

# Digital Transformation in Support of LPG Supply Chain Management

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**Abstract.** Digital transformation (DT) arises as a response to the challenges of the external, competitive, and unpredictable environment in which companies operate. This transformation allows to improve strategic capacity, customer experience, simplifying existing operational models and creating more efficient models. For this reason, within the energy sector, organizations have been increasingly seeking this transition where they reformulate their methods digitally, with the aim of facilitating and improving traditional processes. The main purpose of this paper is to verify digital transformation as an efficient response to the management of the LPG supply chain. In this sense, the objectives include understanding the impacts of this transformation as a gas supply chain management tool and how it helps the companies to face current challenges and improve their position in the market. From an economic point of view, the importance of DT is essentially due to two reasons: financial efficiency and market expansion. Distribution automation reduces operational costs, increasing the company's profitability. At the same time, the possibility of opening new points of sale creates opportunities to increase revenue. This drives resource optimization and waste reduction. Automation is expected to provide more efficient management of the necessary energy resources. Furthermore, offering a more precise and controlled distribution, it contributes to reducing energy waste associated with traditional logistics.

**Keywords:** Digital transformation, Oil and Gas Industry, Supply chain management, Industry 4.0.

## 1 Introduction

Digital transformation (DT) is the process by which an organization responds to today's challenges through the power of digital technologies [1]. Companies take a digital approach to improve and simplify their traditional processes. This transformation makes it possible to improve strategic capability, customer experience, simplify existing operating models and create more efficient models.

Through this transition, companies change several procedures, from the conversion of documents in physical format to digital, the optimization of processes with the help of software, the expansion of networks, to the adoption of the software-as-a-service model and the emergence of the digital economy. Today, organizations are looking to digitize their end-to-end operations, from sales and customer service to supply chain management, to adapt to market changes [2].

In the Oil & Gas industry, the global market has a major influence on local supply chain management practices, as the sector is highly dependent on market access. Today, companies that use cutting-edge technologies to restructure business processes and extract actionable insights from the available dataset stand out within the industry. This is because digitalization plays a crucial role in reducing the gap between exploration, transportation, and refining processes in the Oil & Gas industry by leveraging real-time historical data analytics [3], [4].

This paper aims to fill the gap in the literature of the lack of approaches on the impact of digital transformation from the point of view of supply chain management in the Oil & Gas Industry. It is intended to understand the impacts of digital transformation on gas supply chain management as well as to understand how this transformation helps the companies to face the current challenges and improve their position in the gas market.

## **2 Methodology**

This study is based on extensive bibliographic research on the subject, with the purpose of identifying the essential concepts for its realization. The search for sources included the analysis of dissertations, the consultation of websites, books and scientific articles and internal documents that deal with the topic to be addressed and other pertinent subjects. The last subtopic concern about case studies of successful implementation of digital technologies in the Oil and Gas Industry.

The research was divided into different topics, from more general to more specific ones, concerning the research objective of this work. In this sense, the research, based on Google Scholar base, and Scopus base, focused on: (i) Supply Chain Management (using the complete expression for the search); (ii) Supply Chain Digital Transformation (using the terms “Supply Chain” AND “Digital Transformation”); (iii) Supply Chain Management in the Oil & Gas Industry (using “Supply Chain Management” AND “Oil” OR “Supply Chain Management” AND “Gas”); (iv) Digital Transformation of the Supply Chain in the Oil & Gas Industry (using “Digital Transformation” AND “Supply Chain” AND “Oil” OR, “Digital Transformation”

AND “Supply Chain” AND “Gas”); (v) Digital Transformation Strategy (using the complete expression for the search); (vi) Obstacles to Digital Transformation (using “Obstacles” AND “Digital Transformation”); (vii) Economic and financial impact (using “Economic impact” OR “Financial impact” AND “Digitalization” OR “Digital Transformation”).

It was used a Scoping Review, mapping the key concepts underpinning the research area and the main sources and types of evidence available, allowing to clarify working definitions and conceptual boundaries of the topic. The inclusion criteria was linked to studies that must directly address the research question or topic of interest.

### **3 Supply Chain Management**

The term "supply chain" (SC) is defined as the group of companies involved in making a particular product or service available on the market. In other words, it encompasses all the parts necessary, directly, or indirectly, for a customer's request to be fulfilled [5]. It is the network of organizations involved, through upstream and downstream connections, in the different processes and activities that add value in the form of products and services. In the consumer goods market, any product, as it progresses from raw materials to finished product, goes through a series of consecutive transactions within the market [6]. Vorst [7] describes this chain as a sequence of processes and flows that aim to meet the requirements, demands, and needs of consumers. This covers manufacturers, suppliers, carriers, warehouses, retailers, other intermediaries and even the end customers themselves are considered in some definitions.

Supply chain management (SCM) is the organization and collaboration between these companies and, consequently, the activities practiced between them. It encompasses the planning and management of all practices related to procurement, procurement, conversion, and logistics, including demand forecasting, material ordering, order processing, order fulfillment, transportation services, invoicing, and payment processing [8]. SCM's main objective is to acquire the right products or services, at the agreed place and time, and according to the desired conditions, to optimize costs and maximize return on investment.

### **3 Supply Chain Digital Transformation**

DT is an incremental and disruptive process of change that allows us to create value using digital technologies [9]. For this, it is a process of change, but, mainly, of

improvement through the technological means available, in relation to the platforms used in organizations, their processes and in business activity, with the aim of increasing efficiency and adding value. In other words, it is the process by which the company reformulates its methods digitally, to facilitate and improve traditional ones. This transformation makes it possible to improve strategic capability, customer experience, simplify existing operating models and create more efficient models [10].

Globalization and the need to respond to market demands are two major reasons why digitalization is a priority for organizations. This has emerged as an important phenomenon in the field of management. Today, organizations are looking to digitize their end-to-end operations, from sales and customer service to SCM [2].

Another driving force for the adoption of these technologies is the need to address internal problems and improve organizational performance. Digital technologies offer ways to reduce costs and improve efficiency in a variety of aspects, including procurement, production, warehousing, and logistics [11].

Within the scope of SCM, this transformation arises as a response to the limitations of traditional and inefficient management methods, allowing the implementation of faster and more accurate management methods. This transition adds value by driving greater efficiency of supply SCM, revolutionizing the way companies approach the flow of products and information along the chain [12].

Essential areas of SCM that involve the use of digital technologies include [13]:

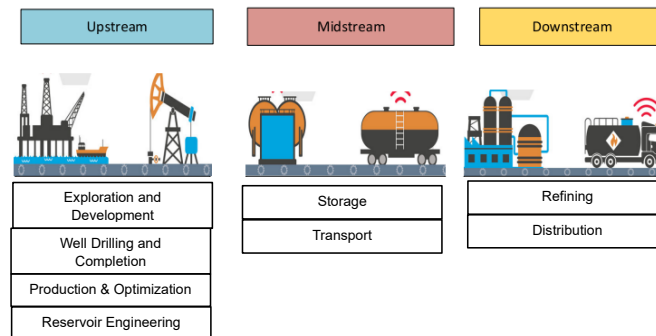
- Digital planning, to plan and predict demand, manage stock and optimize production schedules;
- Digital procurement, to manage relationships with suppliers, automate purchase orders, and track deliveries;
- Digital production, to optimize manufacturing processes, improve quality control and reduce waste;
- Digital logistics, to optimize transport and distribution operations and manage warehouse stock;
- Digital customer service, to improve customer satisfaction, provide real-time support and improve your customer experience.

## 4 Supply Chain Management in the Oil & Gas Industry

Most industries have been investing in DT driven by innovation and technology that increase exponentially. To keep up with this change, the Oil & Gas (O&G) industry adapts its strategies and the way it manages its business, through the adoption of new technologies and digitalization [14]. Technological progress makes it possible to store, transmit and process large amounts of data, considerably increasing the various possibilities of application of digital technologies within industry. In this way, the gradual integration of these contributes to the development of the sector, giving rise to Industry 4.0 [15].

The fourth industrial revolution refers to the intelligent interconnection of machines and processes with the aim of promoting industrial change, characterizing the era of «intelligence» [16]. The strategic framework of Industry 4.0 covers four main themes: smart factory, smart manufacturing, smart logistics and smart services [17]. Figure 1 illustrates the SC of the O&G industry, which is characterized by the division into three stages: upstream, midstream, and downstream [18]. Upstream involves activities, such as exploration and production with the help of acquiring the rights to land for excavation and finding reserves. Midstream encompasses the transportation and storage of raw products, and finally, downstream focuses on refining and distribution.

The management of this SC is quite complex as it deals with different geographical locations to manage demand and supply, transportation, inventory, and distribution in a highly competitive environment [19]. The need for a robust integration system is due to the existence of a complex structure composed of several organizations, suppliers, stakeholders, and customers. In Industry, SCM includes practices such as sourcing, supplier relationship management, raw material procurement, production planning, scheduling, warehousing, and stock management, ordering techniques, distribution management, transportation supply and logistics [19].



**Fig. 1.** Oil & Gas Supply Chain [20]

## 5 Digital Transformation of the Supply Chain in the Oil & Gas Industry

Lu et al. [15] introduced the "Oil and Gas 4.0" concept, which consists of the use of advanced digital technology to achieve greater value in the industry. In this context, the following scenarios are highlighted in stages.

### 5.1. Upstream

Oil and gas exploration relies heavily on seismic exploration, which uses seismic waves to analyze subsurface properties and locate underground resources. Seismic exploration involves the acquisition, processing, and interpretation of seismic data, exhibiting characteristics of big data due to the diversity and volume of data involved. To improve the quality and safety of seismic data collection, wireless technology is applied as an alternative to traditional cables. Wireless sensors are lighter and easier to carry, and technologies such as UWB (Ultra-Wideband) and IoT are exploited to ensure high data rate, self-locating accuracy, and low power consumption.

The concept of "smart oilfield" refers to an advanced approach that integrates coordinated development, mining, production, decision-making, and information technology in oil and gas fields. The implementation of this field involves collaboration across multiple layers, including service, application, platform, resources, broadcast, and perception. Differentiating itself from the digital oilfield, the smart field not only

automates repetitive tasks, but also involves analysis and decision-making, representing a process of knowledge creation.

## **5.2. Midstream**

The rapid advancement of information technology has led to the evolution of oil and gas pipelines to the stage of "digital pipelines". The digital pipeline focuses on communication and remote sensing technologies, while the smart pipeline integrates IoT, cloud computing, big data analytics, automation, and intelligent control. The latter is an observable, controllable and adaptable system, based on the life cycle data of the pipelines and the surrounding environment.

The digital twin of pumps and compressors allows early detection of signs of failure, enabling preventive maintenance measures and cost savings. This technology also extends to other production facilities, where detailed digital twins, combined with sensors, enable real-time monitoring of asset health.

Augmented reality and wearable devices are used in maintenance and operation testing. These solutions break down complex tasks into steps, increasing operational reliability and reducing risks during the maintenance of oil and gas equipment. This technology offers significant benefits such as advanced diagnostics, efficient maintenance, and simplified training.

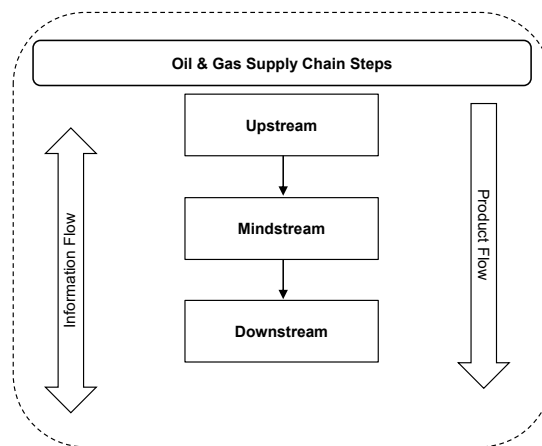
## **5.3. Downstream**

The "Smart Refinery" incorporates technologies such as IoT, big data and equipment monitoring to improve the management of information and services in the digital refinery. This approach encompasses key areas including production control, equipment management, supply chain, energy, safety, environment and health, and ancillary decision-making.

In the global oil and gas trade, blockchain technology represents a potential tool for improving transparency and efficiency across the chain. By tracking products and equipment throughout their lifecycle, it provides improved visibility, reducing logistics costs, increasing operational efficiency, and providing greater safety and reliability in SC.

#### 5.4. SCM

The dependence of major industries on O&G products makes it necessary for flows within the chain to be coordinated effectively and efficiently. SCM must be optimized, responsive, flexible, fully integrated, and with highly secure platforms, with end-to-end visibility to avoid obstacles to the flow of products and information to meet demand and supply needs, depicted in Figure 2. Digital technology is a tool that enables the O&G Industry to manage SC operations more effectively using properties such as transparency, security, cybersecurity, real-time information sharing, reliability, traceability, and visibility.



**Fig. 2.** Oil and gas supply chain steps [19]

The industry employs software systems to manage CS. However, most solutions focus on SCM management or enterprise resource planning, not integration. To develop a real-time, end-to-end digital ecosystem, companies need to be able to achieve enhanced integration between software platforms [21].

The use of emerging technologies is limited, and, for this reason, SMC is less developed, characterized by difficult decision-making and, sometimes, in a scenario of uncertainties [19].



## 6 Digital Transformation Strategy

Defining a set of guidelines that support the digital transition is crucial. They help companies achieve their immediate goals, assess digital progress and, above all, define a system for transforming the core of operations, real assets, and the business model itself. Mittal et al. [22] consider three key questions when implementing a new digitalization project: "How digital are you today?"; "How digital should you become?"; "How do you become more digital?".

Digital maturity is an adaptation of the organization to compete effectively in an increasingly digital environment, through the implementation of new technologies, aligning the company's strategy, workforce, culture, technology, and structure to meet the digital expectations of customers, employees, and partners. It is a long, continuous process of constant adaptation. However, it increases the likelihood that an organization will survive and thrive in the digital age, due to the context of rapid and unpredictable change [23].

Companies are not at the same level of digital maturity. While some are taking the first steps in this transformation process, others have already reached a significantly higher level of maturity [24]. One of the biggest challenges in increasing an organization's degree of digital maturity is creating an effective strategy and linking it to the overall business objectives [22].

In the World Economic Forum [25] a strategic foundation to help the O&G industry keep pace with this transformation was built:

- Make digitalization a priority for the business. It is necessary to establish a clear vision, allocate funding and resources, and actively support the associated change management effort. The overall corporate strategy must ensure that digital is fully integrated into the company's core business model;
- Promote a culture of innovation and technology adoption. Regardless of each company's approach, it is critical to have clear responsibilities to deliver on the digital agenda. Enhancing the company's capabilities by establishing more fluid and multidisciplinary teams is crucial and undoes the rigid hierarchical structure;
- Invest in human capital and development programs that promote 'new digital thinking'. A company can better understand its needs and skills gaps by assessing current capital capabilities and creating a strategic digital workforce plan.

- Outlining a plan to upskill talent, such as deciding between upskilling existing staff or hiring externally, can address deficiencies in the digital experience;
- Develop digital capabilities. Assessing the investment required to digitize the company's core activities and/or capabilities is crucial. Developing a multiannual budget helps to balance the economic and financial benefits. To capitalize on the opportunities presented by digitalization, companies can develop in-house digital capabilities, form partnerships through corporate investment, create innovation hubs, accelerators, or incubators, or acquire companies with existing digital capabilities;
  - Redesign the company's data architecture: Optimize the use of data platforms. These are at the heart of DT, the harmonization, integration and interoperability of data platforms are crucial to support effective decision-making;
  - Invest in the collaborative ecosystem. Ever-changing consumer preferences, shaped by the sharing economy, present potential risks. To circumvent these risks, industry players can develop collaborative partnerships and invest in sharing economy platforms. Partnering with peers and competitors to innovate, build digital capabilities, and leverage new business models are essential activities.

In addition, they highlighted the role of the following practices in changing knowledge management in the industry: commitment to learning, shared vision, open-mindedness, and intra-organizational knowledge sharing [26].

## **7 Obstacles to Digital Transformation**

The main obstacle to successful DT is organizational deficiencies, especially in change management and technology adoption. Pandey & Branson [27] believe that these challenges fall into four areas: 1) business priorities; 2) fundamental capabilities; 3) digital operating model; 4) agile culture.

The first obstacle relates to the inability to identify digital responses that are appropriate to business priorities. The authors point out two reasons why companies do not define DT as a priority. First, the lack of understanding of the needs and requirements of the customer that need to be addressed to effect the transformation in the business. Second, the uncertainty about the financial returns from digital investments, provoking a more receptive opinion. The second focuses on the insufficiency of fundamental capacities, especially those needed for the development and deployment of digital tools and processes. The shortage of digital talent and skills is identified as a primary obstacle to digitalization. Next, the outdated processes and organizational structures are indicated, in addition to the absence of a digital operating model. Organizational dysfunction

related to a lack of leadership is considered among the most significant obstacles to digitalization. DT is hampered by organizational silos, the absence of cross-functional operating models, disconnected project governance, and outdated management rules and structures. Finally, the lack of an "agile" culture that promotes collaboration, knowledge sharing and the adoption of new ways of working is pointed out. The authors identified insufficient collaboration, a low tolerance for failure in trials of new technologies and applications, limited employee involvement, and inadequate knowledge sharing as key obstacles to digitalization.

## **8 Economic and financial impact**

One of DT's main objectives is to make processes and production 'smarter' to achieve economic and financial benefits [28]. While improving organizational processes indirectly contributes to better economic and financial performance, digitalization is mainly driven by the pursuit of profits, adding value to the company by driving innovation and growth. In this context, inherent to DT are benefits such as increased productivity, increased revenues, cost reduction, among others [29], [30].

Guo & Xu [31] proposed the hypothesis: "There is a U-shaped relationship between DT and firm financial performance." Initially, the company's financial performance decreases only up to a certain value, and after that, a higher intensity of DT corresponds to an increase in financial performance. This relationship is explained by the occurrence of certain costs associated with the first stages of the investment, namely operational and integration costs [30]. This cost comes mainly from the need to remove organizational inertia. Companies need to ensure coordination between existing and new digital resources and capacities; adapt their organizational culture; harmonize relationships with new business partners that result from changes in roles along industrial chains [32].

However, it makes it possible to obtain rapid responses to changes in production and failures along the chain; higher quality; personalization of products; reduction of waste and a better use of resources; self-control of the elements of production; flexibility of production processes; productive control of the worker; increased productivity; improved processes; advanced control of real-time data; optimization of logistics processes. These benefits associated with products and processes, enable improvements in productivity and operational, production and resource efficiency, leading to a reduction in product unit costs, total costs and errors on the "Shop Floor". In turn, the launch of 'smart' products and services and new digital business models leads to increased revenues. Overall, digitalization is expected to contribute to the improvement

of profit margins and, consequently, to improve the economic and financial performance of companies [29], [33].

Although not immediate, DT makes great contributions to the growth of companies and operations. After investment in the digital transition, integration costs rise sharply, leading to a significant increase in expenses. However, in the long run, the marginal benefits outweigh these costs, instead driving an increase in revenues. In this way, comparing revenues to the costs incurred to automate or digitize the IR4.0 manufacturing process, revenue increases more and faster than costs [32], [33].

Companies with higher digital maturity tend to outperform financially, due to their greater propensity to value innovation and growth as benefits of their digital investments. Therefore, DT is positively correlating with financial success, positioning companies to thrive in the marketplace [34].

## **9 Case Studies of Successful Implementation of Digital Technologies in the Oil and Gas Industry**

The adoption of digital technologies in the oil and gas industry has led to significant improvements in operational efficiency, cost reduction, and enhanced decision-making capabilities. A prime example of this transformation is seen in the Bien Dong Petroleum Operating Company (Bien Dong POC). By deploying a centralized integrated digital system, Bien Dong POC has substantially enhanced its monitoring and decision-making processes across various offshore platforms. This system facilitates real-time data analytics and predictive maintenance, reducing downtime and operational costs. These advancements have enabled Bien Dong POC to improve safety, efficiency, and overall productivity significantly [35].

Equinor, formerly known as Statoil, provides another exemplary case of digital transformation in the industry. Through their Oseberg Vestflanken 2 project, Equinor has utilized digital twins, advanced analytics, and IoT technologies to optimize operations. This initiative has led to better reservoir management and production optimization, illustrating the immense value of digital tools in enhancing operational efficiency and reducing environmental impact. Equinor's strategy emphasizes the integration of digital innovation, transforming traditional operations, and fostering collaboration to achieve sustainable growth [36].

Additionally, Shell has made significant strides in digital transformation by integrating advanced analytics and automation to enhance business performance. Shell's digital initiatives focus on amalgamating data from various sources to enable data-driven

decision-making and operational excellence. By transforming their IT service environment into a lean and agile platform, Shell has achieved notable improvements in worker productivity and innovation. This transformation underscores the benefits of digital technology in driving substantial operational improvements in the oil and gas sector [37].

These case studies highlight the transformative potential of digital technologies in the oil and gas industry. They provide practical insights into how companies can leverage digital tools to achieve operational excellence, sustainability, and cost-efficiency. As the industry continues to evolve, these examples will be crucial in guiding future digital transformation initiatives.

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