5. BUSINESS PROCESS MANAGEMENT AND PROCESS MINING

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To stay competitive in today's business environment, effective management and ongoing process improvement are critical. This chapter examines Business Process Management (BPM) and Process Mining, two important parts of business intelligence that help companies analyze, optimize, and enhance their operational processes.

BPM provides an organized and structured method for identifying, designing, executing, monitoring, and improving business processes while aligning them with the organization's strategic objectives. Process mining, on the other hand, is a tool for identifying and enhancing actual processes through the extraction of knowledge from event logs found in modern business information systems. The combination of Business Process Management and Process Mining enables an objective, data-driven method for understanding and improving business processes.

By leveraging these methodologies, organizations can find hidden inefficiencies and problems, adapt to changing market demands, and improve their performance and customer satisfaction. The fundamental concepts, methodologies, tools, and real-world applications of BPM and process mining will be covered in this chapter.

5.1. Business process

Every organization, regardless of size or sector, is a complex system of interconnected processes. These processes are the structured activities undertaken to accomplish a specific organizational goal. For instance, in a manufacturing company, key processes might include product design, raw materials procurement, manufacturing, quality control, and distribution. In a service-oriented business like a bank, processes include account opening, loan processing, customer service, and compliance checks. Organizations use processes on a daily basis, and these processes can be as varied as the organizations themselves. In a hospital, processes range from patient admission to medical treatment and discharge. In an educational institution, they encompass student enrollment, course delivery, and examination

administration. Each process is a sequence of steps, involving various departments and personnel, and often supported by technology.

According to Dumas et al. (2018), every business process consists of several events and activities. **Events** correspond to things which do not have a duration and happen atomically (e.g. 'Order received'). On the other side, **activities** are tasks or operations that are interconnected and whose execution fulfills the goal of the business process (e.g. 'Pay the invoice'). A typical process, aside from events and activities, includes **decisions**, which indicate a stage at which the process decides which direction it will go in the future. For example, in the sales process, one decision point could be when the salesperson checks whether the product is in stock. If a product is in stock, the process moves on to the next activity. If there is no product in stock, the process proceeds in a different way (e.g. by informing the customer that the order cannot be fulfilled). The important parts of a process are actors/participants and objects. **Actors** include people, organizations or software systems that perform the process activities, while **objects** are equipment, materials, paper documents (physical objects), electronic documents and records (informational objects).

Dumas et al. (2018) state that the execution of a process results in one or more **outcomes**. An outcome should, in theory, benefit all parties involved in the process (*positive outcome*). Sometimes this value is only partially or never reached (*negative outcome*).

Von Scheel et al. (2015) define **business process** as „a collection of tasks and activities (business operations and actions) consisting of employees, materials, machines, systems, and methods that are being structured in such a way as to design, create, and deliver a product or a service to the consumer".

Understanding a process is just the beginning. The true problem, and opportunity, is to manage these processes in a systematic and planned manner. This brings us to the following chapter: Business Process Management (BPM). In this section, we will look at the approaches and frameworks that allow organizations to not only manage but execute their processes. BPM is more than just process recording and analysis; it is a comprehensive method to developing, implementing, monitoring, and constantly improving business processes.

5.2. Business Process Management

In scientific and professional literature, we can find different definitions of Business Process Management. Gartner (n.d.) defines BPM as „a discipline that uses various methods to

discover, model, analyze, measure, improve and optimize business processes". According to Camunda (n.d.), BPM is „a systemic approach for capturing, designing, executing, documenting, measuring, monitoring, and controlling both automated and non-automated processes to meet the objectives and business strategies of a company". Swenson and Rosing (2015) proposed some wider and maybe most precise definition: „Business process management (BPM) is a discipline involving any combination of modeling, automation, execution, control, measurement, and optimization of business activity flows in applicable combination to support enterprise goals, spanning organizational and system boundaries, and involving employees, customers, and partners within and beyond the enterprise boundaries".

According to Freund and Rücker (2012), the new BPM projects often include one of these scenarios:

1. Process improvement using information technology (IT)
2. Documentation of current processes
3. Introduction of entirely new processes.

Dumas et al. (2018) see BPM as a continuous cycle comprising the following phases:

- **Process identification** - A business problem is given in this step. Processes that are important to the problem being solved are identified, defined, and linked. The result of process identification is a new or improved process architecture. This architecture shows all of an organization's processes and how they connect to each other. It is used to choose which process or set of processes to handle for the rest of the lifecycle.
- **Process discovery (As-is process modeling)** - This is where the current state of all the important processes is documented, usually in the form of one or more "as-is" process models.
- **Process analysis** - During this step, problems with the current As-is process are identified, documented, and, if possible, measured using performance indicators. A structured list of issues is the outcome of this step. These issues are ranked in order of possible impact and estimated effort needed to fix them.
- **Process redesign (To-be process modeling)** – This phase's objective is to find process modifications that will enable the company to meet its performance targets while also addressing the issues found in the preceding phase. This phase usually results in a To-be process model.

- **Process implementation** - The adjustments needed to transfer the As-is process to the To-be process are planned and carried out during this phase. Automation and organizational change management are the two aspects of process implementation. The term "organizational change management" describes the collection of actions necessary to change the way of working of all participants involved in the process. The creation and implementation of IT systems (or improved versions of current IT systems) to support the future process is referred to as process automation.
- **Process monitoring** – after the implementation of the redesigned process, relevant data is gathered and analyzed to assess the performance of the process. Corrective action is initiated after bottlenecks, recurring errors, or deviations from the intended behavior are identified.

This cycle must be repeated continuously because new problems might arise in the same or some other processes. This BPM lifecycle is shown in Figure 5.1.

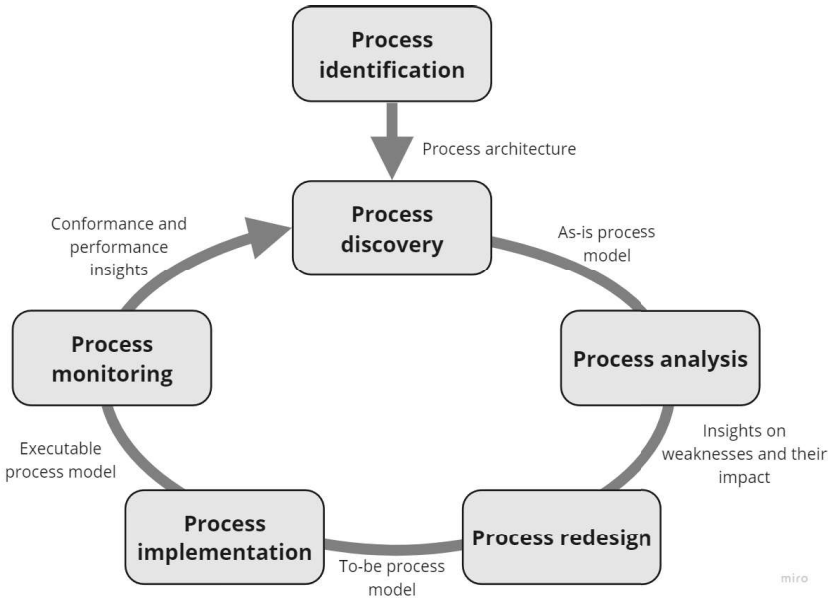

Figure 5.1 BPM lifecycle

Source: Dumas et al. (2018).

Freund and Rücker (2012) list several roles which are involved in BPM projects:

- **Process owner** – person who has strategic responsibility for the processes. He has budget authority, and he is often a member of the first or second tier of management. For example, the process owner can be the company's CEO.

- **Process manager** – person who has operational responsibility for the processes. He is often a low- or middle-level manager. For example, the sales manager could be the process manager.
- **Process participant** – person who works with the process and creates value (e.g. salesperson).
- **Process analyst** – person who understands BPM in general and BPMN in particular, and he is a center of every BPM project.

BPM helps businesses match their processes with their overall goals, become more efficient, and adapt to changing environments. In the next section, the methods and tools that are used to make accurate models of business processes will be presented.

More than merely drawing diagrams, business process modeling aims to capture the core processes in a way that makes them easier to understand, communicate, and analyze. Stakeholders may use it to visualize complex processes, see inefficiencies and bottlenecks, and conceptualize improvements and innovations.

In the next section, the most popular modeling method BPMN (Business Process Model and Notation) will be presented. It will be discussed how this tool can be used to effectively document business processes.

5.3. Business Process Modeling

In order to provide standardized, graphical notation for documenting, designing and analyzing business processes, the **Business Process Model and Notation (BPMN)** was introduced. According to Lucidchart (n.d.), the Business Process Management Initiative (BPMI) created the Business Process Modeling Notation, which has undergone numerous changes. The initiative was taken over by the Object Management Group (OMG) after that group merged with it in 2005. OMG released BPMN 2.0 and changed the method's name to Business Process Model and Notation. With a wider range of symbols and notations for Business Process Diagrams, it established a more comprehensive standard for business process modeling.

These four element categories are represented by BPMN (Lucidchart, n.d.; Freund and Rücker, 2012):

- **Flow objects:** events, tasks (activities), and gateways
- **Connecting objects:** sequence flow, message flow and association

- **Participants:** pool and lanes
- **Artifacts:** data objects, data store and annotations

5.3.1. Events

Aagesen and Krogstie (2015) define events as something that happens in a process. There are three types of events in BPMN: start, intermediate and end events. Start event is a trigger for the beginning of the process. Intermediate events occur during the business process and often mark some milestones or waiting in the process. End events mark the end of a business process. They are represented by circles.

Figure 5.2 Start, intermediate and end event notations

Source: Author.

According to Dumas et al. (2018), the event should be named as [object] + [verb in past participle]. Here are some examples of how to name the events: „Invoice sent", „Order submitted", „Products received".

Table 5.1 shows different types of start, intermediate and end events (OMG, 2006).

Table 5.1 Event types

Type	Description	Symbol
Start event		
None	The type of event is not displayed.	
Message	A message arrives from a participant and triggers the start of the process.	
Timer	The process is triggered at the specific time (e.g. every Monday at 9am).	
Conditional	The event is triggered when some condition is met (e.g. when inventory level is lower than 500 pieces).	
Intermediate event		

None	The type of event is not displayed.	
Message	A message arrives from a participant and triggers the event. This causes the process to continue if it was waiting for the message.	
Timer	It can act as a delay mechanism. For instance, if the process is awaiting the delivery of a product.	
End event		
None	The type of event is not displayed.	
Message	A message is sent to a participant at the end of the process.	
Error	An error should be generated at the end of the process.	
Terminate	All activities in the process should be immediately ended.	

Source: OMG (2006).

5.3.2. Tasks (activities)

Tasks are something that is carried out during a process, activities performed by a person or system. It is represented by a rectangle with rounded corners.

In BPMN, there is a special subset of regular task called sub-process. It is represented by a rectangle with a '+' sign at the bottom. It serves to represent the process within the process. In this way, the complexity of the main process, i.e. the process in focus, is reduced.

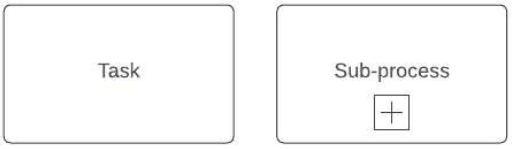

Figure 5.3 Task and Sub-process notations

Source: Author.

The task should be named as [verb in imperative] + [object] (Dumas et al., 2018). Here are a few tasks as examples: „Send the invoice" or „Submit the order".

5.3.3. Gateways

Gateways are locations where processes split or merge. They are represented by the diamond shape. There are three most common types of gateways: XOR (exclusive) gateway, OR (inclusive) gateway, and AND (parallel) gateway.

Figure 5.4 OR, XOR and AND gateway notations

Source: Author.

According to von Rosing et al. (2015), **OR gateway**, when splitting, allows one or more branches to be activated, based on conditions. Before merging, all active incoming branches must be completed in order to continue the flow. An example of an XOR gateway is shown on Figure 5.6.

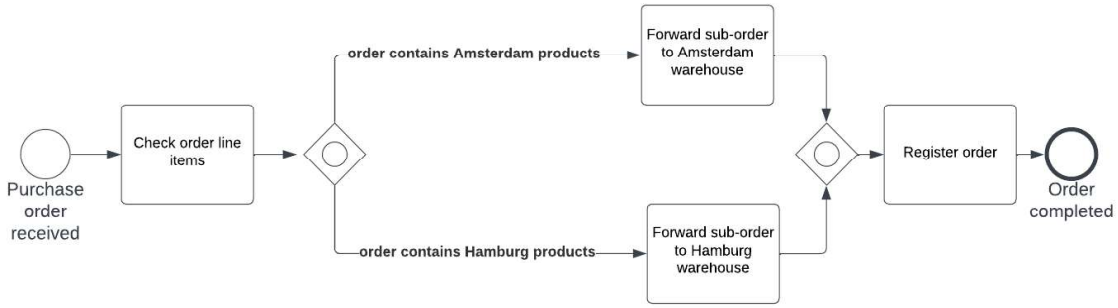

Figure 5.5 An example of the use of OR gateway

Source: Dumas et al. (2018).

In this example, a company has warehouses in Amsterdam and Hamburg, where it keeps different products. Upon receipt of an order, it is split among these warehouses: a sub-order is sent to Amsterdam if certain products are kept there, and a sub-order is sent to Hamburg if certain products are kept there. The procedure then ends when the order is registered (Dumas et al., 2018). We can see that the process can go in both directions (if ordered products are kept in both warehouses) or just in one direction (if ordered products are kept just in one warehouse).

XOR gateway, when splitting, routes sequence flow to only one of the outgoing branches, based on conditions. When merging, it awaits one incoming branch to complete before continuing the flow (von Rosing et al., 2015).

AND gateway is used to execute two or more tasks that do not have any order dependencies on each other and can be executed simultaneously (Dumas et al., 2018). When merging, it awaits all the in branches to complete before continuing the flow (von Rosing et al., 2015). An example of using XOR and AND gateways is shown in Figure 5.6.

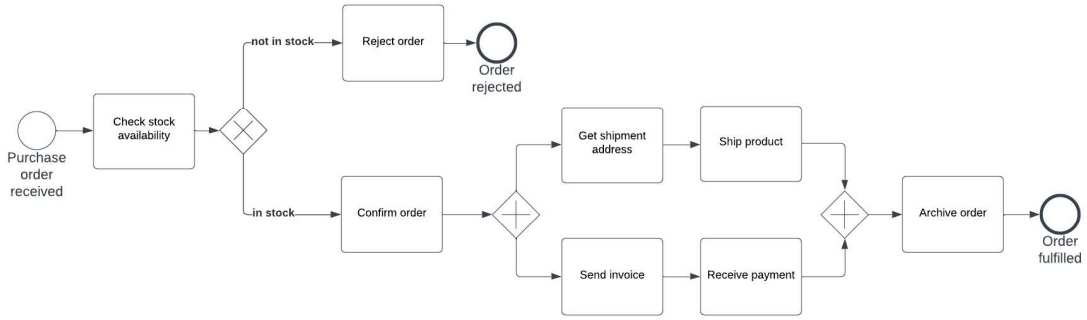

Figure 5.6 An example of the use of XOR and AND gateways

Source: Dumas et al. (2018).

In this example, upon receipt of an order, a salesperson checks stock availability. There is just one and only one possible path – whether the products are in stock or not. On the other hand, it does not matter whether the "Send invoice" or "Get shipment address" activity is carried out first. But only after both sets of activities ("Get shipment address" – "Ship product" and "Send invoice" – "Receive payment") are executed, the order can be archived.

5.3.4. Connecting objects

In BPMN, there are three types of connecting objects: sequence flow, message flow and association.

According to von Rosing et al. (2015), a **sequence flow** shows the order in which tasks will be completed in a process. It is represented by a solid line with a solid arrowhead. A **message flow** is represented by a dashed line. There is a circle on one side of the line and a white arrowhead on the other. It is used to represent the message flow between the process pools. An **association** is used to connect text with flow objects. It is represented by a dotted line.

Figure 5.7 Sequence flow, message flow and association

Source: von Rosing et al. (2015).

5.3.5. Participants

BPMN provides two elements to model process participants: pools and lanes. According to Dumas et al. (2018), **pools** are used to model a whole organization, and a **lane** to model a department or business unit. For example, a pool can be "Company X", and lanes "Sales Department", "Warehouse" and "Accounting". By using pools and lanes, it can be easily seen which participant is doing which activity.

Figure 5.8 Pool and lanes

Source: Author.

5.3.6. Artifacts

There are different types of artifacts: data objects, data store and annotations. **Data objects** represent the data that is required to perform certain tasks (data as input) or is a result of the task execution (data as output). For example, an "Order" document is created after the "Create order" task is executed. On the other hand, the "Send invoice" task requires an invoice as input in order to execute this task. Dumas et al. (2018) states that data objects can be physical objects carrying information (e.g. paper invoice) or electronic objects (e.g. email or an invoice in PDF).

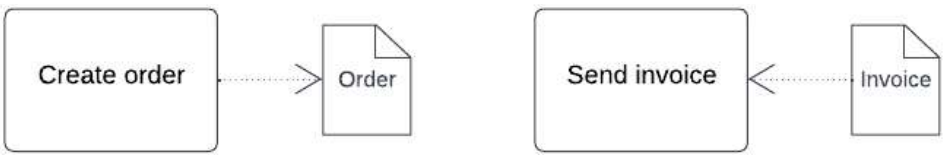

Figure 5.9 Data objects

Source: Author.

According to Dumas et al. (2018), **data store** is a place which contains data objects, e.g. database for electronic objects or a filling cabinet for physical ones. Data stores can be used

by process activities to extract and store data objects. For example, "Check raw materials availability" task looks up the supplier's catalog.

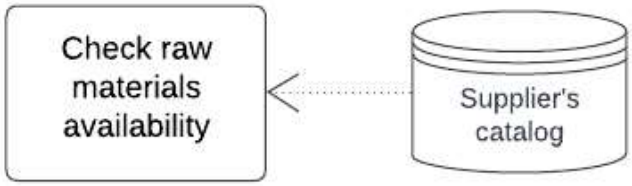

Figure 5.10 Data store

Source: Dumas et al. (2018).

Annotations are a mechanism for a modeler to provide additional text information for the reader of the BPMN diagram (von Rosing et al., 2015).

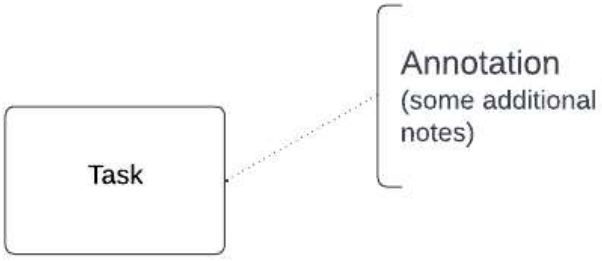

Figure 5.11 Annotation

Source: Author.

BPM has been recognized as an important framework for organizations aiming to optimize their operations and align their processes with strategic objectives. This foundational knowledge is essential for the next topic.

5.4. Process Mining

Process Mining stands at the intersection of data mining and process modeling. It represents an innovative approach to understanding and enhancing business processes. In contrast to the theoretical and methodological focus of BPM, Process Mining explores the actual (real) data generated by business processes. It uses data from various information systems to provide an objective, real-time view of process execution.

Figure 5.11 shows the difference between BPM and Process Mining. In traditional Business Process Management, a process model is developed first. Then, people and IT systems perform

tasks and activities in accordance with this model. In Process Mining, historical data from the IT systems is used to create a process model. This model shows the actual, real processes.

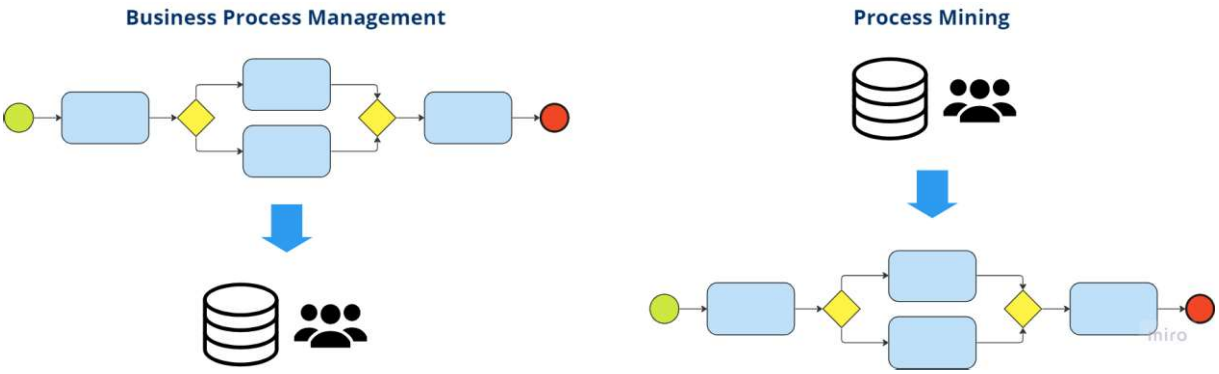

Figure 5.12 Business Process Management vs. Process Mining

Source: Author.

IEEE (2012) defines **Process Mining** as "techniques, tools, and methods to discover, monitor and improve real processes (i.e., not assumed processes) by extracting knowledge from event logs commonly available in today's (information) systems". An event log is a digital record of the events that have been executed within an information system.

In order to perform a process mining analysis, the event log must contain a case ID, an activity name and a timestamp. A **case** (process instance) is the entity being handled by the process that is analyzed (e.g. customer orders, insurance claims, etc.), an **activity** is a well-defined step in the process (IEEE, 2012) and the **timestamp** is the date and time at which the activity is performed.

Table 5.2 shows an example of an event log. In this example, there are two cases (1001 and 1002), each consisting of a series of events for handling customer inquiries.

Table 5.2 Example of an event log

Case ID	Activity Name	Timestamp	Resource
1001	Call Received	2023-15-12 09:00	Agent A
1001	Issue Identified	2023-15-12 09:15	Agent A
1002	Call Received	2023-15-12 10:17	Agent C
1001	Escalation	2023-15-12 10:20	Agent A
1002	Information Given	2023-15-12 10:26	Agent C
1002	Call Concluded	2023-15-12 10:28	Agent C
1001	Tech Support Call	2023-15-12 11:43	Agent B

1001	Issue Resolved	2023-15-12 11:59	Agent B

Source: Author.

After extracting the data (event logs) from the information systems (e.g. as a CSV or XLS file), the data is imported into special process mining software. Nowadays, there is a wide range of process mining software. The most popular are ProM, Fluxicon Disco, ARIS Process Mining, Celonis etc. Based on the imported data, the process mining software discovers a process model. This model can then be analyzed to determine whether there are some bottlenecks, problems or opportunities for improvement.

According to van der Aalst (2018), Process Mining is applicable to all kinds of operational processes (organizations and systems). Analyzing hospital treatment procedures, enhancing customer service procedures in a multinational company, comprehending booking site users' browsing habits, assessing baggage handling system malfunctions, and refining X-ray machine user interfaces are a few examples of applications.

Reil et al. (2021) analyzed a successful implementation of process mining in the practical fields of supply chain management. They stated that in 2020, the Swedish-Swiss energy and automation technology group ABB faced challenges like connecting over 40 ERP systems and managing terabytes of process data. The implementation of process mining in their production processes enabled ABB to gain insights into their global business network performance and move towards a fully digitized supply chain. Benefits included reduced inventory costs, boosted sales processes, improved productivity, on-time deliveries, optimized equipment usage, and increased capacity. The incoming logistics procedures of the automotive supply chain, which are vulnerable to bottlenecks that can cause large revenue losses, benefited greatly from this strategy. Process mining proved useful in efficiently resolving these problems.

BPM's structured way of managing and improving processes makes it possible for businesses to adapt to changing customer needs and operational problems. Process Mining, on the other hand, offers deep insights into actual process performance, highlighting areas of improvement. The integration of BPM and Process Mining is not just a strategic advantage but knowing how to use them and knowing how they work will be important for businesses to be ready for the future.

REFERENCES

1. Aagesen, G. & Krogstie, J. (2015). BPMN 2.0. for Modeling Business Processes. In vom Brocke, J., Rosemann, M. (Eds.). Handbook on Business Process Management 1, 2nd edition. Heidelberg: Springer, pp. 219-250.
2. Camunda (n.d.). What is Business Process Management? [available at: https://camunda.com/glossary/business-process-management-bpm/, access December 28, 2023]
3. Dumas, M., La Rosa, M., Mendling, J. & Reijers, H. A. (2018). Fundamentals of Business Process Management, 2nd Edition. Springer.
4. Freund, J. & Rücker, B. (2012). Real-Life BPMN: Using BPMN 2.0 to Analyze, Improve, and Automate Processes in Your Company. Camunda.
5. Gartner (n.d.). Business Process Management (BPM) [available at: https://www.gartner.com/en/information-technology/glossary/business-process-management-bpm, access December 28, 2023]
6. IEEE (2012). Process Mining Manifesto. IEEE Task Force on Process Mining [available at: https://www.tf-pm.org/upload/1580737631545.pdf, access December 28, 2023]
7. Lucidchart (n.d.). What is Business Process Modeling Notation [available at: https://www.lucidchart.com/pages/bpmn, access December 28, 2023]
8. OMG (2006). Business Process Modeling Notation Specification. Object Management Group.
9. Reil, T., Groher, E. & Siegfried, P. (2021). Process Mining in Supply Chain Management. Supply Chain Management Journal, 12(2), pp. 1-13.
10. Swenson, K. D. & von Rosing, M. (2015). Phase 4: What Is Business Process Management?. In von Rosing, M., Scheer, A.-W., von Scheel, H. (Eds.). The complete business process handbook. Waltham: Morgan Kaufmann, pp. 79-88.
11. van der Aalst, W. (2018). Foreword: Process Mining Book. Fluxicon [available at: https://fluxicon.com/book/read/foreword/, access December 28, 2023]
12. von Rosing, M., Scheer, A.-W. & von Scheel, H. (2015). The BPM Way of Modeling. In von Rosing, M., Scheer, A.-W. and von Scheel, H. (Eds.). The complete business process handbook. Waltham: Morgan Kaufmann, pp. 431-457.

13. Von Scheel, H., von Rosing, M., Fonesca, M., Hove, M. & Foldager, U. (2015). Phase 1: Process Concept Evolution. In von Rosing, M., Scheer, A.-W. and von Scheel, H. (Eds.). The complete business process handbook. Waltham: Morgan Kaufmann, pp. 1-9.