arrow is shown from the left side and is directed into the activity box and consists of factors which caused the activities. Output arrow is shown from the right side and directed out of the activity box and stands for activities results. Mechanism arrow is shown from below of the activity box and stands for resources which are needed for finishing the activity [28]. By using IDEF0, it is possible to represent the functions performed by business and manufacturing processes by creating suitable diagrams that include actions, activities and operations. Its graphical format with 'boxes and arrows' makes it possible to present the relationship of all functions and decompose the processes in lower level activities for representation of process phases. IDEF0 also helps to emphasise in the business process an amount of resources involved in the system, as well as their input and output flows for every process activity [4].

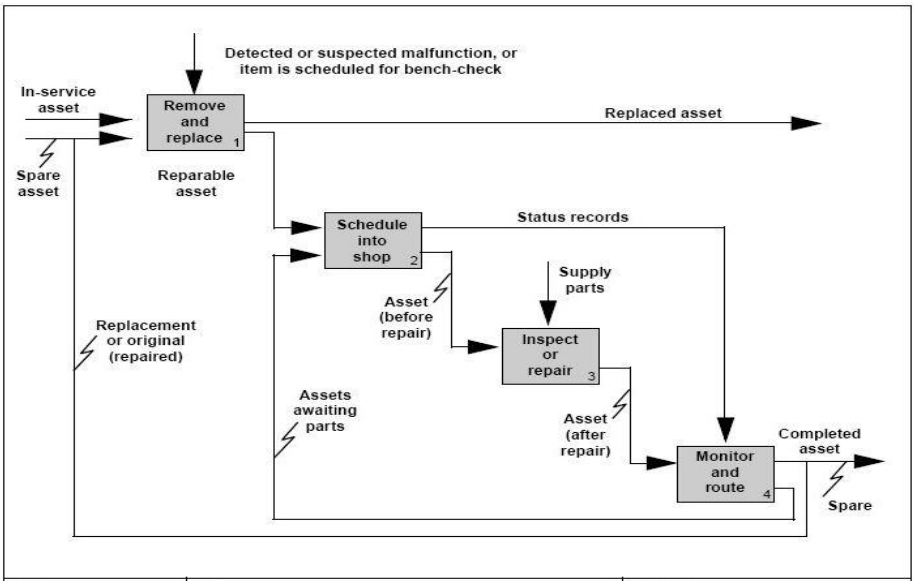

Figure 3. IDEF0 diagram example[1].

A **Heuristic net** is a graphical representation of the process, which consists of rectangles and arcs. Rectangles stand for transitions or activities, while arcs specify the relationships between activities. It is possible to convert the heuristic net into a **Petri net**, which is helpful for performance analysis [23]. A Petri net is called a **Workflow net** when it models an isolated life-cycle of the one case. With Workflow net, it is possible to model realistic and complicated business processes. Process modelled with Workflow net is a case-based, which means that every piece of work is performed for a certain case [26].

The performance and the functionality of the systems can be modelled and analysed using a framework which is provided by Petri nets. Usually, there is a distinction between high-

[1] https://en.wikipedia.org/wiki/IDEF0

level and low-level Petri nets. An example of high-level Petri nets is **Coloured Petri nets (CP-nets)**. CP-nets is a graphical modelling language, which describes the system's state and the events that cause the change of a state of the system. CP-nets connect the strengths of the Petri nets with the strengths of programming languages, where Petri nets are used for describing concurrent processes synchronisation in distributed systems and programming languages are used to define the data types and to manipulate data values. CP-nets are suitable for realistically-sized systems analyses and modelling [18] [47].

Graphs with Results and Actions Inter-related (GRAI) is a modelling method that gives a high-level view of the process as well and helps to identify some essential high-level problematic areas in the process (see Figure 4) [29].

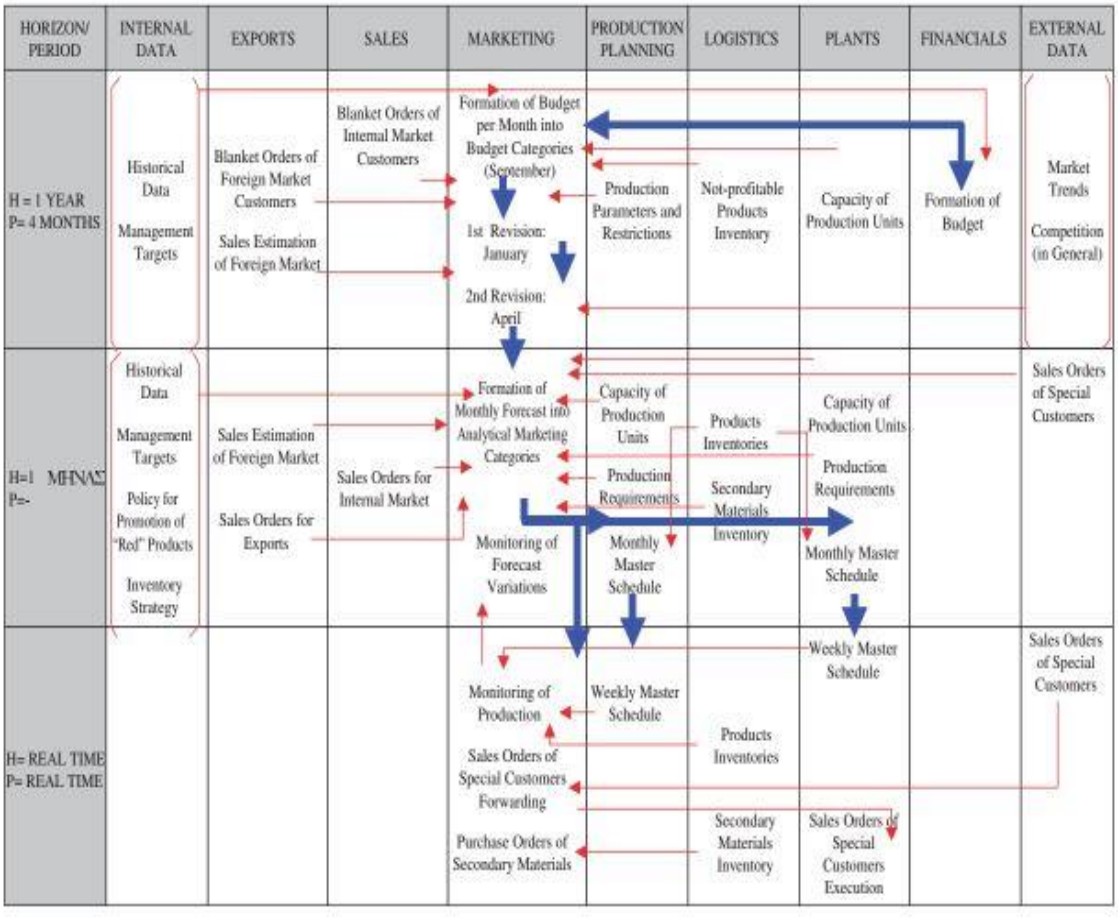

Figure 4. GRAI grid example. [29]

The cause and effect diagram which is also called a **Fishbone diagram** is helpful for identifying the different real or potential causes for a certain effect or problem. Causes of the problem are lined up based on their level of detail or importance, which leads to a description of the relationships of events. This helps to identify problematic areas and un-

derstand the level of importance of diverse causes more deeply than in the case of the GRAI method [46].

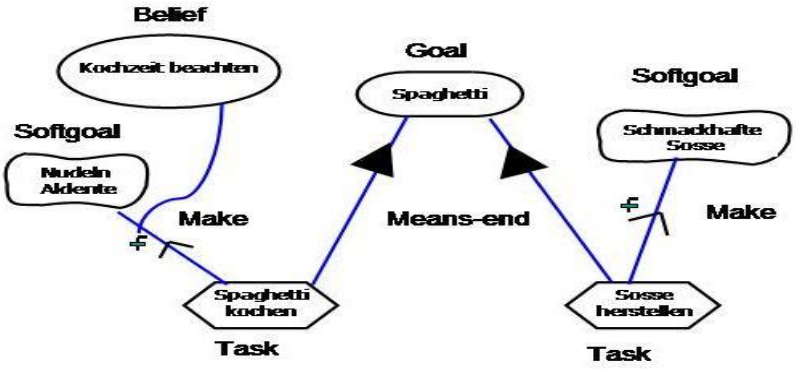

Figure 5. GRL diagram example[2].

Actor Transaction Diagram (ATD) helps to analyse the company's transactions through abstraction and lowering the complexity [25]. **The User Requirements Notation (URN)** is an International Telecommunication Union standard which used to grasp early requirements in the form of goals and scenarios. URN consists of two sub-languages called Goal-oriented Requirement Language (GRL) for goal modelling (see Figure 5) and Use Case Maps (UCM) for scenario modelling (see Figure 6). In the goal model, URN traceability links are used to link tasks to their representation in the UCM model, which provides additional details about the behaviour of the linked tasks. URN's main advantage comparing with other modelling languages is the ability to model processes with UCMs and goals

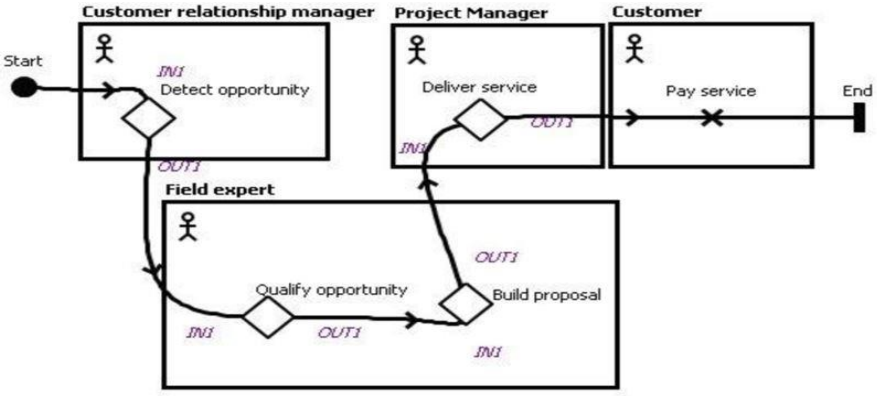

Figure 6. UCM diagram example[3].

[2] https://de.wikipedia.org/wiki/User_Requirements_Notation
[3]https://www.researchgate.net/figure/220920762_fig4_Fig-5-Example-of-use-case-map-for-contract-management

with GRL in a unified form. The UCM and GRL together make the existence of the particular part of a process understandable and answer the who, when, where and what questions of the process models. In spite of its advantages URN notation still needs better support for handling cancellation and exception in process and workflow models [30]. **The Aspect-oriented User Requirements Notation (AoURN)** is an extension of URN, which adds to URN's sub-languages the ability of heterogeneous pattern matching [50].

State diagrams aim to describe the behaviour of the systems. The behaviour of the system is analysed based on a number of events that can happen in one or more possible states. States are changed based on the messages that system receives. In **Value-stream**, the current state is analysed and the new state for the events is created that take a product from its start to the end user [1].

3 State of the Art

3.1 Systematic Literature Review

The purpose of this systematic literature review is to summarise the existing knowledge about the presentation of the BPI changes in real-life cases. The main aim is to analyse the existing knowledge and drive conclusions about the models that are used for capturing the BPI changes. To achieve the research objectives, this systematic literature review targets studies that apply BPI techniques to real-life case studies, capture the BPI changes and identify practical approach in order to present how the improvement is applied. The papers that present BPI techniques for improving the business process itself and not the BPI method were targeted.

The purpose of the literature search stage is to examine studies in a particular way that more or less complete census of relevant literature is collected. The literature search was implemented using principles of a systematic literature review by Kitchenham [17]. Based on its recommendations, in order to make sure that all important studies are included multiple search strategies were used. The first search strategy was an electronic database search having an aim to enable a comprehensive search. Below is the explanation of the primary and secondary searches. To identify an initial set of studies as a primary search an electronic database search was conducted.

As suggested by a number of studies [12] multiple electronic databases were selected in order to cover the existing knowledge about BPI [17]. More concretely, Google Scholar, Web of Science and Scopus electronic databases were selected to ensure the coverage of relevant studies in the area of interest. Chosen search engines considered to be highly relevant because of their multidisciplinary and broad coverage of almost all sciences.

To identify high-quality studies effectively, during a primary search peer-reviewed journal articles and conference papers were targeted. If the paper has a journal and conference versions, then the journal version was selected for further examination. The further constraints for the primary search were the title and the abstract of the article, the language and the year of publication. Studies which had an abstract and were published in English since 1990 were included. The year 1990 was selected because that year considered being the year of the process wave.

To identify the relevant Boolean expressions for primary search acronyms, synonyms and abbreviations related to the term “business process”, “redesign” and “best practices” were considered leading to the following Boolean expressions, which were used in all chosen electronic databases with database-specific headings:

- (("Business process" AND "improvement") AND ("best practices" OR "heuristics" OR "patterns" OR "guidelines" OR "frameworks" OR "techniques"))
- (("Business process" AND "optimisation") AND ("best practices" OR "heuristics" OR "patterns" OR "guidelines" OR "frameworks" OR "techniques"))
- (("Business process" AND "redesign") AND ("best practices" OR "heuristics" OR "patterns" OR "guidelines" OR "frameworks" OR "techniques"))
- (("Business process" AND "re-engineering") AND ("best practices" OR "heuristics" OR "patterns" OR "guidelines" OR "frameworks" OR "techniques"))

After running all five Boolean expressions in Web of Science and Scopus databases totally 763 hits were got. In the case of the Google scholar for each query, first 150 results were considered, because, after this number, papers clearly appear to be out of scope and irrelevant. The overall number of hits for all Boolean expressions in all databases is 1513. After having the initial list of papers 105 duplicates were removed and remaining unique values were examined based on a title to make sure that only BPI papers are included. For example, the paper “A change in process and culture: Implementing quality, reliability and safety in early development” got excluded because from the title it is clear that it is not related to BPI. 314 papers passed the filtering by title stage. These papers’ abstracts were examined to identify the papers which have applied BPI techniques on industry case studies. If it was not obvious from abstract whether the paper should be included or not, papers’ full texts were examined briefly as well. This phase identified 114 relevant papers.

After identifying the set of relevant studies, a secondary search was conducted. For further filtering based on Kitchenham [17] recommendation the inclusion and exclusion criteria were defined as a set questions and based on the answers to the questions it was identified whether to include a study or not. The study was considered in a future research only if all criteria were satisfied. More concretely, for each study, the answers to all questions regarding inclusion criteria should be “Yes” or “?” and the answers to all questions regarding exclusion criteria should be “No” or “?”. The criteria questions are presented below.

1. Does the paper propose or describe existing BPI method or framework?
2. Does the paper describe how the BPI analysis are conducted?
3. Does the paper contain a real-life case?
4. Is there any representation of as-is or to-be process models?

When there were not any relevant concepts the secondary search was stopped. The final number of papers which pass the secondary filtering was 32. These papers are presented in detail in the Appendix I. The literature review results are summarised in Table 1.

Table 1. Summary of search results.

Label	Number of studies
Primary search	1513
Scopus	305
Web of Science	458
Google scholar	750
Duplicates	105
Total after removing duplicates	1408
Total after filtering by title	314
Total after filtering by abstract and full copies	114
Secondary filtering	32

An analysis of the 32 selected articles revealed that selected set consists of journal papers, conference proceedings and dissertation. Those findings are illustrated in Figure 7. As it is seen from the Figure 7 among the selected papers there are almost the same number of journal papers and conference proceedings and only one dissertation. As shown in Figure 8 authors of the chosen studies used different labels to address to redesign of the business processes. The most popular labels are Business Process Improvement, Business Process Redesign and Business Process Reengineering. The existence of such variety of redesign labels makes it challenging to identify relevant articles. This means that the choice of the

articles' searching expressions should be done very carefully in order to cover the complete list of the relevant papers.

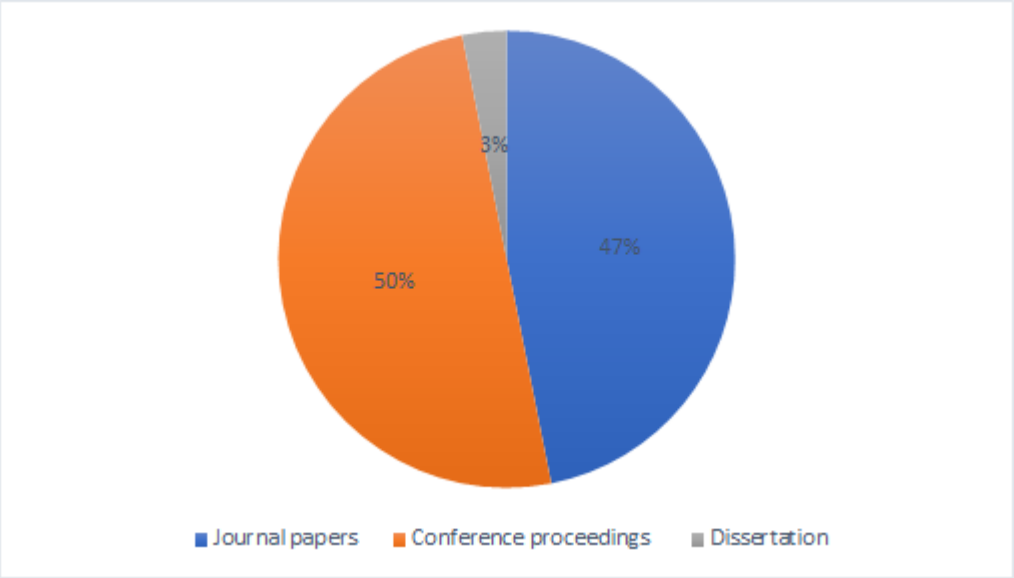

Figure 7. Selected papers' types.

After identifying the final set of the studies that were included in the literature review, the work continued with data extraction and coding. To extract the data fragments from the studies the detailed data extraction form was created and used. Based on the main research question and its sub-questions it was decided to extract two types of data elements from the studies. Firstly, data was extracted regarding real-life cases to which improvement is applied. Secondly, data concerning improvement process was extracted. More

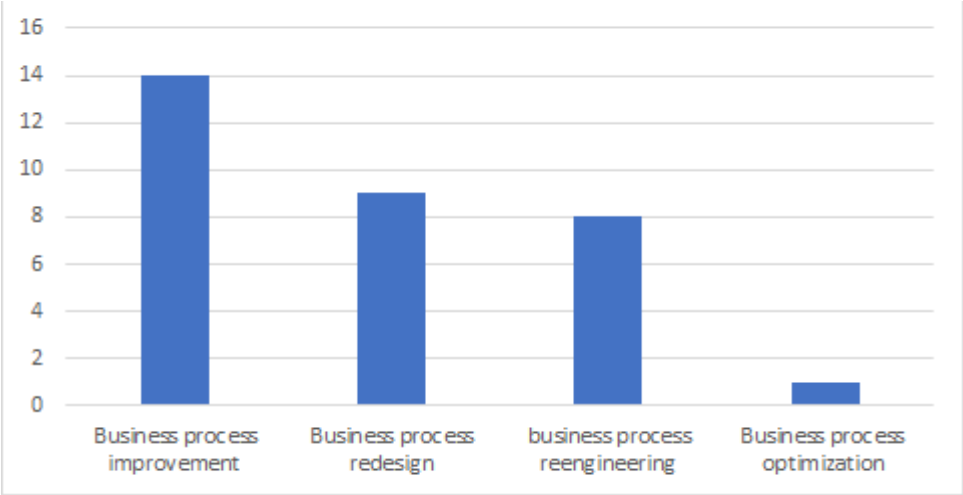

Figure 8. BP labels in selected papers.

precisely, for the real-life cases to which improvement is applied the following data was extracted:

- *size of the process*: how many activities are in the process. The size of the process can be either big, middle or small. A process is considered big if it contains twenty-one or more activities, middle-sized if it contains from eleven to twenty activities and small if it contains up to ten activities.
- *degree of granularity*: how detailed is the description of the process. The degree of granularity can be either big, middle or small. It is considered to be high if the process explanation is thorough made and is in detail, middle if the process is described neither thoroughly nor briefly and low if the process explanation is very briefly.
- *modelling language of the processes*, for example, BPMN, Petri nets, etc. In some papers, the modelling language that was used to present the process was not explicitly stated. In such cases, modelling language was identified based on the look of a diagram.
- *industry-organisation:* the domain of the industry or organisation from where the process was taken.

It is worth mentioning, that some papers have a few case studies, among which only the bigger ones were chosen for evaluation because it was more complex than the others. It was decided not to analyse all cases which were presented in a selected paper because the same framework was applied for that cases and the results were pretty much the same.

Concerning the improvement process the following data was extracted:

- *extent of the change*: size of the improvement, more clearly the number of activities that were changed. The extent of the change does not take into account the size of the process, but rather how many activities were changed, because this research more focused on the analysis of the process change. The extent of the change is considered to be big if eleven or more activities were changed, middle if from six to ten activities were changed and small if up to five activities were changed.
- *communication of the change*: whether the change was described visually or not; which language was used; which kind of annotation was used to explain the change (e.g., text, tables)

- *understandability of the change*: how is it easy to understand the differences with as-is and to-be process models; how is it easy to compare as-is with to-be processes
- *clearness of the improvement*: how is it easy to understand that the process was improved

All of these criteria is used for summarising the different papers and to comparing them in order to identify their similarities and differences.

3.2 Description of the Selected Papers

Thirty-two papers that were identified in systematic literature review were analysed in order to identify if any similarities or recurrent discussions frequently occurred so that some categorisation about the use of redesign methods could be proposed. The proposed categorization aims to help to describe the papers more thoroughly which in its turn will help to answer to RQs. This classification of the papers based on the redesign methods is in some extent related to the way in which the changes are presented and it can be assumed that methods used for redesign would in some extent affect the way the BPI change is presented.

Some papers were grouped together based on the process improvement patterns, which were applied for redesigning the process. The selection of patterns in different papers was done based on different objectives. For example, in [21] the selection is based on organisational objectives, process improvement objectives and process improvement measures; in [31] the selection was more based on understanding if the pattern can be modelled in X modelling language, where as X modelling language is considered AoURN. In [9] and [13] the patterns are chosen from the catalogue based on the improvement goal. Even though these papers chose process improvement patterns based on the different objectives, they all apply process improvement patterns to the process in order to improve it and can be grouped together.

Some group of papers applied BPI approach which is quantitative based. For example, in [46] Six Sigma methodology is applied to improve the process. In [6] Lean Six Sigma methodology is applied, which is a combination of Six Sigma and Lean methodologies. Six Sigma and Lean methodologies have the same goal and only differ by identification of the root cause of waste. In [20] the redesign framework is presented, which is focused on process analyses and based on the results of the analysis suggests the ideas for improve-

ment. Improvement approach which is proposed in [3] is focused on quantitative modelling techniques and their application on supply chains.

Some group of papers applied BPI approach based on the interviews. For example, in [28] in-depth interviews are conducted with the stakeholders in order to identify the guidelines for improvement. In [25] methodology based on the interviews is applied and in [38] the employees of the company are interviewed in order to identify the problems and the process is improved based on the findings of those interviews.

Another group of papers used BPI approaches which are based on simulation. For example, in [42] the iterative BPI approach is based on process mining and agent-based simulation; in [36] it is based on the business process redesign and simulation. In [23] also process mining and simulation methods are used, but it is a bottom-up methodology. In [14] and [15] an approach where CP-nets model of the process is simulated is used and based on that model the appropriate redesign heuristic is applied. As it can be seen, these approaches have quite a bit of difference, but they all use a simulation in order to improve the process.

Table 2. Grouped papers based on the BPI technique.

Name of the group	**Number of articles**	**Articles**
Customer/goal based	8	[37], [16], [4], [2], [22], [5], [39], [50]
Simulation based	7	[7], [42], [36], [23], [14], [44], [15]
Interview based	5	[40], [28], [25], [29], [38]
BPI pattern based	4	[21], [31], [9], [13]
Quantitative based	4	[46], [6], [20], [3]
Modeling language based	4	[30], [26], [33], [48]

Some group of papers used BPI approaches which are based on the modelling language. For example, in [30] aspect-oriented framework is used which is based on URN standard and in [26] an approach which is based on the workflow nets is used. In [33] a methodology for workflow processes is used and in [48] the method for redesigning processes from the viewpoint of knowledge flows is presented. So, in spite of all these differences, the papers can be grouped together because they use redesign approaches that are based on modelling languages.

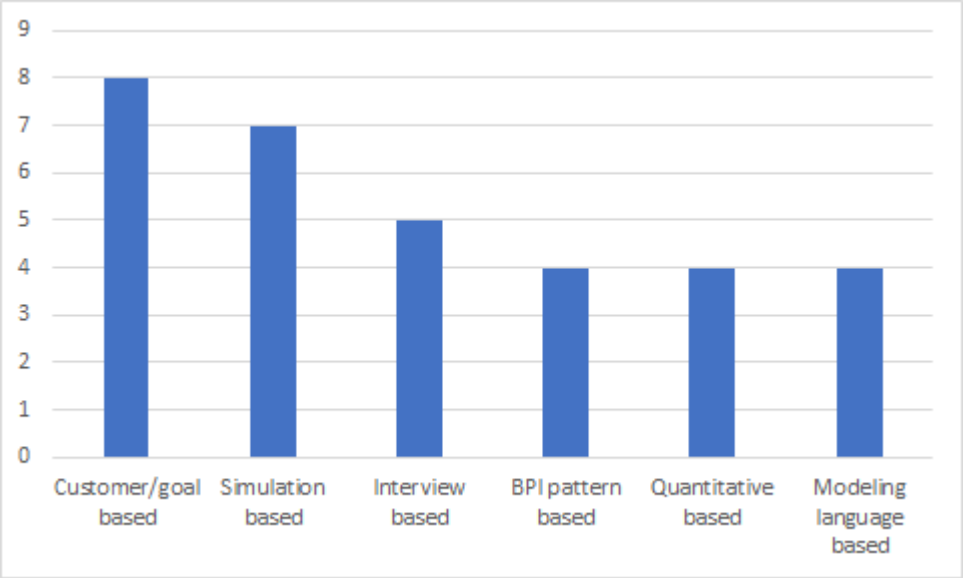

Figure 9. Relation between number of the papers and BPI method.

Remaining papers apply redesign approaches which are customer/goal oriented. For example, in [16] Goal, Exceptions and Dependency (GED) framework is applied and in [22] requirement analysis are made in order to identify goals and redesign the process based on them. In [4] a methodology is applied based on customer satisfaction requirements, which considers an impact of each process phases on the value that is received by customers. In [2] the methodology is customer driven. So, based on these similarities those papers were grouped together. Based on these findings all thirty-two papers were classified into six groups based on the method they used for applying BPI techniques to real-life business process scenarios (see Table 2). As it can be seen from Figure 9 the most popular method for BPI is Customer/goal based, followed by simulation based method. The least popular methods are BPI pattern, quantitative and modelling language based.

3.2.1 Customer/goal based

This group consists of papers that applied customer/goal based improvement method. In [37] a framework for business process model improvement is presented. This framework consists of a set of indicators with validated thresholds which are connected with modelling guidelines, empirically validated measures related to quality characteristics of the models, and a prototype supporting tool. The framework is applied to the big public health service process from health care industry. Redesign of the process is done by applying guidelines which were chosen by IT and health experts driven by the indicator results which caused middle-sized changes in the initial process. The initial and redesigned models are visualised using BPMN.

In [16] GED framework is described. The main advantage of this framework is that it extends existing logistics-based models which makes possible to connect the process' social context with its logistics, which in its turn gives analysts more powerful, detailed and richer description of a process. This framework is applied to non-production materials purchasing small-sized process from MedCom Inc. which is a quickly growing manufacturer with $100M in sales and 450 employees. All services and products that are not connected with MedCom's production are purchased through the non-production materials purchasing process. The process improvement starts with collecting data through interviews, studying of reports and documents that are related to the process and day by day workers' observation. Twenty-five detailed, personal interviews of process members and its customers were conducted lasting from 45 minutes to two hours. Based on the data obtained through the interview process weaknesses were identified and the GED framework was applied in order to improve it.

In [4] business process re-engineering methodology is applied on the basis of customer satisfaction requirements on a small-sized process from fashion footwear industry which is illustrated in IDEF0 model. In order to identify process weaknesses firstly, technical publications were consulted. Then the industry experts were interviewed in order to identify the impact of each phase of a process on the value that customers gain. Based on the received results BPI decisions were made.

In [2] BPI framework is described which is a combination of business process modelling, enterprise information architecture, knowledge management, management control methodologies and techniques. The improvement methodology is a customer-driven and is ap-

plied to the case study from Dutch e-government service department in order to improve it. First, weaknesses of the process are identified and illustrated. Secondly the improvement methodology is applied which leads to a big change of the process, that is presented in the workflow diagram. In [5] the methodology consists of information gathering and relevant customer requirements identification phases. First, the overall value of each process phase is calculated in order to assess how much value it brings to customers. Afterwards, process improvement directions are identified based on the value that different parts of the process are creating for customers. The method was applied to the small-sized process from the wood pallet production industry which is illustrated using IDEF0 and the improvement led to some small changes in the process.

In [22] business process re-engineering methodology is presented based on the requirements analysis. The methodology aims to identify the connection between business process and the goals that it wants to achieve. The methodology is applied to the middle-sized process from health care delivery medicine sector. Following the approach, the functional and security requirements of the initial process are reconstructed at the organisational level in order to meet the desired goals. In [39] Decision Relationship Model for BPI is presented which consists of the following elements: Business Process, Leaf Goal, Decision-Associated-Information, Decision and Action. This is a semi-automatic method for process improvement, which starts from defining business goals and finishes with concrete decisions. The method is applied to a middle-sized process from the healthcare sector.

In [50] a four-dimensional framework is presented that is suitable for enterprise systems improvement and includes: the green dimension, layers dimension, logic dimension and process dimension. This four-dimensional framework is used to redesign a big-sized process from the High-Speed Broadband Metropolitan area networks of HT Company. The main goal of the improvement is environmental protection, so the optimised process begins and ends with it, which is a green service-cantered. The improved process is presented in fishbone diagram.

3.2.2 Simulation based

This group consists of papers which applied simulation based improvement approaches. In [42] an iterative approach for the business process improvement is presented which is based on agent-based simulation and process mining. The approach is applied to the small-sized purchase process which led to small changes in the process. Both initial and changed

processes are illustrated using BPMN modelling language. The advantage of this approach is that the process analyst can identify a better model by inserting changes to the process, which means reconfiguration of simulation platform and generation of a new event log, which leads to mining a new model that is able to consider the relationship between the high-level activities and the low-level behaviour. Repeating those steps will lead to more accurate, balanced and less complex model which is easier to understand.

In [23] a bottom-up process mining and simulation-based methodology for process improvement is presented. The methodology is applied to the big-sized processes from three different industries: gas industry, government institution and agriculture. The methodology starts with the identification of relevant performance problems. On the second phase, the process model is simulated in heuristic net to illustrate the existing situation. During the third phase, redesigned process model is presented in heuristic net to represent a predicted future scenario. After this phase, the performance criteria of both initial and redesigned process models are compared to estimate the gains from the predicted redesign model. For the future analysis, a case study from the gas industry has been chosen, because it was the biggest among existing case studies.

In [14] redesign framework for call centers is presented and applied to the small-sized process from IT help desk of the Dutch company which is presented using Petri nets. The favourable redesign is developed and performed based on the best practices and simulated models are compared in order to understand and choose the one that has higher performance. In [15] BPI approach is presented which is based on redesign heuristics and is developed further by applying CP-nets to the approach. The approach is tested on the middle-sized mental healthcare institute intake process which is presented in Petri nets. First, the CP-net model of the process is simulated and then, according to the BPI approach suitable heuristics are applied to the process. The redesigned process is simulated in Petri nets according to the redesign and the results from initial and redesign simulated models are compared.

In [7] Business Process Execution Measurement Model (BPEMM) for improvement of business processes is presented, which is an extension from Business Process Continuous Improvement Process (BPCIP) and they both are a part of a larger framework called MINERVA. The framework is applied to the big-sized patient major ambulatory surgery process from health care sector which is presented in BPMN modelling language. The improvement of the process is conducted by services based on the execution measurement

which caused small changes in the initial process. Business processes were simulated using CP-net Tools. After the simulation business processes were executed in the selected process engines and after that, the data from the execution of the business process cases was registered and exported for loading in the ProM framework.

In [36] an approach which is a combination of business process redesign and simulation is presented, which is applied step by step on the small-sized process from the municipality. Process as-is model is provided in form of a state model. In [44] business process optimisation framework is presented which uses two components: business process representation and a bunch of evolutionary multi - objective optimisation algorithms. Based on the given requirements the framework can generate a series of alternative optimised business process design. The steps of the framework were applied to real life small-sized online order placement process that led to small changes in the process. Both as-is and to-be process models are presented using fuzzy maps.

3.2.3 Interview based

This group consists of papers in which interviews were conducted to identify guidelines for improvement and/or model the new process. In [40] Sharp & McDermott methodology is applied to the middle-sized purchase request process of Iran Khodro Company. The problems of the process were identified by monitoring it and using some enablers. After extracting the process problems best practices were selected through interviews with company experts, literature review and the company's strategies. After this phase selected best practices were applied that caused small changes in the initial process. The initial and improved processes are presented in BPMN diagram.

In [29] the application of the BPI methodology is described and applied to the middle-sized forecasting process from wood industry. First, the existing forecasting process was analysed using specific techniques, such as personal interviews, the design of process charts, etc. The identified problematic areas were classified into process-related and systematic categories. Based on the results of process analysis, the new forecasting process was designed and documented. The extent of the change of the forecasting process was big and based on the Enterprise Resource Planning (ERP) system functionalities and specifications. The initial and improved processes are presented using GRAI method.

In [38] Positivist Case Research Methodology is applied on middle-sized custom order process in order to improve it. To identify the process problems company’s employees

were interviewed. After interviews, the process redesign phase started which lasted several months. During that period of time redesign team discussed and brainstormed different aspects of the redesigned process. After this phase, the actual implementation of the redesigned process was done and the extent of the change was small. The initial and improved processes are presented using state model.

In [28] big-sized process from milk supply chain is presented in form of IDEF0 diagram. To understand and model the process in-depth interviews with the stakeholders of the milk supply chain were conducted. Based on the results gained from interviews the problems in the process were identified and process improvement guidelines were proposed, which lead to the middle-size changes in the process. In [25] process improvement methodology is presented which is applied on the middle-sized process from the company that deals with engineering services and/or goods for communication maintenance. Interviews were performed to collect the data and based on this the process was improved. The extent of the change was middle-sized and was presented using ATD model.

3.2.4 BPI pattern based

This group includes papers which apply process improvement patterns based on specific requirements in order to improve the process. All the papers in this group illustrated the as-is and to-be process models. In [21] Process Improvement Patterns (PIP) assessment approach is used. The approach is a scenario specific evaluation of PIP, based on different objectives such as organisational, process improvement, etc. The approach is applied to middle-sized process from the human resource management industry. The extent of the change is small and the results gained after applying the approach are validated with practitioners. In [31] the PIP is assessed and grouped, based on the possibility to model the process in X modelling language. A small process from consignment retail store industry is used to apply the framework.

In [9] PIP is searched and applied based on the improvement goal. The PIP selection is based on the two basic requirements. First, there should be selection guide, which helps to select a suitable pattern for a specific problem and second the pattern has to have detailed instructions for its application. This approach is applied to a big-sized studying process from the perspective of register's office. The goal of improvement is to reduce the cycle time. Firstly, based on the model patterns were searched from the PIP catalogue, which results in a reduction of the cycle times without affecting the quality and cost levels of the

process. The next step was to filter these patterns based on the suitable application guidelines. Based on the application of selected patterns process was improved and extent of the change was small.

In [13] a technique for choosing PIP is presented, which is suitable for e-services' improvement and measuring the process performance after improvement to make sure that the process gets better. The technique is applied to middle-sized processes from Dutch municipality and service organisation which caused small changes in the case study. Afterwards, the results of the redesign were verified by collecting feedback from the municipality employees. The process was presented using Petri nets. The technique was applied to the Dutch service organisation as well. For further analysis, the first case study was examined because it is bigger and well explained compared to the second case study.

3.2.5 Quantitative based

This group consists of papers that apply improvement methodologies that are quantitative based. In [46] Six Sigma methodology is applied to small-sized admission process for students which is illustrated in fishbone diagram. The main problem of the process was that it had a lot of delays. Applying Six Sigma methodology identifies the key reasons that were causing the delays. Based on the received results process was improved and visualised in fishbone diagram with a small extent of the change.

In [6] Lean and Six Sigma methodologies were applied to entire small-sized surgical process from health care sector to improve its efficiency. The process is visualised in form of value-stream diagram. Multidisciplinary teams were formed from hospital administrators, financial analysts, anesthesiologists, surgeons, nurse anaesthetists, nurses, systems, procedures and information technology personnel to identify several modifiable points throughout the surgical process. Based on identified findings, process improvement was conducted which lead to substantial increases in financial performance and efficiency.

In [20] a framework for improving enterprise processes is presented. The framework focuses on analysing the existing process and suggesting improvement ideas based on the analysis. The framework is applied to the small and simplified product manufacturing process. The process is analysed based on performance. The analysis leads to small changes in the process. Reengineering approach which is discussed in [3] has four basic stages: mobilisation, diagnosis, redesign and transition. The approach is more suitable for reengineering supply chains and highlights the important role that quantitative modelling

techniques, such as those founded in Operations Research and Industrial Engineering can play in the re-engineering of supply chains.

3.2.6 Modelling language based

This group consists of papers which applied modelling language based improvement approaches. In [30] aspect-oriented framework for BPI is presented which is based on the URN standard and consists of 4 views: process, performance, goal, validation. The framework is applied to the case study, which is a Data Warehouse Approval Process of a healthcare provider. Health information access requests are assessed based on different factors such as ethical and patient privacy concerns, technical feasibility and impact, etc. Framework application led to small changes in the process.

In the [26] workflow based evolutionarily approach for BPI is suggested, which includes the following steps: computing process measures, evaluating conditional statements to find applicable redesign "best practices", creating alternative models according to these best practices and evaluating the performance of the created alternatives. The paper uses small-sized insurance claims handling process. The process as-is model is presented using workflow nets and the framework is applied to it in order to illustrate how it works. In [33] a product - based workflow design method is described, which consists of four phases: scope, analysis, design, evaluation. The design phase is dependent on the strategy that company would like to build with its customers and with other strategic issues such as time and cost. This method is applied step by step on the case study from the social insurance company and the improved process is illustrated using workflow nets.

In [48] a methodology to improve business process using a knowledge map is described. The methodology consists of the five steps and it is applied to the small-sized process from the wedding planning company where the as-is model is provided in form of workflow diagram. After mapping and optimising knowledge flow and profiles, the business process is rearranged. Optimised knowledge flows help corresponding business processes to be optimally reorganised. During final step, the optimal business processes are extracted in form of the workflow diagram and it appears that the extent of the change is small.

4 Analysis

In order to answer to the research questions, all the selected papers were carefully analysed with the aim of identifying different modalities of presentation of the changes after a business process improvement initiative. Consequently, we looked for any repetitions, similarities and differences, in how changes were presented in the selected papers.

It was noticed that as in other scientific fields where some change occurred in a phenomenon [41], [19] changes were presented either visually, or in a numerical way according to some indicators, or described textually. In a similar way, when analysing papers, it was identified these three same categories to describe how changes were presented: in [36] and [13] a numerical way was used to present the improvement changes. The numeric changes of parameters which got changed after improvement are presented in tables.

In nine papers, the changed process is discussed in the text in a narrative way (see row "Change presented textually" in Table 3). For example, in [6] in the text, it is discussed which parameters and how were improved after the change. In [26], [39] and [28] is discussed what part of the process, what redesign patterns, how and for what purpose were applied. It was also identified that the papers which presented BPI change numerically or discussed it in the text also provide the as-is process model, which was created using different modelling languages.

Table 3. Grouped papers based on the presentation of the BPI changes.

Name of the group	**Number of articles**	**Articles**
Entire to-be process presented	16	[50], [46], [9], [21], [37], [40], [42], [44], [48], [38], [14], [2], [29], [31], [23], [33]
Change presented textually	9	[4], [5], [20], [7], [22], [6], [26], [39], [28]
To-be process parts presented	5	[30], [16], [25], [3], [15]
Change presented numerically	2	[36], [13]

In [30], [16], [25], [3] and [15] only the process parts that were changed are visualised and it is worth mentioning that different papers use different modelling languages for process change visualisation. In sixteen papers (see row "Entire to-be process presented" in Table 3) entire as-is and to-be process models of the real-life cases are presented in order to show the BPI changes. In more detail, 5 papers used BPMN modelling language, 3 papers used workflow nets, 2 used fishbone diagrams and remaining 6 papers used URN, Petri nets, heuristic nets, GRAI, fuzzy maps and state diagram to illustrate the processes.

Based on the findings discussed above, four categories of presentation of BPI change and not just only three were identified (Table 3). In fact, two categories were dedicated to visualisation, which is considered the most relevant because most of the papers presented the BPI change using it. So, it was decided to take two different subcategories about visualisation: all the to-be process presented or just the parts improved. This further specialisation of the visual presentation of changes is motivated by the fact that it is possible to consider that the easiness of understanding the change presented in a visual way would be affected by the fact that the visualisation focuses just on the parts which were improved or it is related to the entire process. This last option seems to give the idea that changes are hardly recognised, but this is not necessarily true if for instance, the entire to-be process is easily visually comparable with the original as-is process [10].

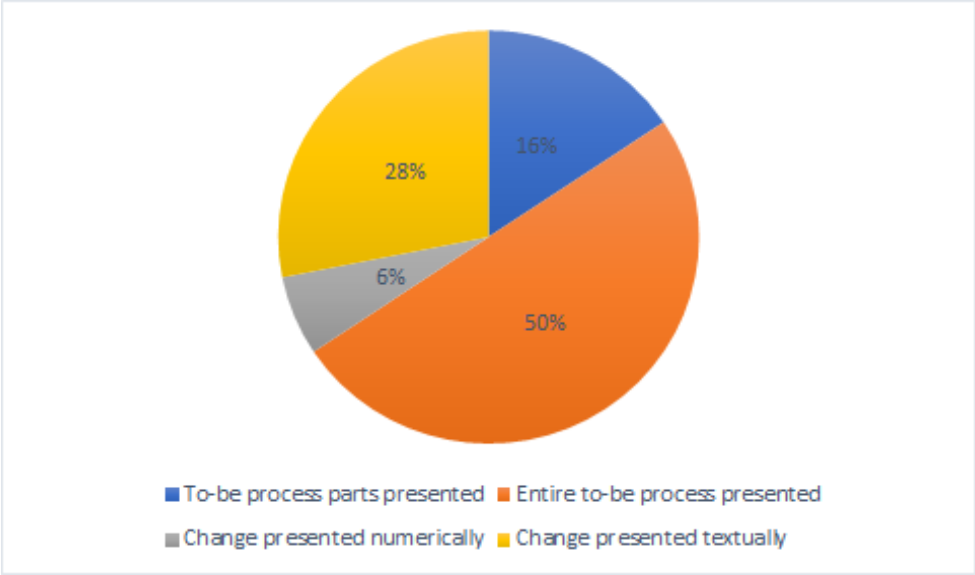

Figure 10. Connection between number of the papers and BPI change presentation method.

4.1 How are applied BPI changes presented in real-life cases? (RQ1)

The classification discussed above aims to help to answer to the **RQ1: How BPI changes that are applied to real-life cases are presented?** In fact, these 4 groups emphasise that the BPI change is presented in four ways (see Table 3). The most common way is to present the BPI change visually by to-be processes which is followed by textual and numerical ways of change presentation. Visual presentation is done by providing either full to-be process model or its parts. It is not surprising that visual way of change presentation is the most common one because it is a part of the BPI and most of the modelling in general is done by means of visual representation of the models. It is surprizing that textual way of BPI change presentation is so common that 9 papers out of 32 used it. It may be possible that textual way of BPI change presentation is so common because it is easier, quicker and requires less skills to explain the change in the text then spend time on visually representing the process. The other possible reason of it could be that authors are hesitant to choose a modelling language. The frequency of BPI change presentation methods is shown in Figure 10.

4.1.1 Entire to-be process presented

Papers in this group present process improvement changes by visualising entire to-be process model. For example, in [50] and [46] a fishbone diagram is used to illustrate the changes made in the processes. The fishbone diagram from [50] is presented in Figure 11. The choice of Fishbone diagram for presenting BPI is quite interesting because it is mostly used to identify the causes of imperfections. In [50] the choice of the diagram is justified by its suitability to present process change from different dimensions. For both [50] and

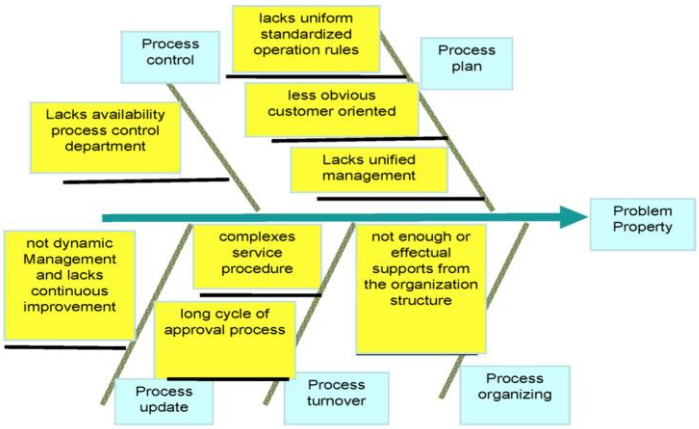

Figure 11. The fishbone diagram of BPI on the whole broadband service layer [50].

[46] papers it is hard to understand that the process was improved because as-is process model is not provided for comparison with to-be model and improved parts in to-be process model are not highlighted as well.

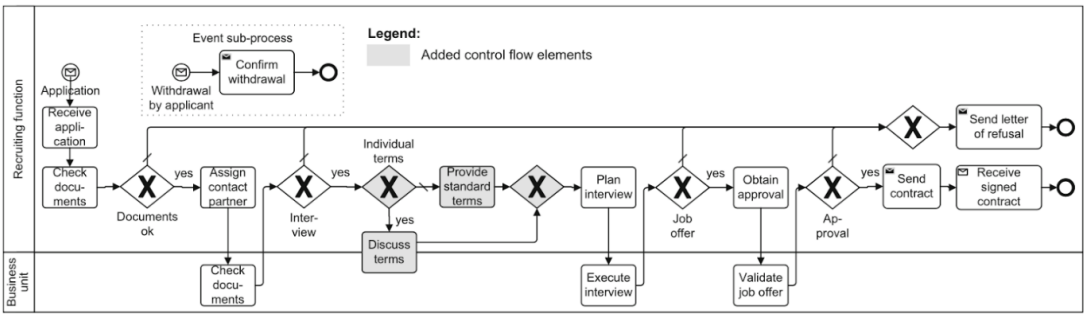

Figure 13. Example of to-be process with marked changes [21].

Five papers in this group used BPMN modelling language in order to present their to-be processes. In these papers, as-is models are presented as well in the same modelling language as to-be process models. Among these five papers in [9], [37] and [40] improved parts before and after the change are shown side by side which highlights the change and makes it more understandable. In [21] the improved parts in the to-be process model are

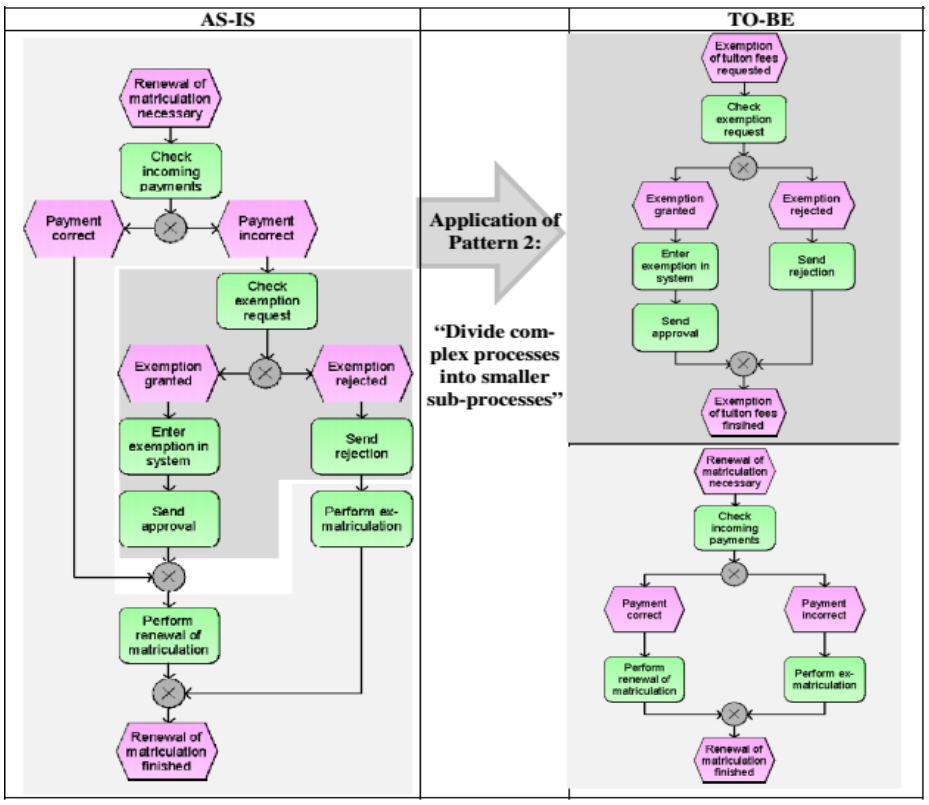

Figure 12. Process parts presented side by side before and after the change [9].

coloured. An example from the paper [21] is presented in Figure 12. From the Figure 12, it can be seen that improved parts are marked in grey which makes the changed parts noticeable. In the case of the [42] change is understandable because the process is small. As-is process model has only three activities and the to-be model has six activities which make it easy to compare process models and understand which parts have been changed. So, in these papers, it is easy to understand the process change because there is a possibility to compare as-is and to-be processes in order to identify where the changes occurred. For more clarity, some papers even presented improved as-is and to-be process parts side by side (see Figure 13). In [14] Petri nets are used for presentation of the improved process. Figure 14 presents a diagram from [14] which shows process parts before and after change side by side, which makes the change more understandable.

In [2] and [48] workflow diagram is used to present the improved process. Both in [29] and [31] as-is and to-be process models are provided using GRAI method and URN model accordingly. In [38] a state model is used for improved process visualisation. In [44] a fuzzy map is used to present the improved process.

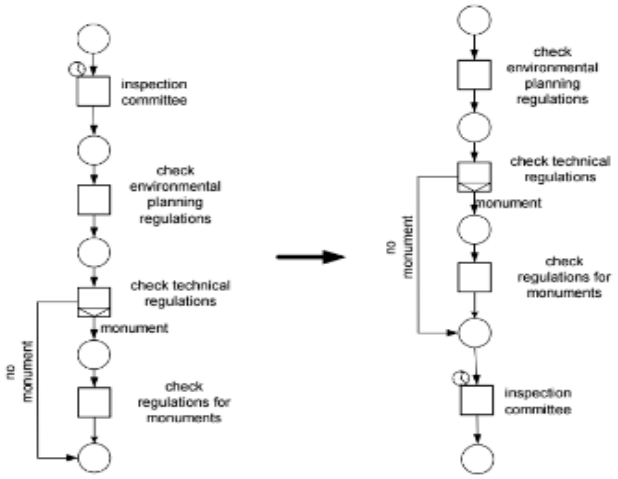

Figure 14. As-is and to-be process parts presented side by side [14].

In [23] the process is presented in heuristics net and in [33] in workflow nets. For both processes it is hard to understand that the processes have been improved based on the visualization, because in [33] as- is process model was not provided for comparison and in [23] the improved parts were not highlighted which makes them less understandable comparing with as-is process because the process is big.

Based on those observations it seems that the easiness to understand the change could be related to the fact that for example, in [9] both as-is and to-be process models are displayed, while in [46] only to-be model is shown. So, the possibility to easily compare the changes by referring to both as-is and to-be process models affects the understandability of the process change. Also, the improvement is more understandable because in the visualisation of the process authors highlight the parts that were changed. So, both these strategies: side by side (with both as-is and to-be parts are printed side by side in the same figure displayed with the same modelling language and without annotation) and explicit encoding (where annotation focuses on the changed occurred) help to easily understand the change.

In this process, we suggested that storage tanks should have an impeller design so that raw milk will be mixed thoroughly and provided a spreadsheet to determine the blending formula. Next, raw milk will be delivered to customers in a temperature-controlled truck. We found that the milk plant staff could not track the milk truck on a real-time basis. Then, coordination between two organisations should be established so that the staff are prepared to receive and produce accordingly. Finally, if the raw milk fails to meet the customer specification, then it will be rejected and sent back to the collector.

Figure 15. Change description in the text. [28]

4.1.2 Describe the BPI changes in the text

This group of papers presents only as-is process visualisation where BPI changes are discussed in a paper without any illustration. In [4], [28] and [5] IDEF0 visualisation model is used to visualise as-is processes. An example of the way change is presented in textual form in [28] in presented in Figure 15 and Figure 16. Figure 15 presents identified prob-

Activities	Problems	Improvement guidelines
Plan	Lack of strategic forecast	Long-term supply and demand forecast
		Data analysis from number of milk cows and productivity
		Determine the optimal location and numbers of collecting centres
Source	Lack of traceability at farm level	Implement database and traceability system
	Lack of raw milk price system considering nutrient composition	Nutrient composition checking at farm level
	Lack of consistency of raw milk quality	Cooperate with agricultural technician to increase the productivity and quality of raw milk
	Lack of temperature measurement at farm level	Vehicle routing with time windows
Make	High volume of water usage	Implement green technology and lean production
	Inefficient blending of raw milk	Design the optimal impellers for storage tank
	Lack of decisional support for blending of raw milk	Spreadsheet for decisional support for blending of raw milk
Deliver	Real-time tracking and coordination between driver and raw milk receiving staff	Real-time control and milk truck tracking system

Figure 16. Summary of problems and suggested improvements [28].

lems described in a narrative way and Figure 15 shows overall problems that were identified in the process and corresponding improvements, where the change presented in a more structured way than Figure 15. In [20], [7], [22] and [39] BPMN modelling language is used to visualise as-is processes. In [6] and [26] a value – stream and workflow diagrams are used respectively to present as-is process models. Other example from [39] is provided in Figure 17, where the process change is thoroughly described in the text in a narrative way.

For the directives *doctor should not check blood pressure AND/OR nurse should check blood pressure* the realization should be at two levels. At the *business level*, the nurses would be asked to check the blood pressure whereas the doctors will be stopped from doing it. At the *process level*, the process model will be re-designed in such a way that the blood pressure activity will be disassociated from the doctor (actor) and associated with a new actor (nurse). In this way, the goal *'doctor's availability will be used optimally'* can be fulfilled.

Figure 17. Summary of problems [39].

In this group of papers in a textual form is described what part of the process and what parameters are changed. The description is not thorough and is hard to refer to as-is model. Also, because most of the papers in this group do not provide the number of activities that were changed, it is hard to define the extent of the change.

4.1.3 To-be process parts presented

Papers from this group present process parts that have been improved using one of the modelling languages. BPI decisions were made based on the analysis of the process. It was discussed what parts of the process and how were redesigned and what problem it was solving and only the redesigned parts were visualised. Different papers used different modelling languages to visualise improvements. For example, [15] uses CP-nets and the [30] uses URN diagrams. In [15] the process is improved using an approach based on the redesign heuristics. It was not explicitly stated in the approach that only CP-nets should be used but rather CN-net is chosen by authors to identify the suitability of CP-net models for process redesign. In [15] authors present to-be process parts that they were able to model straightforwardly using CN-net and entire as-is process visualisation, but in spite of that, the change is not understandable because as it is mentioned by authors CP-net model turns out to be too complex.

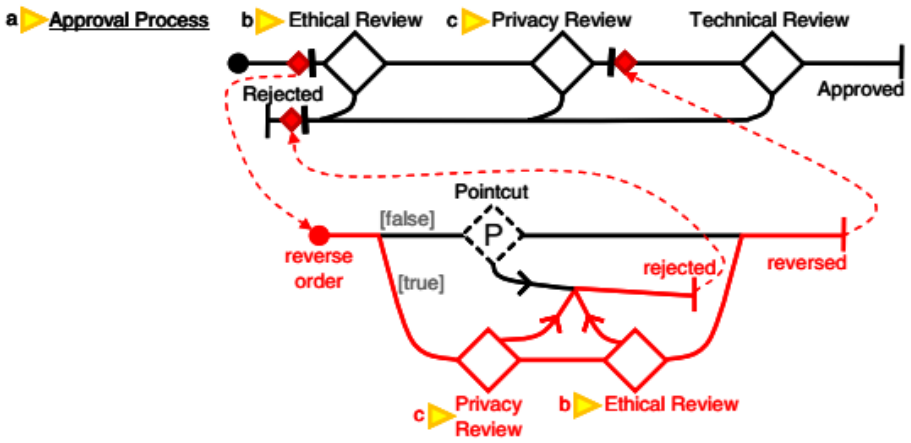

Figure 18. Application of knockout pattern [30].

[30] presents URN based framework. It is explicitly stated and explained in the description of the framework to use URN model. It is not possible to use the framework with another modelling language. In [30] as-is process model and redesigned parts of to-be process are presented using URN model and Figure 18 shows one of the process redesigned part from [30]. As it can be seen from the Figure 18 the redesigned parts are marked, which helps to understand exactly which parts and how were changed.

In [16] and [3] the processes are presented using workflow nets and value - stream diagrams accordingly. In [25] a proposed methodology can be used if model the process using one of the six modelling languages that are acceptable for methodology (see Figure 19). ATD model is one of the six suggested modelling languages, which was chosen by authors because it is best suitable for the particular case study that was redesigned in the paper. In [25] as in the case of the [30] improved parts are shown with some form of graphical annotation, in the case of the [25] the improved parts are coloured.

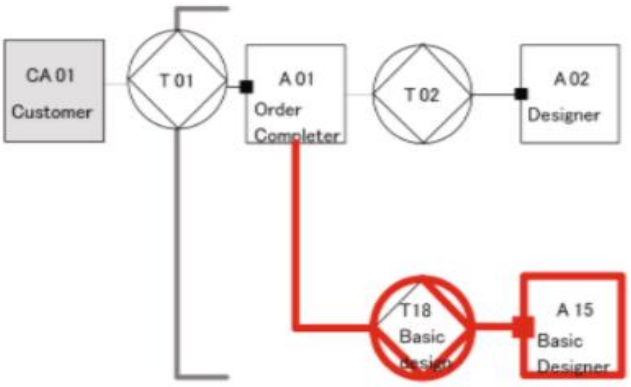

Figure 19 . To-be process part [25].

Changes in all papers in this group are well described, but due to the fact that the whole to-be process was not provided, it is hard to estimate the extent of the change. Also, in some papers annotation strategy is used to emphasise the parts that were changed. It was also identified that in some cases redesign approach suggests the usage of the modelling language. For example, in [25] and [30] redesign approach suggests using specific modelling language for process presentation and in [15] CP-nets were used for process visualisation because redesign framework was based on CP-nets. So, it can be concluded that in some cases the redesign technique suggests the modelling language which should be used in order to apply this technique.

4.1.4 Show redesign changes numerically

This group of papers presents two papers that visualise the as-is process model and show redesign changes numerically in the tables. In the table in [36], to-be configurations that met redesign objectives are listed and described. Also, summary of the results for to-be process is presented in the table with an aim of as-is and to-be process comparison. Table 4 presents an example from [13] where redesign changes are presented numerically. Results are given in the form of numeric values of parameters, such as throughput time, resource utilisation, etc. that have been changed after the redesign.

Table 4. Simulation resolts of three one-level designs. Lower Bound (LB) and Upper Bound (UB) are given for 95% reliability intervals [13].

design	scenario	service level	resource utilization	speed of answer	throughput time special calls LB – AVG – UB	throughput time standard calls LB – AVG – UB
1	1	100	0.342	0.000	1472-1489-1506	143-144-144
1	2	100	0.431	0.005	1468-1482-1496	144-145-145
1	3	100	0.282	0.000	1484-1513-1542	147-148-148
1	4	100	0.403	0.002	1474-1488-1502	133-134-135
1	5	100	0.354	0.000	1461-1482-1503	144-145-145
2	1	89	0.286	2.292	2488-2533-2578	146-147-148
2	2	85	0.339	3.533	2602-2637-2672	148-149-150
2	3	89	0.228	4.786	2413-2465-2517	152-153-154
2	4	83	0.313	1.670	2595-2645-2696	133-134-135
3	1	99	0.307	0.067	2414-2457-2500	143-144-145
3	2	98	0.377	0.277	2396-2440-2485	144-145-145
3	3	100	0.235	0.010	2324-2390-2408	148-149-149
3	4	97	0.369	0.509	2398-2439-2484	132-133-134
3	5	99	0.315	0.084	2391-2437-2483	144-145-146
3	6	99	0.307	0.145	2383-2423-2463	143-144-145

In [36] the as-is process is presented in a state model and in [13] the as-is process is presented using Petri nets. Both these papers use simulation based redesign approach and simulated as-is and to-be process models. It is interesting that they decided to not provide simulated to-be process model, but rather present the simulation results in a numerical form. In [36] it is mentioned that 50 to-be scenarios were simulated. So, maybe authors had no room in the article to put all processes and for some reasons decided not to put some of them as an example.

4.2 Does the size of the project or extent of the process affect how BPI changes are presented? (RQ1.1, RQ1.2)

The RQ1.1 and RQ1.2 are considered together in this section because both of the questions concern a matter of size, as the first focuses on the size of the process to be changed and the second one on the size of the change, it was decided to collect these two questions together.

The size of the process is identified by a number of activities in the process and extent of the change is defined by a number of activities that were changed during the redesign process. The size of the process and extent of the change can be either big, middle, small or N/A. Where N/A stands for undefined, which means that the size of the process or extent of the change were not mentioned in the paper or there was no visualisation of the entire case study that was studied in order to identify the size or extent based on the number of activities of the process model. The process is considered to be big if it contains twenty-

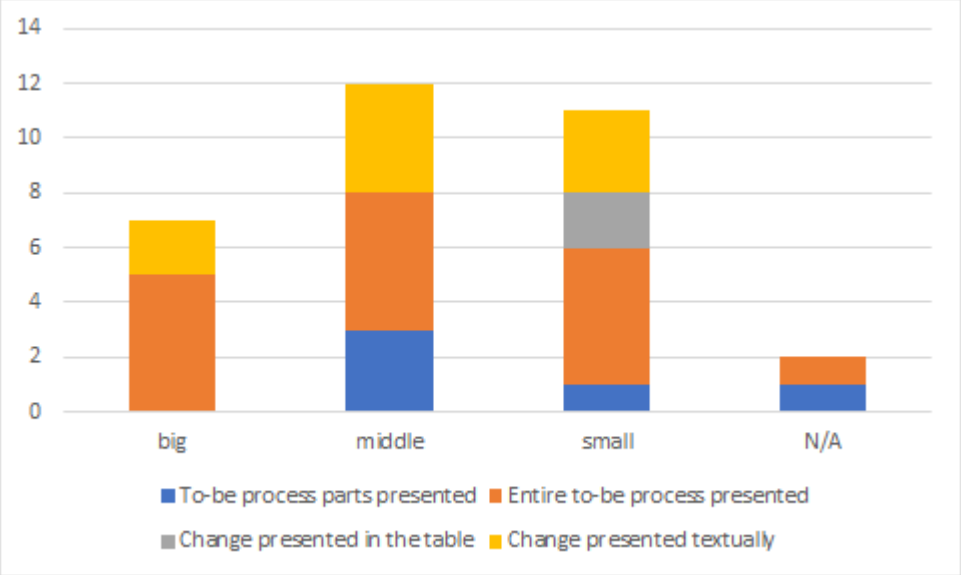

Figure 20. Connection of BPI change presentation group and size of the process.

one or more activities, middle-sized if it contains from eleven to twenty activities and small if it contains up to ten activities. The extent of the change is considered to be big if eleven or more activities were changed, middle if from six to ten activities were changed and small if up to five activities have been changed. Those number of activities for defining big, middle and small size of the process or extent of the change were chosen based on the information which was given in the papers. Some papers mention the number of activities that the entire case study has and call it either big, middle or small sized. Based on this data the number of activities for different sizes was identified and applied to define the size of the process and extent of the change for other papers that did not mention the size of the process.

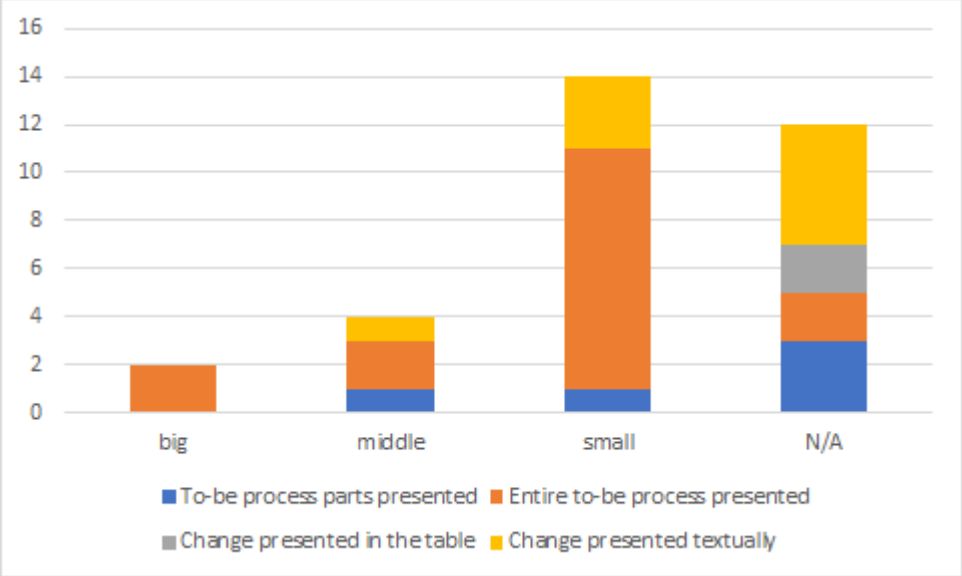

Figure 21. Connection of BPI change presentation group and extent of the change.

As it can be seen from the Figure 20 that if the process is small-sized then all four categories are used to identify the change. In the case of the big and middle sized processes, two and three categories accordingly are used to present improvement change. Figure 21 shows the connection between the way of presentation of the BPI change and extent of the change. From the figure, it can be seen that distribution of extent of the change among BPI change presentation categories is random. For example, "Entire to-be process presented" way of BPI change presentation is used for all extents of the change. It seems that there is no correlation between the size of the process or extent of the change and the way that BPI change is presented. So, answering to **RQ1.1: Does the size of the case study affect the way BPI changes are presented?** and **RQ1.2: Does the extent of the change of the case**

study affect the way BPI changes are presented? it seems that according to the analysis the size of the process and extent of the change does not affect the way of BPI change presentation.

4.3 Does the industry domain matter in how BPI changes are presented? (RQ1.3)

Data extracted from thirty-two papers regarding the industry of the case studies shows that processes are from twelve different domains. Figure 22 shows the connection between BPI change presentation group and industry from where the case study is taken. As it can be seen from the figure "Entire to-be process presented" group is the most popular one.

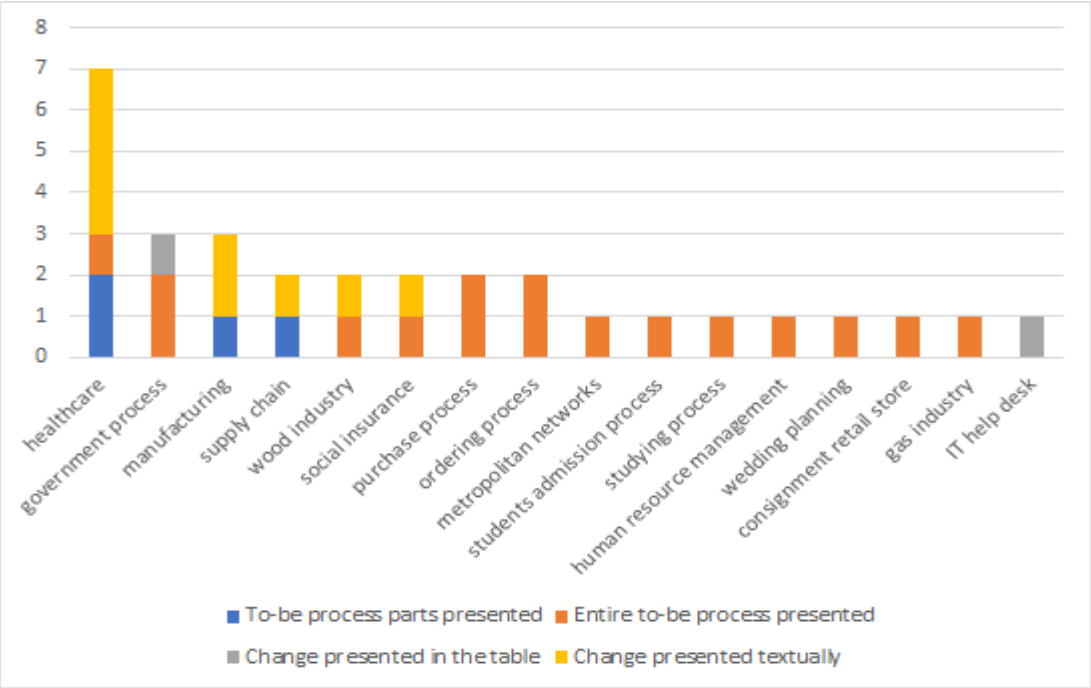

Figure 22. Connection of BPI change presentation group and industry.

Figure 22 shows that healthcare domain has the higher number of case studies followed by processes from government and manufacturing sectors. There is more than on case study presented in eight domains. Only in two among this eight domains process change is presented using the same method. Processes which are from the same industry used different BPI change presentation methods. For example, there are eight processes from healthcare sector and different papers used different BPI change presentation methods: two papers used "To-be process parts presented" method, one process used "Entire to-be process presented" method and four others used "Changes presented textually" method. So, answering to **RQ1.3: Does the industry from where the case study is affect the way BPI**

changes are presented? it seems that there is no pattern between the industry and the way of BPI change presentation.

4.4 Does the modelling language affect the way BPI changes are presented? (RQ1.4)

Data extracted from the papers show that fourteen different modelling languages were used in thirty-two papers for process visualisation. Among those languages, thirteen were used in twenty-one papers for process change presentation. One language (IDEF0) was used for only as-is process visualisation. An interesting finding is that IDEF0 was used in three different papers for as-is process model visualisation, but was not used for process change presentation.

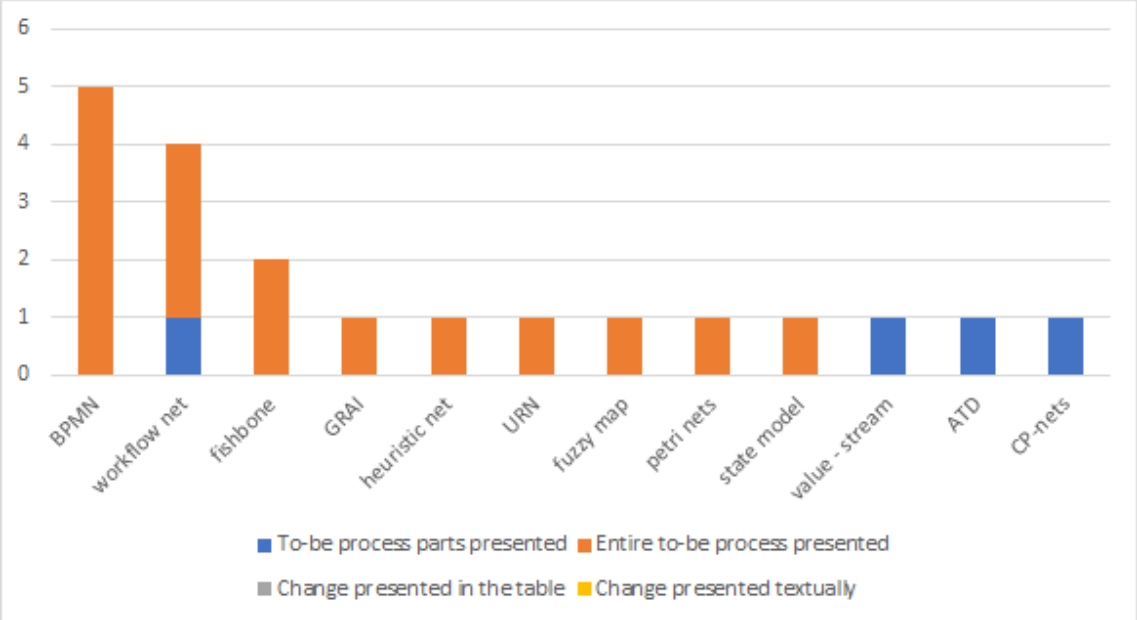

Figure 23. Connection of BPI change presentation group and modeling language.

Figure 23 shows modelling languages that were used in the papers which use a BPI change presentation method that uses modelling language for presenting the improvements. As it can be seen from Figure 22 the most popular modelling language for BPI change presentation is BPMN, which was used in five different papers. The popularity of BPMN modelling language shows the tendency of it gaining a standard for business process visualisation. The next popular language after BPMN is the workflow net, which is used in four papers for BPI change presentation. The popularity of BPMN and workflow net is not surprising because they are both process-oriented languages. Figure 24 shows the ratio between process oriented and non - process oriented modelling languages. Process orient-

ed are those modelling languages that allow parallel tasks. It is clearly seen from Figure 24 that most of the papers (62%) used process oriented modelling languages, such as BPMN, fuzzy maps, CP-nets, Petri nets, workflow net, heuristic net, URN, value-stream and the other papers (38%) used non – process oriented modelling languages such as fishbone, state model, IDEF0, GRAI, ATD.

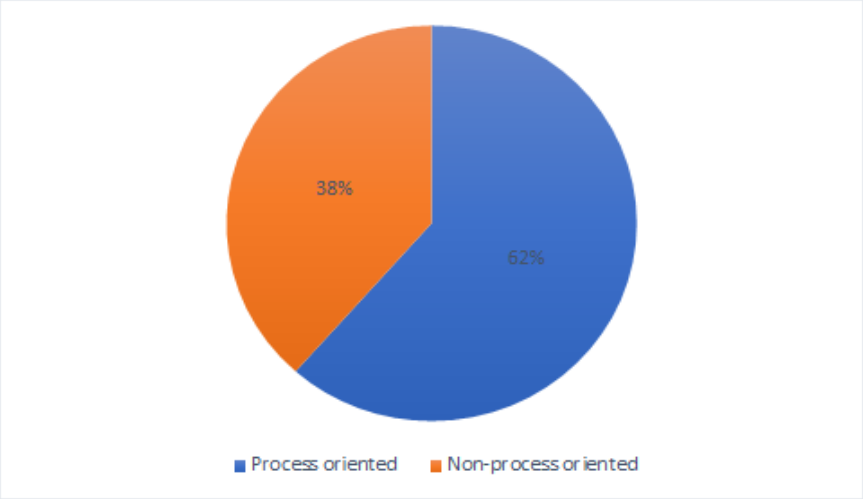

Figure 24. Correlation between process and non-process oriented modeling languages.

It seems, from the Figure 23 and 24 that in most of the cases different modelling languages were used via the same method of BPI change presentation. These modelling languages are either process oriented or non-process oriented. So, answering to **RQ1.4 Does the modelling language affect the way BPI changes are presented?** it can be stated that modelling language does not affect the way of BPI change presentation.

4.5 Discussion

The analyses of the selected papers identify four categories that are used in the selected papers to present the BPI change. So, it can be said that BPI changes that are applied to real-life cases are presented in three ways: visually, numerically and textually. Most of the papers used visual method of process change presentation, so two separate categories of visualisation were considered: all to-be process and to-be process parts presented. It was also an interesting finding that the textual way of the change presentation was the second popular after visualisation, which is surprising because it is not intuitive and the description of the change in the text can be not thorough enough, but perhaps authors used this way because it was more convenient for them and was dependent on the particular case study or BPI technique.

The papers were further analysed in order to identify whether different parameters of the process, such as size, extent of the change, industry, modelling language affect the way of BPI change presentation in identified four categories. The analysis of the papers show that there is no systematic approach of choosing the way of presentation of the BPI changes. There is no correlation between how the changes are presented and size of the process, the extent of the change, industry or modelling language. Even though it was identified that most of the papers used process driven modelling languages for process change presentation.

It was also noticed that there is no connection between as-is and to-be process models. Some papers presented only as-is model and the others only to-be giving no explanation for this choice. Nevertheless, in most of the papers while whether just the improved parts are shown, then annotation strategy is used to emphasise the parts changed. This means that only the parts of the to-be process which were improved are shown with some forms of graphical annotation on the parts improved (e.g., by encircling them, by writing some text just close to the part or colouring the improved parts with a different colour). Usage of this strategy helps to understand the change.

In most of the papers when the to-be process is entirely provided as-is process is fully presented as well. This makes it easier to understand the change compared with the cases when only to-be process is presented. Availability of as-is process helps to compare both as-is and to-be processes which make the change more understandable. So, it might be that as-is process is presented in order to make it possible to compare it with to-be process in order to identify where the changes occurred through visual comparison.

4.6 Threats to validity

In this section, the threats to the validity that could affect this work are analysed. Threats are divided into categories to make their description more clear and understandable [51].

Internal validity (contextual): It is also possible that some relevant papers were excluded because they do not contain chosen keyword in their title or abstract. Although the search was done in three online digital libraries and it is believed that the majority of the high-quality publications are covered with these selected databases.

Reliability: With regard to reliability there is a threat that the data extracted and analysis at some extent are dependent on the researcher. This threat was to some extent mitigated by clearly explaining and describing the process of choosing articles and data extraction and

coding of the collected data. Also, two very knowledgeable researchers looked at the papers in order to find any inconsistence based on their wide experience in the field or to see perhaps some papers are lagging.

5 Related Work

The search of the related work did not find papers that present BPI changes. The more related papers that were found are those which provide a classification of the modelling languages or BPI methods. There are a number of studies in the literature concerning redesign approaches where BPI methods, tools and techniques are reviewed and classified.

In [49] and [11] BPI approaches and their impact to the act of improving the processes are reviewed in a structured way. In [49] papers that are identified from a literature review by following the mandatory elements of the method are evaluated. [11] categorises and identifies papers which support the act of improvement. In [34] an overview of heuristic rules is given, which helps to radically improve a business process design compared with a current one. They presented a conceptual framework in order to estimate the impact of each best practice which helps a user who is implementing BPR to choose correct best practice. In [43] comprehensive methodological framework is created, based on the systematic literature review conducted by the authors. The framework contains method options for generating process improvement ideas.

In [45] business process modelling techniques are reviewed and classified based on their suitability to analyse and optimise business processes. Modelling languages were grouped into three sets based on their modelling capabilities. A framework is provided based on that three sets which classify analysis and optimisation approaches. It was identified that the most business process modelling techniques do not provide sufficient support for structured business process improvement. In [1] also a framework for classifying business process modelling techniques is provided. The classification is based on the purpose and model change permissiveness of the modelling technique and aims to make it is easy to understand the meaning of the modelling language.

None of the papers discussed in this section analyses or classifies presentation of the redesign changes. The purpose of this work was therefore to provide an overview of the illustration of redesign changes focusing on papers that apply redesign approaches to industry case studies and to try to identify the main reasons for choosing one or another way of presentation of the process redesign change.

6 Conclusions

In this thesis, a systematic literature review was conducted in order to find answers to five research questions concerning the means of BPI change presentation and different aspects, such as the size of the process, the extent of the change, industry and modelling language that could affect the way of BPI change presentation. In the systematic literature review, 32 relevant papers to the given topic were identified. The papers have been analysed in order to find if any similarities occurred so that some categorization about the use of redesign methods could be proposed. Based on the analysis thirty-two papers have been classified into six categories based on the method used to apply BPI techniques to real-life business process scenarios.

In order to answer the research questions, all the selected papers were carefully analysed this time for identifying different means of presentation of the changes after a business process improvement. Consequently, papers were examined in order to identify any repetitions, similarities and differences, in how changes were presented in the selected papers. Based on the findings of analyses four categories of BPI change presentation were identified, namely to-be process parts visualised, entire to-be process visualised, change presented numerically or textually.

All in all, based on the analyses of the selected 32 papers it can be said that BPI changes are presented in three ways: visually, numerically and textually. Further analysis of the papers also show that there is no structured way of choosing the mean of presentation of the BPI changes. There is no correlation between how the changes are presented and size of the process, the extent of the change, industry or modelling language. It was also identified that some papers except to-be provided as-is process model as well, enabling the comparison of the original as-is model with the improved one, which makes it easier to understand the change. In some other cases when to-be process model was not presented entirely, parts of the to-be process which were improved were shown with some forms of graphical annotation on the parts improved, which made the change more understandable. It was also an interesting finding that some papers use the text to describe changes, even though analyses show that this method of BPI change presentation is not thorough and is hard to capture the BPI change when throwing quick look at it.

As a future work, it is planned to implement experimental validation of preliminary answers given in this paper. It is suggested to find a number of subjects with appropriate

background and ask them which is the way in which they perceive that an improvement is better understood in a case with respect to another.

Also, results presented in this paper can be used as a starting point for researchers to investigate the area of presentation of BPI changes, which will help to lighten the process of redesign, which is usually a black box and make it more understandable and give an insight into redesign opportunities for a particular process.

Additionally, we use the knowledge of authors in presenting their results (i.e., their presentation strategies) to get some hints on how changes should be conveyed, and this knowledge could be also used to gather requirements for the design of tools supporting the presentation of changes (or better supporting people in better understanding the changes occurred in a process after a business improvement initiative).

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Appendix

I Papers selected through systematic literature review

A: Reference
B: Group of BPI technique
C: Group of BPI change presentation
D: Visualisation
E: Modeling Language
F: Degree of granularity
G: Extent of the change
H: Number of activities changed
I: Size of the process
J: Number of activities (as-is)
K: Number of activities (to-be)
L: As-is and to-be are side by side
M: Improved parts are marked

A	B	C	D	E	F	G	H	I	J	K	L	M
[21]	BPI pattern based	Entire to-be process presented	as-is, to-be	BPMN	middle	small	2	middle	11	13	no	yes
[31]	BPI pattern based	Entire to-be process presented	as-is, to-be	URN	low	small	1	small	5	6	no	yes

[9]	BPI pattern based	Entire to-be process presented	as-is, to-be	BPMN	high	small	1	big	22	21	yes	no
[20]	Quantitative based	Change presented textually	as-is	BPMN	middle	small	N/A	small	5	N/A	no	N/A
[50]	Customer/goal based	Entire to-be process presented	to-be	Fishbone	middle	middle	6	big	37	31	N/A	no
[30]	Modeling language based	To-be process parts presented	sups	URN	high	small	5	middle	16	N/A	yes	yes
[37]	Customer/goal based	Entire to-be process presented	as-is, to-be	BPMN	high	middle	8	big	46	38	yes	no
[7]	Simulation based	Change presented textually	as-is	BPMN	high	small	2	big	22	N/A	N/A	yes
[46]	Quantitative based	Entire to-be process presented	as-is, to-be	Fishbone	low	small	3	small	9	?	no	no
[26]	Modeling language based	Change presented textually	as-is	Workflow nets	low	N/A	N/A	small	10	N/A	N/A	N/A
[16]	Customer/goal based	To-be process parts presented	sub	Workflow nets	low	N/A	N/A	small	9	N/A	N/A	N/A
[14]	Simulation based	Entire to-be process presented	as-is, to-be	Petri nets	low	small	3	middle	12	9	yes	no

[40]	Interview based	Entire to-be process presented	as-is, to-be	BPMN	middle	small	2	middle	15	17	yes	no
[28]	Interview based	Change presented textually	as-is	IDEF0	low	middle	8	big	31	N/A	N/A	N/A
[42]	Simulation based	Entire to-be process presented	as-is, to-be	BPMN	low	small	3	small	3	6	no	no
[25]	Interview based	To-be process parts presented	sups	ATD	high	middle	6	middle	15	N/A	no	yes
[4]	Customer/goal based	Change presented textually	as-is sub process	IDEF0	low	N/A	N/A	middle	18	N/A	N/A	N/A
[2]	Customer/goal based	Entire to-be process presented	as-is, to-be	Workflow nets	middle	big	14	big	25	15	no	no
[36]	Simulation based	Change presented numerically	as-is	State model	middle	N/A	N/A	small	6	N/A	N/A	N/A
[23]	Simulation based	Entire to-be process presented	as-is, to-be	Heuristic net	middle	N/A	N/A	big	142	N/A	no	no
[13]	BPI pattern based	Change presented numerically	as-is	CP-nets	middle	N/A	N/A	small	8	N/A	N/A	N/A
[33]	Modeling language based	Entire to-be process presented	to-be	Workflow nets	high	N/A	N/A	N/A	N/A	18	N/A	N/A

[5]	Customer/goal based	Change presented textually	as-is	IDEF0	high	small	2	small	6	N/A	N/A	N/A
[22]	Customer/goal based	Change presented textually	as-is	BPMN	high	N/A	N/A	middle	17	N/A	N/A	N/A
[29]	Interview based	Entire to-be process presented	as-is, to-be	GRAI	high	big	not clear	middle	15	18	no	no
[3]	Quantitative based	To-be process parts presented	subs	Value - stream	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
[39]	Customer/goal based	Change presented textually	as-is	BPMN	high	N/A	N/A	middle	13	N/A	N/A	N/A
[44]	Simulation based	Entire to-be process presented	as-is, to-be	Fuzzy map	middle	small	1	small	5	6	no	no
[15]	Simulation based	To-be process parts presented	subs	CP-nets	middle	N/A	N/A	middle	18	N/A	N/A	N/A
[48]	Modeling language based	Entire to-be process presented	as-is, to-be	Workflow nets	high	small	1	small	6	5	no	no
[6]	Quantitative based	Change presented textually	as-is	Value - stream	middle	N/A	N/A	middle	19	N/A	N/A	N/A
[38]	Interview based	Entire to-be process presented	as-is, to-be	State model	high	small	2	middle	18	20	no	no

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