Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Management and Marketing



Bachelor Thesis

Business Processes Management using Factorial Designs

Tangirkyz Izbaskan

© 2026 CZU Prague

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

BACHELOR THESIS ASSIGNMENT

Tangirkyz Izbaskan

Informatics

Thesis title

Business Processes Management using Factorial Designs

Objectives of thesis

The goal of this thesis is to analyze and optimize selected business processes through the application of factorial designs. The thesis focuses on identifying key factors influencing the efficiency of these processes and evaluating the benefits of using factorial designs as a tool for process planning and management in a business environment. Based on theoretical analysis and practical examples, the aim is to propose improvements in process management that will lead to increased organizational performance.

Methodology

The bachelor thesis deals with the issue of business process management. It examines the possibilities of using factorial designs to optimize and effectively manage processes in a business environment.

The theoretical part of the thesis focuses on the definition of business processes, the principles of their management, and an overview of traditional and modern methods used in this area. Emphasis is placed primarily on factorial designs as a specific method of planning and controlling, enabling investigation of various factors' influence on business processes.

The empirical part of the work presents concrete examples of the use of factorial designs within selected business processes and analyzes their effectiveness and benefits for the given organization.

The proposed extent of the thesis

30 – 40 pages

Keywords

business process management, factorial designs, process optimization, efficiency, organizational performance, business process analysis.

Recommended information sources

BILGIN, Mehmet Huseyin.; DANIS, Hakan.; DEMIR, Ender.; CAN, Ugur. and SPRINGERLINK (ONLINE SERVICE). *Regional Studies on Economic Growth, Financial Economics and Management [electronic resource] : Proceedings of the 19th Eurasia Business and Economics Society Conference.* Cham: Imprint: Springer, 2017. ISBN 9783319541129.

BREM, Alexander.; VIARDOT, Eric. and SPRINGERLINK (ONLINE SERVICE). *Revolution of Innovation Management [electronic resource] : Volume 2 Internationalization and Business Models.* London: Imprint: Palgrave Macmillan, 2017. ISBN 9781349951239.

MEAD, R. *The design of experiments : statistical principles for practical applications.* Cambridge [England] ; New York: Cambridge University Press, 2000. ISBN 0-521-28762-6.

MÜLLER, W. G. *Collecting spatial data : optimum design of experiments for random fields.* Berlin ; New York: Springer, 2007. ISBN 978-3-540-31174-4.

WESKE, Mathias. *Business process management : concepts, languages, architectures :.* Berlin: Springer, 2007. ISBN 978-3-540-73521-2.

Expected date of thesis defence

2024/25 SS – PEF

Thesis supervisor

doc. Ing. Tomáš Macák, Ph.D.

Supervising department

Department of Management and Marketing

Electronic approval: 02. 11. 2024

doc. Ing. Ladislav Pilař, MBA, Ph.D.

Head of department

Electronic approval: 07. 11. 2024

doc. Ing. Tomáš Šubrt, Ph.D.

Dean

Prague on 15. 03. 2026

Declaration

I declare that I have worked on my bachelor thesis titled "Business Processes Management using Factorial Designs" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on 15.03.2026 _____

Acknowledgement

I would like to thank my supervisor doc. Ing. Tomáš Macák, Ph.D. for all the support, guidance and advice during my work on the bachelor's thesis. I would also like to thank my family and friends for their support.

Business Processes Management using Factorial Designs

Abstract

The main purpose of the thesis is to analyse and optimise an administrative business process using the factorial experimental design method. The research consists of two parts: theoretical and practical.

In the theoretical part, the basic concepts of business process management, process analysis and modelling are presented. Special attention is paid to performance measurement and experimental design as quantitative tools for improving organisational processes. The theoretical part also explains the principles of factorial design and its application in the optimisation of business processes. Thus, this part provides the theoretical background for the analysis conducted in the practical section.

The practical part of the thesis is based on the examination of a real administrative process related to invoice indexing in the financial department of an international company. The author identified key organisational factors influencing process performance and developed a full factorial experimental model to analyse alternative organisational scenarios. After calculating the productivity of individual configurations, the results were compared and interpreted in order to determine the most appropriate organisational solution.

Based on the obtained findings, conclusions were formulated regarding the optimal process configuration and the potential benefits of using factorial experimental design for improving administrative efficiency and supporting managerial decision-making.

Keywords: business process management, factorial designs, process optimization, efficiency, organizational performance, business process analysis.

Řízení obchodních procesů pomocí faktoriálních návrhů

Abstrakt

Hlavním cílem práce je analýza a optimalizace administrativního obchodního procesu pomocí metody faktoriálního experimentálního návrhu. Výzkum se skládá ze dvou částí: teoretické a praktické.

V teoretické části jsou prezentovány základní koncepty řízení obchodních procesů, procesní analýzy a modelování. Zvláštní pozornost je věnována měření výkonnosti a experimentálnímu návrhu jako kvantitativním nástrojům pro zlepšení organizačních procesů. Teoretická část také vysvětluje principy faktoriálního návrhu a jeho aplikaci při optimalizaci obchodních procesů. Tato část tak poskytuje teoretický základ pro analýzu provedenou v praktické části.

Praktická část práce je založena na zkoumání reálného administrativního procesu souvisejícího s indexováním faktur ve finančním oddělení mezinárodní společnosti. Autor identifikoval klíčové organizační faktory ovlivňující výkonnost procesu a vyvinul plně faktoriální experimentální model pro analýzu alternativních organizačních scénářů. Po výpočtu produktivity jednotlivých konfigurací byly výsledky porovnány a interpretovány za účelem určení nejvhodnějšího organizačního řešení.

Na základě získaných zjištění byly formulovány závěry týkající se optimální konfigurace procesu a potenciálních přínosů použití faktoriálního experimentálního návrhu pro zlepšení administrativní efektivity a podporu manažerského rozhodování.

Klíčová slova: řízení obchodních procesů, faktoriální návrhy, optimalizace procesů, efektivita, výkonnost organizace, analýza obchodních procesů.

Table of content

1 Introduction 7

2 Objectives and Methodology 8

2.1 Objectives 8
2.2 Methodology 8

3 Literature Review 9

3.1 Business Process Management 9
3.1.1 Definition of business processes 9
3.1.2 Types of business processes 10
3.1.3 Process efficiency and process improvement 11
3.2 Business Process Analysis 13
3.2.1 Process analysis in organizations 13
3.2.2 Traditional methods of process improvement 14
3.2.3 Organizational structure of business processes 15
3.2.4 Process capacity and workload management 16
3.3 Process Modelling 16
3.3.1 Process modelling in business process management 17
3.3.2 BPMN as a process modelling tool 19
3.3.3 Application of BPMN in administrative processes 20
3.4 Experimental Design in Business Process Optimization 20
3.4.1 Design of experiments in organizational research 20
3.4.2 Factorial design 21
3.4.3 Application of factorial design in business processes 25
3.5 Performance Measurement in Business Processes 25
3.5.1 Key performance indicators in business processes 26
3.5.2 Process capacity and productivity 26

4 Practical Part 27

4.1 Data Collection 27
4.1.1 Description of the company 27
4.1.2 Organization selection 27
4.1.3 Stuff consultation 28
4.2 Selected process overview 28
4.2.1 Description of the invoice indexing process 29
4.2.2 Process roles and responsibilities 29
4.2.3 Process modelling (BPMN diagram) 30

4.3 Analysis of the organizational structure 31
4.3.1 Initial organizational model 32
4.3.2 Current organizational model 32
4.3.3 New organizational model 33
4.4 Definition of Experimental Variables 34
4.4.1 Identification of key factors 34
4.4.2 Definition of factor levels 34
4.4.3 Definition of performance indicators 35
4.5 Factorial Experiment Design 36
4.5.1 Experimental design model 36
4.5.2 Experimental matrix 37
4.5.3 Calculation of response variable 38
4.6 Analysis of Experimental Results 39
4.6.1 Analysis of scenario performance 39
4.6.2 Main effects analysis 40

5 Results and Discussion 42

5.1 Results interpretation 42
5.2 Advantages and disadvantages of factorial design 43
5.3 Discussions 43
5.4 Research limitations 44

6 Conclusion 45

7 References 47

8 Appendix 50

8.1 Table of figures 50
8.2 Table of formulas 50
8.3 Table of tables 50

1 Introduction

In an environment of increasing competition and growing volumes of information, the efficiency of administrative business processes is particularly important for modern organizations. Rational organization of work processes enables companies to complete operational tasks in a timely manner, reduce costs, and improve the quality of management decisions. One of the key areas for improving efficiency is optimizing financial document processing, as these operations are directly linked to the stability of financial flows and interactions with business partners.

Modern approaches to business process management involve the use of quantitative analysis methods to assess the impact of various organizational factors on performance. In this context, the factorial experimental design method is an effective tool for systematically exploring alternative workflow options and supporting management decisions.

The relevance of this bachelor's thesis topic stems from the need to improve the efficiency of administrative processes in the face of increasing workload and limited resources. The study aims to analyze the invoice indexing process in the finance department of an international company and evaluate possible options for its optimization. The aim of this study is to identify key factors influencing the performance of the process under consideration and to develop recommendations for improving the organizational model using a factorial experimental design. To achieve this goal, the study addresses the theoretical foundations of business process management, examines the existing organizational structure of the process, constructs an experimental model, and interprets the results.

The practical significance of this study lies in the potential use of the proposed approaches to improve the efficiency of administrative operations, more rationally allocate labor resources, and reduce employee overtime.

2 Objectives and Methodology

2.1 Objectives

The goal of this thesis is to analyze and optimize selected business processes through the application of factorial designs. The thesis focuses on identifying key factors influencing the efficiency of these processes and evaluating the benefits of using factorial designs as a tool for process planning and management in a business environment. Based on theoretical analysis and practical examples, the aim is to propose improvements in process management that will lead to increased organizational performance.

2.2 Methodology

The bachelor thesis deals with the issue of business process management. It examines the possibilities of using factorial designs to optimize and effectively manage processes in a business environment.

The theoretical part of the thesis focuses on the definition of business processes, the principles of their management, and an overview of traditional and modern methods used in this area. Emphasis is placed primarily on factorial designs as a specific method of planning and controlling, enabling investigation of various factors' influence on business processes.

The empirical part of the work presents concrete examples of the use of factorial designs within selected business processes and analyzes their effectiveness and benefits for the given organization.

3 Literature Review

To gain a deeper understanding of the topic and familiarize oneself with the theoretical basis of this bachelor's thesis, a literature review of scientific sources was conducted. Studying the theoretical aspects provides a foundation for further practical research and substantiation of the selected process optimization methods.

3.1 Business Process Management

Business process management is not just a tool, but an entire discipline aimed at improving organizational performance. This approach allows for the analysis of current processes, identification of problem areas, and decision-making aimed at improving performance. Systematic process management ensures the achievement of strategic goals and ensures more stable organizational functioning. (Dumas, et al., 2018)

Business process management plays a vital role in daily operations, helping to structure work tasks and coordinate employee actions. Using process connectivity allows organizations to increase operational transparency and improve resource management. This is especially important in a highly competitive environment and the need for presence with the emergence of business activities. (Brocke, et al., 2014)

To fully understand business process management, it is necessary to define what a business process is, what types of processes exist, and what factors influence process efficiency and improvement. (Brocke & Rosemann, 2015)

3.1.1 Definition of business processes

A business process can be defined as a sequence of actions aimed at achieving a specific outcome. These actions are performed in a prescribed order and lead to the transformation of input resources into the final output of an organization's activities. Inputs can include information, materials, or customer requests, while outputs can include finished products or services. (Dumas, et al., 2018)

Business processes play a crucial role in work, as they help streamline the execution of assigned tasks and ensure the consistency of the actions of the organization's employees.

They create the basis for effective interaction between different departments and allow for clearer definition of responsibility for the execution of operations. This ensures transparency of activities and improves control over results. (Brocke, et al., 2014)

Furthermore, business processes are part of the overall organizational system and often span multiple departments. This means that successful process execution requires coordination between multiple departments or branches within the organization. This interaction contributes to the achievement of organizational goals and improves the quality of services or products provided. (Butt, 2020)

3.1.2 Types of business processes

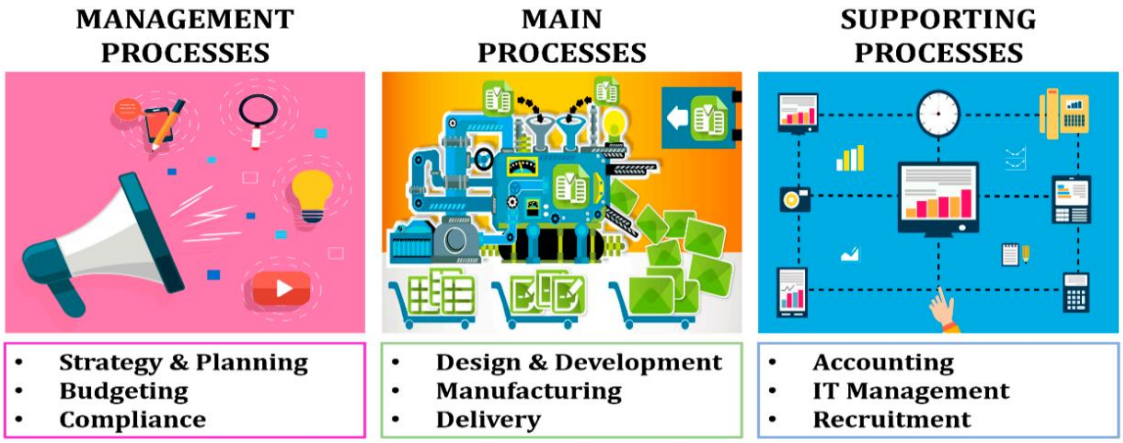
Business processes can be classified by their degree of structure and execution conditions. One approach is to divide processes into competitive and adaptive. Predictable processes are characterized by clearly defined, continuous actions and stable standards. They are most often found in standard operations, such as order processing or the execution of processing procedures. (Harrison-Broninski & Modellers, 2012)

Adaptive factors are characterized by greater flexibility and can be modified depending on the specific situation. Their implementation requires employees with professional experience and the ability to make decisions under uncertainty. Such processes are often associated with an intellectual environment and customer interaction. (Harrison-Broninski & Modellers, 2012)

Furthermore, business processes can be performed individually or collaboratively by multiple participants. Modern processes involve the violation of various principles and the effective distribution of roles. This is especially important in project-based activities and when performing complex tasks. (Harrison-Broninski & Modellers, 2012)

In organizations, business processes can perform various functions and are therefore also classified by their role in the company's operations. One of the most common approaches is to divide processes into operational, management, and support processes. This division helps to better understand the structure of the organization's operations and determine the role of each process in value creation. The figure below shows the key characteristics of each type of business process (Grefen & Vanderfeesten, 2024):

Figure 1 Different types of business processes



Source: (Butt, 2020)

Operational processes are directly related to creating a product or delivering a service to a customer. They include an organization's core activities, such as production, customer service, or key business operations. These processes create core value for customers and are the foundation of a company's operations. The effectiveness of operational processes directly impacts an organization's competitiveness. (Butt, 2020)

Management processes are related to planning, controlling, and coordinating an organization's activities. These include strategic planning, management decision-making, and task monitoring. Management processes ensure the effective functioning of an organization and enable it to direct its activities in accordance with its goals and strategy. (Butt, 2020)

Supporting processes support the functioning of core and management processes. These processes include administrative, financial, and information operations that help an organization effectively perform its core activities. For example, invoice processing is a support process because it supports the company's financial operations and other business processes. (Butt, 2020)

3.1.3 Process efficiency and process improvement

Business process efficiency is a key factor in an organization's success. Process efficiency is defined as the ability of a process to achieve its objectives with minimal resource and time

expenditures. Analyzing process efficiency allows organizations to identify problem areas and take action to improve them. Improving process efficiency leads to cost reduction, increased productivity, and improved work quality.

In modern organizations, business process optimization is viewed as a process of continuous improvement. Companies regularly analyze their processes to identify bottlenecks, duplicated operations, and inefficient resource use. Process improvement may involve process restructuring, task redistribution among employees, or the implementation of new technologies. This approach allows organizations to adapt to changing conditions and improve their operational efficiency.

Furthermore, process optimization plays a significant role in enhancing organizational productivity and competitiveness. Effective processes allow companies to perform operations faster, improve service quality, and utilize available resources more efficiently. Therefore, analyzing and improving business processes are important tasks in modern organizational management.

Business process efficiency is also a prerequisite for ensuring organizational security. It reflects the ability of processes to achieve established goals, taking into account time, resource, and performance trends. High levels of efficiency lead to increased productivity and ensure the quality of business results. (Vergidis, et al., 2008)

Process improvement occurs as a continuous process, incorporating problem areas and quality changes. Organizations strive to adjust process structure, reduce redundant operations, and improve managerial alignment. The use of digital metrics allows for a more objective assessment of results and informed management decisions. (Vergidis, et al., 2008)

Thus, increased efficiency and improved business processes are standards that meet organizational development requirements. Systematic process management enables more stable results, improved resource utilization, and increased competitive effectiveness. (Smirnov, et al., 2012)

3.2 Business Process Analysis

Business process analysis is an important part of organizational management, as it allows for a better understanding of the nature of work and identifies factors affecting its performance. Process analysis helps organizations assess the current state of operations, identify problem areas, and make decisions aimed at improving operational efficiency. This approach allows for more efficient use of resources and maintaining the quality of task execution. (Brocke, et al., 2014)

3.2.1 Process analysis in organizations

Business process analysis is an important step in process management in organizations. Its primary goal is to understand how a process is executed, its stages, and the resources used at each stage. Process analysis allows organizations to gain a holistic view of their operations and identify process weaknesses that need to be modified or improved. Furthermore, analysis helps determine how effectively time, resources, and employee labor are being used. This allows companies to make informed decisions about improving processes and increasing overall organizational efficiency.

One of the key objectives of process analysis is identifying bottlenecks. A bottleneck is a stage in a process where tasks accumulate and slow down work. Such limitations can arise due to insufficient resources, inefficient work organization, or outdated technology. Bottleneck analysis helps determine which stages of a process are limiting its performance and require optimization. Identifying such issues is an important step toward improving business processes.

In addition to identifying bottlenecks, process analysis helps uncover various types of inefficiencies. For example, a process may include unnecessary stages, duplicated tasks, or suboptimal resource allocation. Such problems often lead to increased process execution times and decreased productivity. Systematic process analysis allows organizations to identify such deficiencies and develop corrective actions. This leads to increased operational efficiency and improved process quality.

Organizations use business process analysis to improve international operations and increase task transparency. Understanding how processes are executed helps identify weaknesses and

develop measures to address them. This approach improves collaboration between departments and enhances the quality of management decisions. (Dumas, et al., 2018)

Process analysis also helps identify factors that may hinder the successful implementation of business process management. These factors include insufficient support for guidelines, a lack of clear change planning, excessive reliance on technology, and insufficient alignment of processes with government strategies. Taking these factors into account allows organizations to more effectively implement a process-based approach and reduce the risk of failure. (Smirnov, et al., 2012)

Using business process analysis methods helps organizations assess the current effectiveness of their operations and identify opportunities for improvement. Such analysis may include a study of time costs, workload distribution among employees, and resource utilization. The results obtained enable informed decisions on process improvement and increased efficiency. (Vergidis, et al., 2008)

3.2.2 Traditional methods of process improvement

Traditional process improvement methods are already widely used by organizations to improve process efficiency, reduce costs, and enhance the quality of products or services. One traditional approach to business process improvement is the concept of reengineering. This approach involves revising existing processes with the goal of significantly increasing the organization's efficiency. Reengineering focuses on eliminating outdated procedures, reducing redundant operations, and creating new, more efficient task models. This approach enables the implementation of measures to improve productivity and quality. (Vergidis, et al., 2008)

Another widely used method is the Lean concept, which aims to eliminate waste in processes and improve their effectiveness. The primary goal of Lean is to create value for the customer by optimizing the sequence of operations and activities that do not produce useful results. This approach involves more efficient use of resources and maintaining the quality of task execution. (Naslund, 2008)

Lean methods also focus on continuous process improvement and engaging employees in identifying opportunities for improvement. Using visual management and analysis tools

helps organizations better monitor operations and identify problems more quickly. This allows for increased flexibility and continued collaboration among process participants. (Naslund, 2008)

Six Sigma, a methodology aimed at reducing process variability and minimizing errors, is also a common method. It utilizes numerous analytical methods and statistical tools to identify the causes of deviations and develop solutions to eliminate them. The application of Six Sigma allows organizations to improve process stability and achieve more profitable results. (Naslund, 2008)

Furthermore, Six Sigma provides a structured approach to process compliance, including stages of analysis, quality improvement, and results achievement. This approach fosters a quality culture and improves the effectiveness of management decisions. As a result, organizations gain the opportunity to increase productivity and reduce costs. (Naslund, 2008)

3.2.3 Organizational structure of business processes

The organizational structure of business processes determines how tasks and responsibilities are distributed among employees within an organization. This structure influences how employees interact with each other and how individual process steps are completed. Proper task distribution improves work efficiency and reduces the likelihood of errors. However, an ineffective structure can overload individual employees and slow down work. Therefore, analyzing the organizational structure of processes is an important element of business process management.

The distribution of tasks among employees directly impacts the efficiency of process execution. If responsibilities are distributed unevenly or do not match employee competencies, this can lead to decreased productivity and increased task completion times. Furthermore, insufficient coordination between process participants can cause delays and errors. Therefore, it is important for organizations to regularly analyze task distribution and, if necessary, adjust the work structure. This approach helps improve process efficiency and employee collaboration.

3.2.4 Process capacity and workload management

Capacity determines the number of operations that can be completed in a given period of time. It depends on available resources, the number of employees, and the time required to complete the tasks. When the volume of incoming tasks exceeds capacity, overload occurs. As a result, employees are unable to process all incoming tasks, leading to delays. Capacity analysis helps determine whether resources are sufficient to complete all operations.

One consequence of insufficient process throughput is the formation of a backlog. A backlog is the accumulation of tasks that were not completed on time due to limited resources or poor process performance. In business processes, a backlog can lead to delays and reduced service quality. Therefore, it is important for organizations to monitor the level of backlog and take measures to increase process throughput or optimize their structure.

When a process's workload exceeds its capacity, employees are often forced to work overtime. Overtime is a temporary solution to the overload problem, but in the long term, it can lead to decreased productivity and an increased likelihood of errors. Furthermore, regular overtime can negatively impact employee motivation and increase the organization's costs. Therefore, effective management of workload and process capacity is an important task for organizations seeking to ensure the sustainable and efficient operation of their processes.

3.3 Process Modelling

Process modeling plays a central role in business process management, as it is through the model that an organization gains a clear understanding of how work is performed using an example. A process model allows one to describe the sequence of actions, participants, flows, and key decision points. This makes modeling not only a means of documenting a process but also a means of analyzing, controlling, and drawing conclusions. (Dumas, et al., 2018)

The importance of analysis increases especially when technological processes are complex, encompass multiple activities, or require coordination between various parties. In such circumstances, a model helps simplify the review process, make it more understandable for employees, and create a unified basis for discussing problems and improvements.

Furthermore, process models allow for better alignment of day-to-day operational activities with broader organizational criteria. (Brocke & Rosemann, 2015)

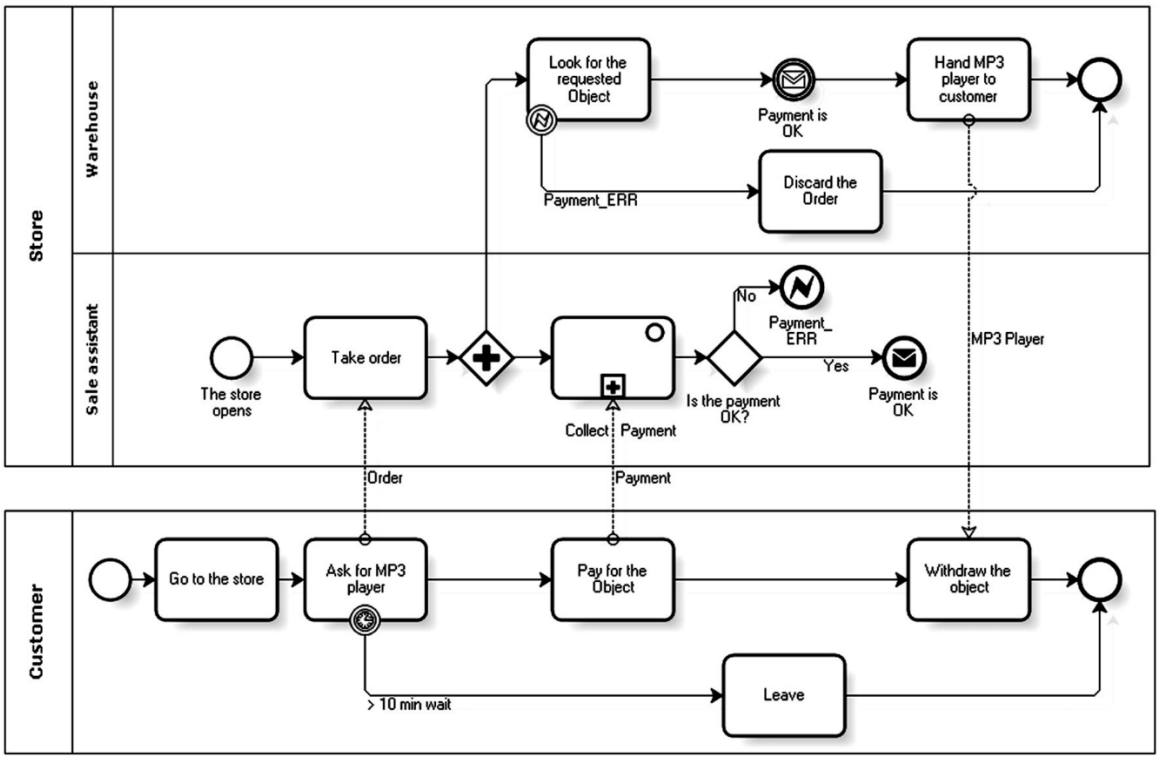
Modeling is also important because the same process can be viewed at different levels of detail. In some cases, an organization uses more general models for management review and more complex constructs for analyzing activities, roles, and resources. This approach helps to adapt the process to the needs of different users. (Dumas, et al., 2018)

3.3.1 Process modelling in business process management

Process modeling is an important tool for business process management. It allows you to visually represent the structure of a process and understand the sequence of activities performed within an organization. Process models help describe the interactions between process participants and map the flow of information and resources. In business process management, modeling is used to analyze current processes, identify problems, and develop potential improvements. By visualizing processes, organizations can better understand how work is performed and what changes can improve efficiency.

Preliminary implementation of business processes using models allows for a more visual representation of the sequence of activities, the distribution of roles, and possible process development options. The figure below shows a customer service model in a retail store, implemented in BPMN notation. The diagram illustrates the main stages of the process—from contacting the customer and placing an order to verifying payment and handing over the goods. Alternative scenarios are also shown, such as a situation where payment fails and the order is from me. Using such models helps organizations better understand the structure of processes, identify problem areas, and improve coordination between participants. (White, 2004)

Figure 2 Example of a Business Process Model in BPMN Notation



Source: (Chinosi & Trombetta, 2012)

It's important to distinguish between the process itself and its model. A business process exists as an actual sequence of actions within an organization, while a model is its representation. This representation helps organizations translate complex work procedures into a more understandable form suitable for analysis, discussion, and expected results. (Brocke, et al., 2014)

Process models can be used for various purposes. They help document the current order of work, train employees, align process understanding among participants, and lay the groundwork for automation. (Brocke, et al., 2014)

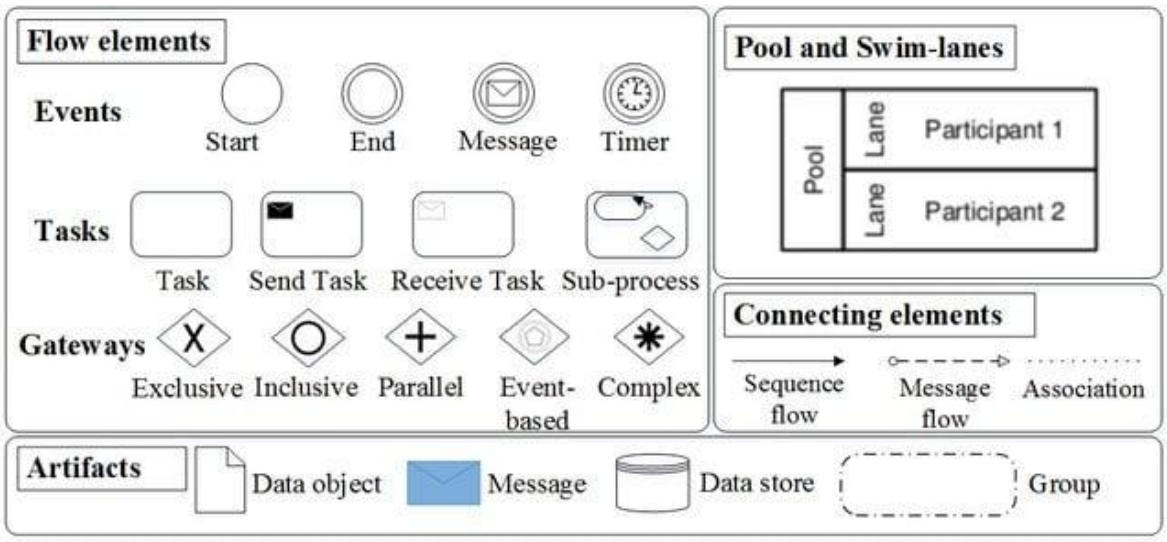
Furthermore, modeling helps manage the complexity of modern processes. Using different levels of abstraction allows you to first see the overall flow of the process and then, if necessary, move on to a more detailed analysis of individual stages. (Dumas, et al., 2018)

3.3.2 BPMN as a process modelling tool

One of the most common business process modeling tools is BPMN (Business Process Model and Notation). BPMN is a standardized process modeling language used for graphical representation of business processes. The primary goal of BPMN is to create understandable and universal process diagrams that can be interpreted by both process management and technical specialists. Through standardization, BPMN allows organizations to create a unified process description format and facilitates communication across departments.

To describe business processes in BPMN notation, BPMN uses a set of standard graphical elements that visually represent the structure of the process and the interactions between its participants. The main elements are events, tasks, and gateways, which facilitate process execution. Events indicate the beginning, end, or change in the flow of a process. For example, a start event indicates the start of a process, and an end event indicates its completion. Message or timer events can also be used to represent the exchange of information or waiting for a specific time. (White, 2004)

Figure 3 Basic Elements of BPMN Notation



Source: (Dechsupa, et al., 2019)

In addition to the main elements, pools and lanes are also used to demonstrate the distribution of roles among process participants. This is especially important when analyzing processes carried out by departments or organizational managers. (White, 2004)

3.3.3 Application of BPMN in administrative processes

Although BPMN was originally widely used in manufacturing and information systems, today this tool is also widely used to analyze administrative processes. Administrative processes often involve a large number of sequential actions and interactions between different roles. These processes involve employees from different departments performing various tasks within a single workflow. Modeling administrative processes allows for a better understanding of the structure of these processes and the identification of potential problems in their organization.

Using BPMN to analyze office processes helps organizations visualize the flow of documents, information, and tasks between employees. This makes it easier to determine which process steps take the most time, where delays occur, and how responsibilities are distributed among process participants. Visualizing administrative processes also helps identify opportunities for automation or optimization of individual work steps. Thus, BPMN is an effective tool for analyzing and improving office processes in organizations.

BPMN is especially useful in managing processes where the sequence of actions, information flow, and financial responsibility are important. Such processes often involve document processing, decision approval, and employee interaction. The graphical model helps make these processes more understandable and clearer. (White, 2004)

3.4 Experimental Design in Business Process Optimization

The use of experimental methods is particularly relevant in complex organizational systems, where numerous additional factors influence performance. Experimental design allows for structuring process research, identifying variables and analysis errors, and assessing their impact on key performance indicators. This enables organizations to make more informed changes and reduce uncertainty in management decision-making. (Bouchekara, et al., 2011)

3.4.1 Design of experiments in organizational research

Experimental methods are widely used in various fields of science and management to analyze complex systems and processes. In the context of organizational research, the design of experiments (DOE) method is used to study the impact of various factors on

organizational performance. The basic idea of this method is that the researcher systematically varies process parameters and observes the impact on the outcome. This approach allows one to determine which factors have the greatest impact on process performance and which conditions produce the best results.

In business process management, experimental methods allow one to analyze various process design options and assess their impact on performance. Unlike simple observation, an experimental approach involves deliberately changing process parameters and subsequently analyzing the results. This allows for a more accurate identification of cause-and-effect relationships between process characteristics and their outcomes. Using experimental methods helps organizations make more informed management decisions and improve the efficiency of their processes.

When conducting experiments, it is important to correctly define independent variables, the levels of their changes, and the indicators by which the outcome will be assessed. This approach allows for the generation of objective data and minimizes the influence of random factors. As a result, the organization is able to create more efficient process execution models and improve the quality of management decisions. (Antony, et al., 2011)

3.4.2 Factorial design

Factorial design is one of the most common experimental design methods. It is used to simultaneously study the influence of multiple factors on process outcomes. The basic idea of a factorial experiment is that the researcher considers all possible combinations of factor levels and analyzes their impact on the outcome. This approach allows for a more complete understanding of the process's functioning and identifies the most important factors influencing its effectiveness.

In a factorial experiment, the key concept is the factor. A factor represents a variable characteristic of a process that can influence its outcome. Each factor has several levels representing different values or variations of this characteristic. For example, a factor could describe the number of employees, the method of task distribution, or the technology used. Analyzing different combinations of factor levels allows the researcher to determine which factors have the greatest impact on the process outcome.

The basic idea of a factorial experiment is that each factor can have specific values, and the experiment is conducted for all possible combinations of these outcomes. This allows for the determination of not only the influence of individual factors but also their combined impact on the final outcome. (Mukerjee & Wu, 2006)

The number of experimental cases in a full factorial design is determined by the formula:

Formula 1 General Factorial design

$$N = k^p$$

where

- N is the common experimental run,
- k is the number of treatment levels,
- p is the number of factors. (Cheng, 2014)

The most common is a two-level experiment, in which each factor takes a low and a high value:

Formula 2 Factorial design – 2 levels

$$N = 2^p$$

For example, if three factors are being investigated, eight experimental studies are required. This approach ensures complete information on the influence of the factors and their effects. (Antony, et al., 2011)

Once the number of factors and their levels has been determined, an experimental matrix is created. This is a table in which each row corresponds to one experimental scenario, and the columns reflect the values of the factors. The matrix allows for a systematic organization of the experiment and ensures that results are obtained for all factor combinations. (Mukerjee & Wu, 2006)

The figure below shows an example of a matrix used in the analysis:

Figure 4 Example of a Full Factorial Experimental Design Matrix

Exp. no.	Factors		
	x_1	x_2	x_3
1	−	−	−
2	+	−	−
3	−	+	−
4	+	+	−
5	−	−	+
6	+	−	+
7	−	+	+
8	+	+	+

Source: (Malenović, et al., 2004)

The table above shows the "+" (Higher Level) and "-" (Lower Level) values, which are specified individually for each factor (parameter). The table below shows how similar levels are recorded: (Vicente, et al., 1998)

Figure 5 Alternative Representation of Factor Levels in Factorial Design

Parameter	Minimum Value [mm]	Maximum Value [mm]
x_1	0	15
x_2	35	45.9
x_3	25	26.5
x_4	15	20
x_5	70	80

Source: (Bouchekara, et al., 2011)

In factor analysis, an important concept is the main effect, which measures the change in the mean value of a result when a factor moves from one level to another. The main effect can be defined as the difference in the mean sounds responding to different factors:

Formula 3 Main Effect Calculation

$$Effect = \frac{\sum Y_{high} - \sum Y_{low}}{n}$$

Where

- Y is the observed value of the process outcome. Main effects analysis helps determine which factors have the greatest impact on the process outcome. (Mukerjee & Wu, 2006)

An important element of experimental analysis is the process response variable. The response is an indicator measured during the experiment that reflects the outcome of the process. Organizational responses can include task completion time, document volume, level of responsibility, or management performance. Response analysis helps determine the most likely balance of change in the situation and develop recommendations for improving business processes. (Antony, et al., 2011)

There are two main types of factorial experiments: full factorial designs and fractional factorial designs. A full factorial design involves conducting experiments for all possible combinations of factor levels. This approach ensures an accurate assessment of natural phenomena and their interactions, but with a large number of factors, it requires significant time and resources. Therefore, a full factorial experiment is often used when the number of factors is limited and obtaining the most accurate results is important. (Mukerjee & Wu, 2006)

Fractional factorial designs are used when conducting a full experiment is impossible or economically impractical. In this case, only a subset of factor combinations is examined, reducing the amount of experimental work. Despite some reduction in the precision of interaction estimates, fractional designs still effectively support the analysis of complex processes, especially in the early stages of research. (Antony, et al., 2011)

Thus, factorial designs are an effective means of process optimization, as they allow for simultaneous manipulation of multiple factors and decision-making based on objective data. The use of these methods improves management efficiency, promotes sustainable resource utilization, and ensures more stable organizational performance. (Antony, et al., 2011)

3.4.3 Application of factorial design in business processes

Factorial design is widely used to analyze and optimize processes in various business sectors. It is applied in manufacturing, logistics, marketing, and operations management to study the impact of various factors on productivity. By simultaneously analyzing multiple factors, factorial design allows organizations to obtain more accurate information about process performance and make more effective management decisions.

One of the main advantages of factorial design is the ability to analyze the interactions of factors. In real-world business processes, the influence of one factor often depends on the value of another. Factorial design allows us to identify such interactions and take them into account when making management decisions. This is especially important when analyzing complex processes involving numerous organizational or technological parameters.

Furthermore, factorial design significantly increases the effectiveness of research compared to methods that analyze factors individually. Analysis of all factor combinations provides a more complete picture of process performance and helps determine the optimal configuration of operating conditions. This makes this method widely used for optimizing business processes and improving organizational performance.

3.5 Performance Measurement in Business Processes

Assessing the effectiveness of business processes is an important part of organizational management, as it allows organizations to determine whether operations are being successfully implemented and achieve their goals. Measuring process results helps organizations identify problem areas, make informed management decisions, and develop improvement initiatives. Using a systematic approach to improving effectiveness promotes operational transparency and resource management control. (Clarkson & Eckert, 2005)

3.5.1 Key performance indicators in business processes

Evaluating business process performance is an important element of organizational process management. Key performance indicators (KPIs) are used to measure process efficiency and assess their compliance with established goals. KPIs are quantitative indicators reflecting various aspects of an organization's performance, such as productivity, work quality, and resource utilization. Using KPIs helps organizations track process performance and make decisions about improvement. (Dawande, et al., 2020)

KPIs are widely used to evaluate both operational and administrative processes. They allow organizations to measure performance and identify areas for improvement. For example, administrative processes may use metrics such as operation completion time, number of tasks processed, or error rate. Systematic use of KPIs allows organizations to track process efficiency and quickly identify operational issues. (Wannes & Ghannouchi, 2019)

3.5.2 Process capacity and productivity

Business process performance is defined as the number of operations or tasks that can be completed in a given period of time. One key performance indicator is process throughput, which reflects the maximum number of operations that can be completed with available resources. Process performance depends on various factors, including the number of employees, work organization, and the time required to complete individual operations. Performance analysis helps determine how efficiently resources are being used and whether the process can handle the current workload. (Wang, et al., 2005)

If the volume of incoming tasks exceeds the process throughput, overload occurs. In this case, employees are unable to complete all incoming tasks, leading to a backlog of work and delays in completing operations. To address this issue, organizations can increase resources, restructure the process, or optimize the distribution of tasks among employees. Process performance analysis helps identify such problems and take action to address them.

Process analysis often uses metrics such as throughput (productivity), operation completion time (cycle time), and resource utilization (resource utilization). Studying these metrics helps identify bottlenecks that slow down work completion and reduce operational efficiency. Removing such limitations ensures increased process efficiency. (Vergidis, et al., 2008)

4 Practical Part

The practical part of this work is based on a real example of an organization selected by the author, which agreed to provide all the information necessary for the study.

4.1 Data Collection

4.1.1 Description of the company

For the practical part of the study, the author chose an American company that supplies compressor units with gas turbine engines. Its financial office is located in Prague, which allowed the author to personally visit the company and ask employees the necessary questions for the research.

The company's Prague office primarily handles financial and administrative operations in various regions, including Europe, Asia, the Middle East, Africa, Australia, and Oceania. The company employs approximately 8,000 people worldwide, including approximately 800 in the Czech office.

Furthermore, the company has representative offices and branches in more than 100 countries and continues to grow and develop, opening new representative offices in various countries.

4.1.2 Organization selection

For this study, the author needed to select a company that could provide the necessary information and that also met a number of criteria required for this type of analysis. Therefore, based on the factors presented below, the author selected this organization:

1. The company uses a number of structured business processes related to financial document processing, which have been modified and still require further improvement.
2. The author was able to directly contact the company's employees and obtain all the necessary data, as I am familiar with some of them. I also had the opportunity to contact the manager and other employees of the finance department in question.

3. The author received permission to use the data in this bachelor's thesis, which simplified the search for information.
4. The organizational model in question is suitable for factor analysis because it incorporates multiple roles, offers a variety of work options, and allows for the identification of key influencing factors.

4.1.3 Stuff consultation

As part of collecting and preparing information, the author conducted several consultations with employees of one of the company's finance departments, who provided information on the invoice processing process and identified factors affecting its effectiveness.

First, the author consulted with one of the company's managers, who described the process for dividing responsibilities between two groups of employees: accountants and assistants, who are most actively involved in entering invoices into the company's system.

The author then consulted with several accountants and their assistants to more accurately understand their workflow, the volume of work they perform weekly, and the time they spend on their tasks. The author also collected employee opinions on the system's effectiveness and their personal views on potential improvements.

4.2 Selected process overview

The study focused on the invoice processing and indexing process implemented in the company's finance department. This process is a crucial part of the organization's administrative activities, as it ensures the accurate processing of financial documents and subsequent payments to suppliers or to the company's branches in other countries.

The invoice processing process involves several sequential steps and requires collaboration between various finance department employees. It involves assistants, two types of accountants, and a manager. Each employee performs specific functions that help monitor the accuracy of the process and eliminate errors.

Due to the increasing number of incoming invoices, this process has become characterized by a high workload. This necessitated an analysis of the process structure and an assessment of the effectiveness of the existing work organization. To this end, the study conducted a

detailed analysis of the invoice indexing process, including a description of its key stages, the roles of the participants, and the operational structure.

4.2.1 Description of the invoice indexing process

The invoice processing process begins with the receipt of an invoice from a supplier or another company department. Invoices are sent to a shared corporate email address accessible to the finance department. In most cases, the initial invoice processing is performed by assistants, but in some situations, accountants may process documents themselves if this is within their purview.

After receiving an invoice, the assistant opens the document and enters the information contained therein into the corporate accounting system. This step is called invoice indexing. During the indexing process, an employee manually enters key document data, including the invoice date, business partner information, payment purpose, payment amount, tax code, and other necessary information. A scanned or electronic copy of the invoice is also attached to the entry in the system.

After data entry, the invoice is sent for review to the accountant responsible for the relevant region or transaction type. The accountant verifies the accuracy of the entered information and makes any necessary changes. After reviewing, the document is sent to the local accountant for further confirmation of data accuracy and compliance with the company's internal requirements. Once all verification steps are completed, the invoice is returned to the accountant responsible, who initiates the payment process. Before final payment processing, the transaction must be confirmed by a manager. Once final confirmation is received, payment is processed, and invoice processing is considered complete.

4.2.2 Process roles and responsibilities

Several categories of employees, each performing specific functions, are involved in invoice processing. A clear division of roles is essential for the efficient organization of the process and ensures control at the various stages of financial document processing.

The first participant in the process is the supplier, who sends the invoice to the company. Upon receipt of the document, the finance department employees begin processing it. The

primary task of these employees is indexing the invoices, i.e., entering the document data into the company's accounting system. This stage requires attention and precision, as input errors can lead to delays in document processing.

The next step in this process is the accountant's work. The accountant verifies the accuracy of the data entered by the assistant and further processes the invoice. In some cases, accountants may also index the invoices themselves if assistants are unable to process the entire volume of documents.

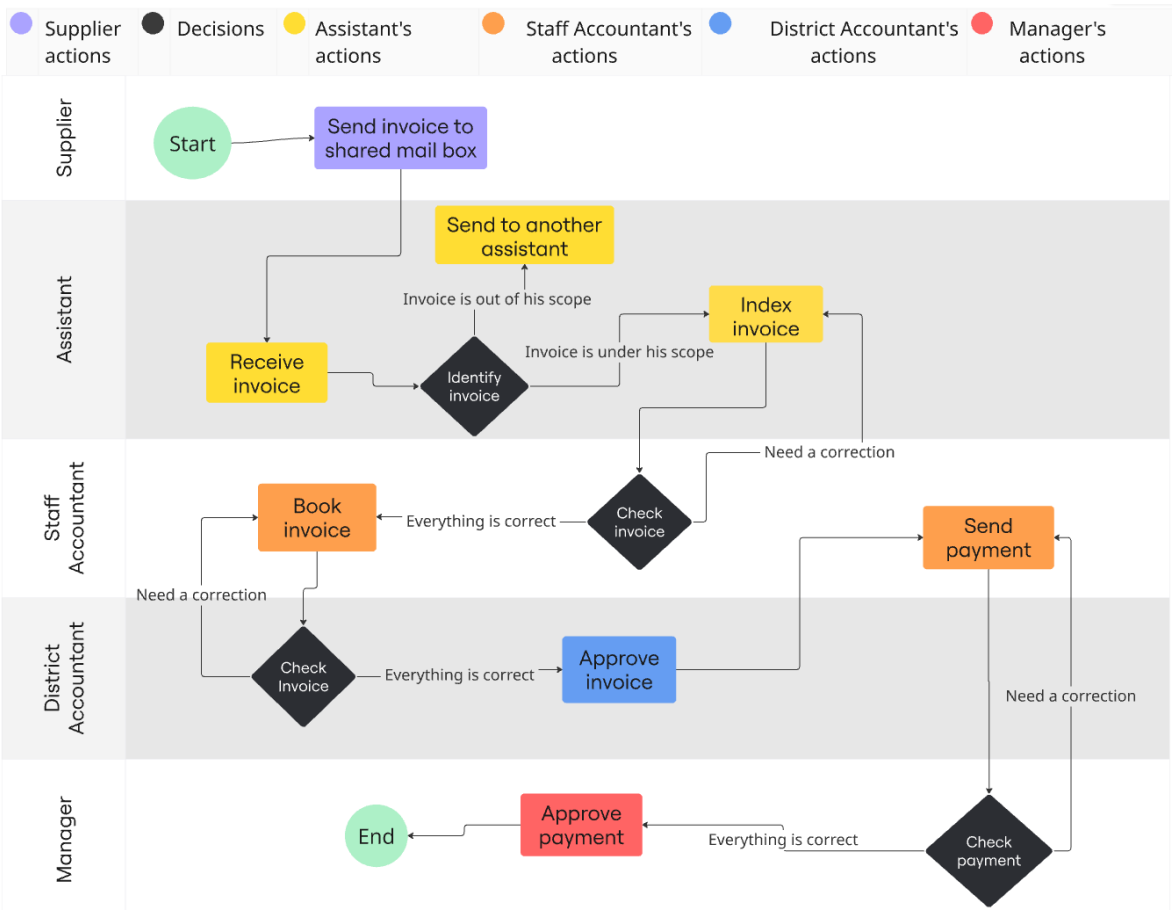
The invoice is then sent to a local or district accountant, who conducts an additional review of the document. This employee's primary responsibility is to confirm the accuracy of the financial information and the document's compliance with the company's internal policies.

The manager is involved in the final stage of the process, performing the final payment approval. The manager checks whether the previous steps have been completed correctly and decides whether the payment should be processed.

4.2.3 Process modelling (BPMN diagram)

To better and more clearly understand the process, the author created a BPMN diagram that clearly shows which employees perform each function and the consequences of their decisions. If an error is detected at any stage, the invoice is sent for correction and re-verification by the responsible person.

Figure 6 BPMN diagram of invoice indexing process



Source: author, based on company data through Miro

4.3 Analysis of the organizational structure

As the company grew, the invoice processing structure changed several times. The primary reason for these changes was the gradual increase in the number of incoming invoices and the company's expansion. With the growth in financial transactions, it became necessary to reassess the distribution of tasks among finance department employees.

At various stages of the process's development, the company used various organizational models for invoice processing. These models varied in the number of employees involved in the process, as well as the principles for distributing tasks among them. Analyzing these models allows us to evaluate the effectiveness of various organizational approaches and identify factors influencing process performance.

4.3.1 Initial organizational model

The initial organizational model for the invoice processing process included four part-time assistants. Each assistant worked approximately 20 hours per week and performed tasks indexing invoices in the company's system.

In this model, tasks were distributed among assistants not by region or country, but by invoice type. For example, different assistants could be responsible for processing specific document categories, such as purchase order invoices, non-purchase order invoices, or other types of financial documents. This approach allowed employees to specialize in a specific type of transaction.

However, this model also had certain drawbacks. Because the assistants worked part-time, the available working time for document processing was limited. Furthermore, in some cases, accountants had to index invoices in the system themselves to speed up document processing. This increased their workload and reduced the efficiency of task distribution among employees. Due to the increasing volume of incoming invoices, the company's management decided to reorganize the process. In the second model, four part-time assistants were replaced by two full-time assistants.

It was hoped that increasing assistant hours would improve productivity and reduce the number of tasks performed by accountants. In this model, two assistants worked 40 hours per week and performed invoice indexing tasks.

However, the principle of task distribution remained the same. Assistants continued to specialize in specific invoice types, rather than regions or countries. Despite increasing assistant hours, this model did not completely resolve the overload issue. In some cases, accountants still had to index invoices themselves as the volume of incoming documents continued to grow.

4.3.2 Current organizational model

The current organizational model was implemented due to the growing volume of invoices received. Invoice processing is currently handled by two full-time assistants and one part-time assistant. The main change compared to previous models is the shift in task allocation.

Instead of being assigned by invoice type, employees are now responsible for processing documents based on region or country.

This approach has allowed for a clearer division of responsibilities among employees and improved control over document processing. Each assistant is responsible for a specific set of countries or regions and processes invoices received from these sources. This method is faster and more efficient because each region processed has its own specific invoice issuance and indexing procedures.

Each assistant has received specific training from local accountants, which has helped speed up the process because each assistant now understands the specifics of their specific region and does not need to learn all the regions, as was the case under the previous organizational model.

Despite these changes, situations still arise during the workflow where accountants must independently index some invoices. This occurs because the volume of incoming documents sometimes exceeds the processing capacity of assistants. As a result, finance department staff are periodically forced to work overtime.

Analysis of these organizational models allows us to identify key factors influencing the efficiency of the invoice processing process. These factors will be used to construct a factor model and analyze possible alternative organizational options.

4.3.3 New organizational model

During consultations with assistants and accountants, it became clear that employees consider the current model ineffective, as assistants still lack the time to enter invoices into the system. The model is particularly challenging during busy periods for the finance department, such as the end of a quarter and the end of a year. The volume of incoming invoices can be several times higher than during normal periods throughout the year. The workload increases especially sharply in December, when employees must enter all invoices into the system before the end of the calendar year.

Based on all the issues and comments, the author proposes implementing a new organizational model that would increase the working hours of one assistant, and instead of

two full-time and one part-time assistant, three assistants would work full-time. This, in theory, should facilitate the work of both assistants and accountants.

4.4 Definition of Experimental Variables

4.4.1 Identification of key factors

To improve the efficiency of the invoice indexing process, the author analyzed factors that could significantly impact system performance. The analysis was based on a study of the existing organizational structure of the process, consultations with department employees, and an assessment of available operational data.

• Factor A – Staffing

This factor indicates how many assistants are involved in the process and how much time they work daily and weekly.

• Factor B – Distribution

This factor shows how invoices are distributed among assistants: by region or by invoice type. It also helps determine how much time each assistant spends indexing one invoice: distribution by invoice type takes approximately 5 minutes, while distribution by region takes approximately 3 minutes.

• Factor C – Accountant Involvement

This factor indicates whether an accountant is involved in the indexing process. If an accountant is involved, they index approximately 125 invoices per week. If they are not involved, invoices are indexed only by assistants.

4.4.2 Definition of factor levels

For each identified factor, two levels were defined, corresponding to alternative work organization options. The selection of levels was based on the department's actual operating practices and possible resource allocation scenarios.

A low level for the "Staffing" factor corresponds to a situation where the process involves the equivalent of 2.5 administrative assistants (two full-time employees and one part-time employee). A high level assumes the involvement of three employees, increasing the total available working time.

The "Allocation" factor also has two levels. The low level corresponds to the distribution of documents by type, with the average processing time per invoice being approximately five minutes. The high level reflects the distribution of documents by region, which reduces the average processing time to three minutes due to employee specialization.

The "Accountant Participation" factor characterizes the accountant's involvement in the indexing process. At a low level, the accountant is not involved in document processing, while at a high level, they are expected to perform an additional volume of operations, equivalent to approximately 125 processed invoices per week.

The table presents the selected factors and their corresponding levels.

Table 1 Factors and levels

Factor	Description	Low level	High level
A	Staffing	2.5 assistants	3 assistants
B	Allocation	Type (5 minutes)	Region (3 minutes)
C	Accountant involvement	No	Yes

Source: author, based on company data

4.4.3 Definition of performance indicators

The primary performance indicator is process throughput, which is defined as the maximum number of invoices that can be processed within a week under a given configuration of factors. This indicator is calculated based on available employee time and the average processing time per document.

4.5 Factorial Experiment Design

4.5.1 Experimental design model

A 2^3 full factorial design was used to analyze the impact of the selected factors on process performance indicators. This method allows for the simultaneous assessment of the individual impact of each factor and their potential combined impact on system performance.

Each factor was assigned coded values: a "-" sign corresponds to a low factor level, and a "+" sign to a high factor level. The experimental design includes eight combinations of factor levels, providing full coverage of possible process organization scenarios, as shown in the table below:

Table 2 Factorial Design Matrix

Run order	Factor 1	Factor 2	Factor 3
1	-	-	-
2	-	-	+
3	-	+	-
4	-	+	+
5	+	-	-
6	+	-	+
7	+	+	-
8	+	+	+

Source: author, based on company data

4.5.2 Experimental matrix

Based on the coded model, an experimental matrix was created reflecting real scenarios of invoice processing in organizations:

Table 3 Factorial Design Scenarios

Scenario	Staffing	Allocation	Accountant involvement
1	Low	Type	No
2	Low	Type	Yes
3	Low	Region	No
4	Low	Region	Yes
5	High	Type	No
6	High	Type	Yes
7	High	Region	No
8	High	Region	Yes

Source: author, based on company data

Each scenario represents a unique combination of staffing levels, document distribution methods, and accountant involvement. This allows for a comparative analysis of the effectiveness of various process organization options.

4.5.3 Calculation of response variable

In this experiment, the dependent variable and performance indicator are employee productivity, which represents how many invoices per week can be indexed under each of the eight scenarios.

Productivity is calculated using a formula developed specifically for the specific situation and process at the selected organization:

Formula 4 Productivity of weekly invoice indexing

$$Productivity = \frac{Staffing * Working\ time}{Allocation} + accountant\ involvement$$

Where:

- Staffing – the number of working assistants, from 2.5 to 3 assistants
- Working time – calculated based on working hours per day – approximately 7 hours including breaks, multiplied by the number of working days – 5 days per week, and multiplied by 60 to convert all values to minutes:

$$Working\ time = 7 * 5 * 60 = 2100\ (minutes\ per\ week)$$

- Allocation – the invoice distribution method, where if they are allocated by type, the value is equal to 5 minutes of processing, and if allocated by region, the value is equal to 3 minutes.
- Accountant involvement – indicates whether accountants index invoices or not. If yes, the value is 125; if not, the value is 0.

The table below shows the calculated productivity values for each scenario:

Table 4 Factorial Design Scenarios with response variable

Scenario	Staffing	Allocation	Accountant involvement	Productivity
1	Low	Region	No	1750

2	Low	Region	Yes	1875
3	Low	Type	No	1050
4	Low	Type	Yes	1175
5	High	Region	No	2100
6	High	Region	Yes	2225
7	High	Type	No	1260
8	High	Type	Yes	1385

Source: author, based on company data

To determine which scenario is most effective, we'll use information from employees indicating that the department receives approximately 2,000 invoices weekly, on average, which ideally should be indexed within the same week. This suggests that scenario 5 is the closest to this value.

4.6 Analysis of Experimental Results

4.6.1 Analysis of scenario performance

Based on the results of a factorial experiment, a comparative analysis of the effectiveness of various invoice indexing process scenarios was conducted. The focus was on system performance and utilization metrics, which assess the process's ability to process the incoming document flow.

The analysis revealed that system performance is significantly dependent on the chosen invoice distribution method. Scenarios with regional distribution demonstrate a significant increase in process throughput. This is explained by a reduction in the average processing time per document due to employee specialization and a more homogeneous task structure.

In contrast, document distribution by type leads to increased processing time and a decrease in overall system throughput. Under these conditions, a significant increase in utilization is observed, indicating the risk of process overload and the possible accumulation of unprocessed documents.

It was also found that increasing the number of staff members has a positive effect on process efficiency. Hiring an additional employee increases the total amount of available working time and, therefore, increases system throughput. However, the impact of this factor is less pronounced than that of the task distribution method. Accountant involvement in the indexing process also contributes to improved document processing efficiency. This additional resource allows for redistribution of the workload among employees and reduces system overload. However, the impact of this factor is of a supporting nature and does not determine the overall efficiency of the process.

4.6.2 Main effects analysis

To quantify the relative importance of factors, a main effects analysis was conducted. The effect of each factor was defined as the difference between the mean performance values at high and low levels of the corresponding factor.

Table 5 Main Effect Analysis Results

Factor	Description	Low level	High level	Effect
A	Staffing	1462.5	1742.5	280
B	Allocation	1217.5	1987.5	770
C	Accountant involvement	1540	1665	125

Source: author, based on company data

The analysis results show that invoice allocation has the greatest impact on process efficiency. Switching from invoice allocation by type to invoice allocation by region increases weekly productivity by approximately 770 processed documents. This result

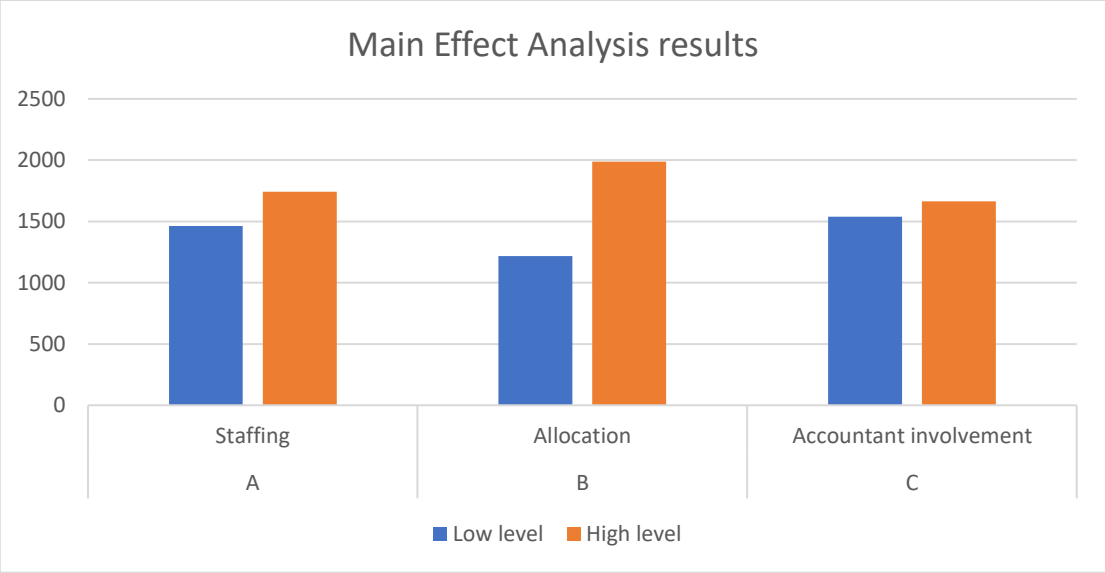
confirms the key role of the organizational approach to task allocation in improving process efficiency.

The second most significant factor is headcount. Increasing the number of employees from the equivalent of 2.5 to 3 allows for an increase in productivity by approximately 280 documents per week. This demonstrates that additional work time has a significant impact on system throughput.

Accountant involvement also has a positive impact on process efficiency; however, its effect is the smallest among the factors examined, amounting to approximately 125 documents per week. Therefore, accountant involvement can be considered an additional productivity enhancement tool, but not the primary method of process optimization.

The graphical representation of the main effects confirms the quantitative results obtained and demonstrates the relative importance of each factor:

Figure 7 Main Effect analysis chart



Source: author, based on Table 5

5 Results and Discussion

5.1 Results interpretation

The results of the factorial experiment showed that the most effective organizational configurations for the invoice indexing process are represented by scenarios 5, 6, and 2, as these options provide the highest system throughput compared to other factor combinations.

Scenario 2 is characterized by increased throughput compared to the basic process organization options due to the accountant's involvement in document indexing. However, this level of throughput remains insufficient to process the actual volume of incoming invoices, which averages approximately 2,000 documents per week. This means that when this scenario is implemented, the process may accumulate unprocessed tasks and experience delays in processing operations.

Scenario 6, on the other hand, demonstrates a very high level of throughput, achieved through a combination of increased staffing, regional distribution of tasks, and accountant involvement. Despite the positive impact of these factors on system throughput, this organizational model can lead to excessive use of labor resources. Given a steady incoming document flow, this can reduce the overall operational efficiency of the process and increase the organization's costs. Scenario 5 appears to be the most balanced option, combining high productivity with more efficient resource utilization. This configuration enables the processing of document volumes close to the actual invoice incoming volume while maintaining a moderate throughput reserve. This reserve is an important factor in process stability, as periods of significant workload increases occur throughout the year, particularly at the end of quarters and the end of the financial year.

It should be noted that the performance indicators used in the study are approximate and based on employee assessments. Furthermore, performance can be impacted by various external and internal factors, including fluctuations in incoming document volume, employee skill levels, and the specifics of the current work situation. Therefore, the author suggests that the choice of organizational model should take into account the need for a moderate throughput reserve while simultaneously preventing resource overuse.

Therefore, Scenario 5 can be considered the most suitable organizational process configuration option for the given organization.

5.2 Advantages and disadvantages of factorial design

The use of a factorial experimental design in this study allowed us to systematically assess the impact of key organizational factors on the effectiveness of an administrative business process. The primary advantage of this method is the ability to simultaneously analyze multiple process parameters and their combined impact on system performance. This provides a more comprehensive understanding of process performance compared to methods that rely on a sequential examination of individual factors.

Factorial design also facilitates the formation of quantitatively substantiated management decisions, as it enables the comparison of alternative organizational configurations based on calculated performance indicators. This approach can be used as a tool for preliminary assessment of potential changes to business processes.

At the same time, the use of factorial design in this study was largely theoretical and analytical in nature. The author did not have access to the full range of the organization's operational data and was forced to use simplified assumptions regarding document processing times and employee workload levels. This limits the accuracy of the quantitative assessment and requires caution in interpreting the results.

5.3 Discussions

Research into the efficiency of the invoice indexing process has important practical implications for the organization in question. Rational distribution of tasks among employees reduces the likelihood of a backlog of unprocessed documents, reduces workload overload, and improves process stability.

For employees, improved work organization efficiency may mean reduced overtime and a more even distribution of workload throughout the week. For the company, process optimization has economic implications, as overtime at the organization in question is paid and leads to increased operating costs.

Implementing an organizational model that involves increased staffing may require additional financial resources. However, the author suggests that these costs can be offset by a reduction in the volume of paid overtime and an increase in overall process stability.

Scenario 6, which involves the active participation of accountants in document indexing, can be considered a temporary organizational measure during periods of peak invoice receipt, such as at the end of reporting periods. In the long term, a more sustainable solution appears to be streamlining task distribution and ensuring sufficient staffing. Thus, the results of the study can be used as a basis for making management decisions aimed at improving the efficiency of administrative processes and more rational use of labor resources.

5.4 Research limitations

Despite the obtained results, this study has several limitations. The analysis was conducted based on a single administrative process within a specific organization, limiting the direct applicability of the findings to other companies or industries.

Furthermore, the factorial experiment was of a modeling nature and relied on approximate employee estimates of document processing time and workload volume. The productivity calculation formula used was developed by the author based on a description of the actual organization of the process and is not a universal scientific model. It reflects the specific functioning of the unit in question and may differ in other organizational settings.

Furthermore, the study examined a limited number of factors, while process efficiency can be influenced by other parameters, including the level of automation, employee qualifications, the quality of information systems, and organizational culture.

These limitations create the basis for further research aimed at conducting empirical observations, expanding the range of factors analyzed, and using more sophisticated quantitative analysis methods.

6 Conclusion

The objective of this bachelor's thesis was to analyze and optimize the administrative business process of invoice indexing using a factorial experimental design. The study examined the theoretical foundations of business process management, methods for their analysis and optimization, and the specifics of applying quantitative approaches in an organizational environment.

The practical portion of the work was based on a study of a real process implemented in the finance department of an international company. Through consultations with employees and an analysis of the existing organizational structure, key factors influencing process performance were identified, namely, staffing levels, task allocation principles, and accountant involvement in document indexing.

The use of a full factorial experimental design allowed us to develop alternative work organization scenarios and evaluate their impact on process throughput. The results showed that the method of task allocation among employees has the greatest impact on invoice indexing efficiency, while increased human resources and accountant involvement serve as additional productivity enhancers. Based on a comparative analysis of scenarios, the author concluded that the most balanced organizational configuration is one that ensures sufficient productivity with a moderate capacity reserve. This approach improves process stability in the face of fluctuating incoming document volumes and promotes more efficient use of labor resources.

The practical significance of this study lies in the potential use of the obtained results when planning changes to administrative business processes. Optimizing the organizational structure of the process can help reduce employee overtime, improve the stability of operations, and reduce additional costs associated with overtime.

However, it should be noted that this study is modeling in nature and is based on a number of simplifying assumptions. This necessitates further research aimed at empirically validating the proposed organizational solutions, expanding the range of factors analyzed, and studying the impact of digitalization and automation on the efficiency of administrative processes.

Thus, this study confirms the feasibility of using quantitative analytical methods in business process management and demonstrates the potential of factorial experimental design as a tool for supporting management decisions in organizational practice.

7 References

Antony, J. et al., 2011. Design of Experiments for Non-Manufacturing Processes: Benefits, Challenges and Some Examples. *Proceedings of the Institution of Mechanical Engineers Part B Journal of Engineering Manufacture,* 225(11), pp. 2078-2087.

Bouchekara, H. R. E. H., Dahman, G. & Nahas, M., 2011. Smart Electromagnetic Simulations: Guidelines for Design of Experiments Technique. *Progress In Electromagnetics Research B,* 31(31), pp. 357-379.

Brocke, J. v., Mathiassen, L. & Rosemann, M., 2014. Business Process Management. *Business & Information Systems Engineering,* Volume 6, p. 189.

Brocke, J. v. & Rosemann, M., 2015. *Handbook on Business Process Management 1.* 2nd ed. Vaduz, Liechtenstein/Brisbane: Springer Heidelberg New York Dordrecht London.

Butt, J., 2020. A Conceptual Framework to Support Digital Transformation in Manufacturing Using an Integrated Business Process Management Approach. *Design,* 4(3), pp. 1-39.

Cheng, C.-S., 2014. *Theory of Factorial Design: Single- and Multi-Stratum Experiments.* s.l.:Taylor & Francis Group, LLC.

Chinosi, M. & Trombetta, A., 2012. BPMN: An introduction to the standard. *Computer Standards & Interfaces,* 34(1), pp. 124-134.

Clarkson, J. & Eckert, C., 2005. *Design Process Improvement: a review of current practice.* s.l.:Springer.

Dawande, M., Feng, Z. & Janakiraman, G., 2020. On the Structure of Bottlenecks in Processes. *Management Science,* 67(6).

Dechsupa, C., Vatanawood, W. & Thongtak, A., 2019. Hierarchical Verification of the BPMN Design Model Using the State Space Analysis. *IEEE Access,* Volume 7, pp. 16795-16825.

Dumas, M., La Rosa, M., Mendling, J. & Reijers, H. A., 2018. Introduction to Business Process Management. In: 2nd, ed. *Fundamentals of Business Process Management.* Berlin: Springer-Verlag GmbH Germany, part of Springer Nature, pp. 1-33.

Grefen, P. & Vanderfeesten, I., 2024. Chapter 1: Business process definition. In: *Handbook on Business Process Management and Digital Transformation.* s.l.:Edward Elgar Publishing, pp. 9-27.

Harrison-Broninski, K. & Modellers, R., 2012. Types of Business Process. In: *Workflow Management Coalition Handbook.* s.l.:Workflow Management Coalition, pp. 59-68.

Malenović, A. et al., 2004. Retention modelling in liquid chromatographic separation of simvastatin and six impurities using a microemulsion as eluent. *Journal of Separation Science,* 27(13), pp. 1087-1092.

Mukerjee , R. & Wu, J., 2006. *A Modern Theory of Factorial Designs.* New York: Springer Science+Business Media, Inc..

Naslund, D., 2008. Lean, Six Sigma and Lean Sigma: fads or real process improvement methods? Business Process Management. *Business Process Management Journal,* 14(3), pp. 269-287.

Safa, Y. & Bhatti, H. N., 2011. Adsorptive removal of direct textile dyes by low cost agricultural waste: Application of factorial design analysis. *Chemical Engineering Journal,* 167(1), pp. 35-41.

Smirnov, S., Reijers, H. A., Weske, M. & Nugteren , T., 2012. Business process model abstraction: a definition, catalog, and survey. *Distributed and Parallel Databases,* Volume 30, pp. 63-99.

Vergidis, K., Tiwari, A. & Majeed, B., 2008. Business Process Analysis and Optimization: Beyond Reengineering. *IEEE Transactions on Systems Man and Cybernetics Part C,* 38(1), pp. 69-82.

Vicente, Coteron, Martínez & Aracil, 1998. Application of the factorial design of experiments and response surface methodology to optimize biodiesel production. *Industrial Crops and Products,* 8(1), pp. 29-35.

Wang, Y., Zhao, Q. & Zheng , D., 2005. Bottlenecks in production networks: An overview. *Journal of Systems Science and Systems Engineering,* Volume 14, pp. 347-363.

Wannes, A. & Ghannouchi, S. A., 2019. KPI-Based Approach for Business Process Improvement. *Procedia Computer Science,* Volume 164, pp. 265-270.

White, S. A., 2004. Introduction to BPMN. *BPTrends,* p. 11.

8 Appendix

8.1 Table of figures

Figure 1 Different types of business processes 11
Figure 2 Example of a Business Process Model in BPMN Notation 18
Figure 3 Basic Elements of BPMN Notation 19
Figure 4 Example of a Full Factorial Experimental Design Matrix 23
Figure 5 Alternative Representation of Factor Levels in Factorial Design 23
Figure 6 BPMN diagram of invoice indexing process 31
Figure 7 Main Effect analysis chart 41

8.2 Table of formulas

Formula 1 General Factorial design 22
Formula 2 Factorial design – 2 levels 22
Formula 3 Main Effect Calculation 24
Formula 4 Productivity of weekly invoice indexing 38

8.3 Table of tables

Table 1 Factors and levels 35
Table 2 Factorial Design Matrix 36
Table 3 Factorial Design Scenarios 37
Table 4 Factorial Design Scenarios with response variable 38
Table 5 Main Effect Analysis Results 40