

# **DATA ANALYSIS IN THE INDUSTRY 4.0 ERA: INVESTIGATING THE O2C PROCESS AND ORGANIZATIONAL PERFORMANCE WITH SAP SIGNAVIO**

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**Abstract:** The digital transformation characteristic of the Industry 4.0 era has brought to the fore the need for a deep understanding of operational processes, especially in companies that depend on integrated production and sales flows. In this context, operational data analysis becomes an essential tool for informing managerial decisions and optimizing organizational performance. This paper investigates how SAP Signavio Process Intelligence technology can be used to analyze and visualize the Order-to-Cash (O2C) process, providing a granular view of actual activity sequences, deviations from the standard path, logistical bottlenecks, and the impact of these phenomena on financial and operational performance. Based on a set of operational data extracted from an ERP system and analyzed using process mining techniques, the study highlights the relationships between process behavior, execution quality, and operational efficiency. The results demonstrate that integrating process intelligence into the Industry 4.0 ecosystem not only increases end-to-end visibility into processes, but also supports the development of advanced monitoring and continuous improvement mechanisms. The paper argues the importance of adopting intelligent tools such as SAP Signavio in assessing organizational performance and configuring robust, flexible O2C processes adapted to the requirements of the contemporary digital environment.

**JEL classification:** M21, M31, M15, C61, M41, P41

**Key words:** Industry 4.0, ERP, SAP, Digital accounting skills, Data-driven management decisions, Digital transformation, Economic process analysis, Operational efficiency

## 1. INTRODUCTION

The accelerated digitization of economic and operational processes is one of the fundamental directions of organizational transformation in the Industry 4.0 era. In this new technological ecosystem, companies are challenged to rethink their internal flows, integrate smart technologies, and develop advanced data analysis mechanisms that enable a deeper understanding of actual process performance. Unlike traditional approaches based on retrospective reporting and synthetic indicators, the Industry 4.0 paradigm emphasizes end-to-end visibility, automation, connectivity, and near real-time decision-making.

In this context, the Order-to-Cash (O2C) process takes on central importance, as it is one of the most critical cross-functional processes within companies. It connects commercial activities with logistics operations and financial reporting, directly influencing customer experience, revenue levels, and cash flows. That is why analyzing how the O2C process is executed in practice becomes essential for optimizing organizational performance, especially in the small and medium-sized enterprise (SME) sector, where resources are limited and operational variations are frequent.

Process intelligence and process mining technologies, such as SAP Signavio, provide an advanced methodological framework for investigating real processes based on data extracted directly from ERP systems. These tools enable the automatic reconstruction of activity flows, the identification of deviations, the detection of bottlenecks, the comparison of operational scenarios, and the quantification of the impact on performance indicators. By combining these functionalities with Industry 4.0 principles—connectivity,

transparency, autonomy, and digital integration—organizations can transform the way they govern their economic processes.

This paper aims to investigate the O2C process using SAP Signavio Process Intelligence and highlight how operational data analysis contributes to a clearer understanding of organizational performance. The study focuses on a set of real data extracted from an ERP system and aims to reveal dominant paths, deviations from the standard process, weak links in the flow, and their implications for operational and financial management. Through this approach, the paper contributes to the literature on digital transformation, demonstrating the essential role of process mining technologies in the evolution of performance management systems in the Industry 4.0 era.

## 2. LITERATURE REVIEW

In the era of Industry 4.0, the existence of advanced digital technologies and tools in production processes allows for their continuous monitoring, responding dynamically to changes that can influence production at any stage (Monti et al., 2024). Along with the technological advances of I4.0, management science has also evolved, and business processes have become complex, relying more on computer systems and mathematical models to analyze and improve a process. (Ackoff, 1956) states that operational analysis is not just a set of techniques, but has become a scientific discipline. This has led to computer systems controlling the execution of business processes, resulting in the emergence of SAP-ERP systems, founded in 1979, which have become the world leader in commercial activity management software.

The ability to respond to changes in the external environment depends on how companies manage and analyze data obtained from business processes (Bicocchi et al., 2019). In order to survive and innovate in a highly competitive business environment, companies seek to optimize their business processes using information extracted from operational processes (Janvrin et. al., 2017). The Order to Cash (O2C) process within the SAP system is a critical flow in terms of the business process because it integrates several departments into a single database, being the most visible process for customers, so its management and improvement is very important (Kääriä & Shamsuzzoha, 2023).

The operational data generated during the O2C process lifecycle can provide valuable information about the organization's efficiency. This data may include transactional information such as sales orders, deliveries, invoicing, payment collection, or time-related information such as order cycle time, delivery time (Taipaleenmäki & Ikäheimo, 2013). Operational data generated by IT systems following the execution of processes is leveraged using advanced analytics by transforming raw data into organizational knowledge (Kagermann & Wahlster, 2022).

Many organizations face challenges in leveraging large volumes of data and converting them into relevant information for strategic decision-making (Chen et al., 2012). Process Mining (PM) - data mining is currently the most widely used and effective method for extracting information from operational business process data. It collects information about the process model during actual execution based on the event log recorded in an information system. PM combines techniques based on machine learning (ML) and business process management (BPM) to improve a company's business

processes. Recent studies by (Shen et al., 2024) have shown that advanced analysis of operational data contributes to cost reduction and process efficiency improvement.

(van der Aalst & Weijters, 2004) defines PM as a set of techniques that aims to analyze a process based on information extracted from the event log rather than on a theoretical model. From this perspective, there are three types of extraction processes, including: process discovery - taking data from an event log and producing a process model; compliance verification - comparing an existing process model with the event log of the same process; improving existing processes based on data - providing an objective view of actual execution versus the theoretical model (Posada et. el., 2015). Such an approach is necessary for a complex process such as O2C, characterized by multiple interactions between sales, logistics, finance, and customers, emphasizing the need for advanced operational data analysis tools.

Process models reflect how organizations operate, but in reality, execution differs. Manual data entry, temporary solutions, and system variations can affect their efficiency and compliance. Most corporate IT systems use clearly defined process models, and workflow is standardized according to an explicit process model.

PM bridges the gap between static, manually designed models such as traditional BPM and modern BPM techniques based on real data generated by IT systems. (van der Aalst, 2016) explains that techniques based on predefined process models do not capture operational bottlenecks or unofficial routes derived from actual execution data, while data-based models analyze transactions and events without knowing the logical flow of activities or process rules (Ghasemi et al., 2011). Thus, PM addresses these limitations by efficiently using event data to improve the end-to-end process (Zhong et. al., 2017).

### **3. METHODOLOGY AND DATASET – PERSPECTIVES**

The methodology used in this study is based on the integration of two complementary approaches: the analysis of economic processes using process mining techniques and the investigation of operational performance in the context of Industry 4.0-specific digital transformation. Within this methodological framework, the central analysis tool is SAP Signavio Process Intelligence, a platform that allows the extraction, modeling, and interpretation of the actual behavior of the Order-to-Cash (O2C) process based on data actually recorded in the ERP system. The analysis process was structured in four main stages. In the first stage, transactional data was selected and extracted from an SAP ERP ECC system, targeting documents relevant to the O2C flow: sales orders, deliveries, stock movements, invoices, and payments.

This stage involved identifying the source tables, verifying data integrity, and transforming them into a format compatible with SAP Signavio requirements, where each case represents a complete document flow associated with a sales order, and each event reflects a distinct operational action. In the second stage, the dataset was loaded into SAP Signavio and subjected to the event log transformation process. In total, the analysis was based on 3,316 cases and 29,732 events, covering the entire operational chain from order registration to debt collection. This volume allows for a robust assessment of dominant paths, as well as the identification of deviations and exceptions that affect process performance. The third stage consisted of applying the process discovery technique, through which SAP Signavio automatically generated a visual model of the O2C process,



(Figure no. 1) shows the Order-to-Cash process map generated by SAP Signavio, using the Event count criterion to highlight the intensity of activities and routes. According to the visualization, the process begins with an initialization activity ("Start"), followed by the dominant flow that quickly leads to Delivery and Goods Movement, the two activities with the highest operational volumes, recording 4,809 and 4,548 events, respectively. This suggests that the analyzed organization is in an environment where logistics activity is at the core of operations, characteristic of manufacturing or high-volume sales companies. Another focal point of the process is the Invoice activity, which accumulates 3,640 events, confirming the robust flow between logistics and invoicing. The main route highlighted by the thick blue line indicates that most cases follow the classic sequence of Delivery-Goods movement-Invoice-Clearing, reflecting good operational discipline in the standard process. The visualization also highlights the existence of secondary branches

For example, there are 449 cases that follow a parallel path to Clearing, suggesting the existence of peculiarities in financial behavior, possibly related to accounting adjustments or alternative cash flows. At the same time, exception activities such as Returns, Credit memo request, and Debit memo, although marginal in terms of volume, influence the variability of the process and can cause delays or additional costs if not monitored. The Activities 100% and Paths 99% indicators show that the visualization captures almost the entire complexity of the process, including rare variations and low-probability paths. This level of granularity is essential in Industry 4.0 analysis, as it allows the identification of counterintuitive operational patterns, the detection of causes that generate bottlenecks, and the substantiation of optimization measures. Therefore, the results obtained confirm both the stability of the O2C flow in its basic structure and the existence of operational deviations that may constitute opportunities for improvement. The analysis of these deviations, in conjunction with performance indicators such as cycle time, cost-to-serve, or cash conversion, can significantly contribute to the optimization of the financial and logistics function in the context of Industry 4.0.

## 5. CONCLUSIONS

The visual analysis of the Order-to-Cash (O2C) process performed with SAP Signavio, using the Event count criterion and including 100% of activities, reveals a number of key insights into how the organization executes its operational processes in the context of Industry 4.0. First, the dominant flow identified between Delivery, Goods Movement, and Invoice demonstrates that process performance is strongly influenced by the logistics area. The high volumes associated with deliveries (4.8k events) confirm the central role of distribution activities in the organization's operating model, but also highlight the dependence of the entire process on the synchronization between logistics and financial operations. Secondly, the analysis of secondary routes and low-frequency events - such as Credit Memo Request, Returns Deliveries, or Debit Memo—shows that the organization faces a number of operational exceptions which, although marginal in percentage terms, can have a significant impact on costs, process times, and customer satisfaction.

The presence of these activities indicates the need for stricter process governance and control mechanisms to prevent deviations and standardize flows. Thirdly, the high number of billing-related events (3.6k) and the presence of significant volumes in clearing

activity suggest a direct correlation between the efficiency of logistics processes and the financial health of the organization. Specifically, differences between the number of invoices and the number of clearing entries signal delays in debt collection or incomplete processes that require additional monitoring. In the context of Industry 4.0, this relationship highlights the need to integrate financial and operational processes and adopt digital mechanisms that enable end-to-end visibility and rapid response to performance variations. Finally, the image confirms that process mining is not only an organizational diagnostic tool, but also an essential resource for continuous optimization, for informing managerial decisions, and for developing the digital skills of professionals. SAP Signavio allows the decoding of the actual behavior of the O2C process, the identification of bottlenecks, the comparison of routes, and the quantification of operational impact, thus providing robust support in evaluating efficiency and planning improvement interventions.

Thus, the overall conclusion of the study emphasizes that, in the Industry 4.0 era, organizational performance can no longer be assessed solely by traditional financial indicators. It must be analyzed through the lens of economic process behavior, and process intelligence tools such as SAP Signavio become indispensable for understanding, optimizing, and governing operational flows. The integration of these technologies contributes to increased transparency, strengthened process discipline, and the development of a data-driven and continuous improvement organizational culture.

Analyzing the Order-to-Cash (O2C) process through SAP Signavio, using the Event count criterion and visualizing the entire spectrum of activities (100%) and routes (99%), provides management with an accurate picture of how the organization actually conducts its operations, beyond official procedures. The data highlights that the segments with the highest operational intensity - particularly Delivery (4.8k events), Goods Movement, and Invoice - are critical areas for overall process performance. From a management perspective, these activities are "leverage points" where investments in optimization can generate the greatest gains in terms of speed, accuracy, and costs. The high frequency of invoicing events compared to the number of flows completed in Clearing indicates gaps in the rapid conversion of sales into cash.

This suggests the need for stronger management mechanisms to coordinate between operational, logistics, and financial departments. An efficient O2C does not depend only on the correct delivery of goods, but also on the immediate synchronization between delivery, invoicing, and collection, and the variations identified by Signavio signal strategic opportunities to reduce the cash conversion cycle. Also, secondary routes - such as Credit Memo Request, Returns Delivery, Debit Memo - although present in small volumes, are important indicators for management regarding potential areas of operational risk or recurring customer dissatisfaction.

Identifying these deviations allows for the formulation of proactive policies to reduce returns, clarify commercial policies, or improve after-sales services. Another essential element for management is the end-to-end transparency generated by process analysis. A clear view of actual flows allows for the identification of bottlenecks, the detection of non-compliant routes, and the accurate assessment of the efficiency of each operational segment.

This transparency provides a solid basis for setting strategic priorities, scaling resources, and implementing optimization initiatives focused on financial impact. In the

context of Industry 4.0, the key conclusion is that organizational efficiency depends directly on management's ability to use modern process intelligence tools. SAP Signavio thus becomes not just an analytical tool, but a strategic facilitator, capable of transforming operational data into insights relevant for quick, well-founded, and performance-oriented decisions. Management has the opportunity to move from a reactive approach based on delayed reports to a proactive approach based on continuous monitoring and optimization of processes. Essentially, analysis interpreted from a managerial perspective confirms that organizations that integrate intelligent tools such as SAP Signavio into process governance increase their resilience, reduce operational uncertainties, and strengthen their competitive advantage in an environment where speed, transparency, and accuracy are crucial.

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