

Data-Driven Digital Transformation in Pharmaceutical Supply Chain

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This executive brief discusses how manufacturing and supply chain processes create valuable data and the importance of leveraging this data through digital transformation initiatives. It addresses the shift to value-based pricing and its impact on traditional business processes.

Abstract:

The pharmaceutical supply chain has been undergoing significant transformations and has been driven by data-driven technologies and digitalization. Many digital enablers are driving the pharmaceutical supply chain, and they also extend their impact to value-based pricing in the pharma industry. This paper aims to explore how the manufacturing and supply chain processes generate valuable data. It also explores the importance of leveraging this data through digital transformation initiatives. The study also highlights the role of artificial intelligence, advanced analytics and blockchain technologies in optimizing the efficiency of supply chains and in ensuring regulatory compliance. Also, it examines the shift to value-based pricing and its impact on traditional business processes.

Keywords: Pharmaceutical supply chain, data analytics, artificial intelligence, digital transformation, big data, regulatory compliance.

INTRODUCTION:

Digital transformation has been reshaping the pharmaceutical industry, especially in the domain of the supply chain. This is where predictive analysis, real-time data, and automation play a significant role (Kumar et al., 2020). Pharmaceutical companies are indeed compelled to adopt digital solutions with increasing complexities in regulatory requirements. This is also propelled by the rising costs and the shift towards personalized medicine, order to maintain their competitive advantage (Chopra & Meindl, 2021).

The pharmaceutical supply chain involves the production, storage, and distribution of drugs so that high-quality products can get into the hands of patients in good time (Friedli et al., 2013). Traditional supply chains are not capable of handling disruptions, counterfeit drugs, and loss of visibility. (Papadopoulos et al., 2017). The integration of digital technologies will address these challenges by enabling data driven decision making. (Monostori et al., 2016). In this paper, we discuss how data-driven transformations can optimize supply chain processes, improve regulatory compliance, and contribute to value-based pricing models. We present how artificial intelligence, blockchain, and big data analytics, as essential technologies, impact both supply chain resilience and security.

ROLE PLAYED BY DATA IN THE PHARMACEUTICAL SUPPLY CHAIN:

Large pharmaceutical companies are now focusing on the development of the entire supply chain and on achieving sustainable supply performance through effective supply chain management. They plan on achieving this by leveraging data and big data analytics.

1. Data helps improve supply chain visibility:

One of the most critical aspects of the pharmaceutical supply chain is real time visibility. This allows the companies to track their drugs right from the stage of raw material sourcing to the final distribution of the drugs (Baryannis et al., 2019). The data collected through the RFID tags, the IoT devices, and the blockchain

technologies will enable continuous monitoring of the shipments and will also mitigate the risks of spoilage, counterfeiting, and supply chain bottlenecks (Treiblmaier, 2018).

2. Data analysis helps optimize inventory management:

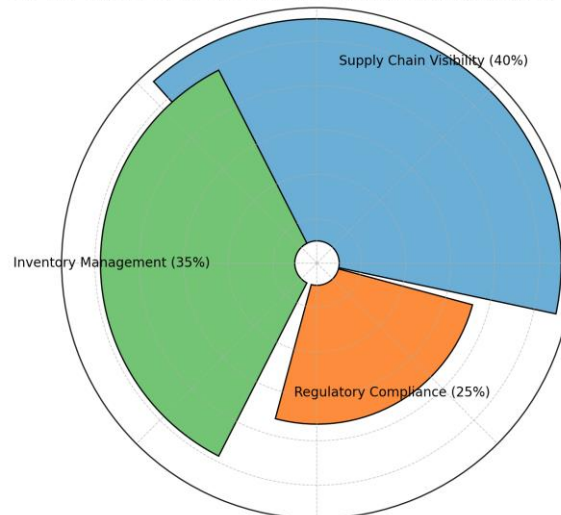
It is very difficult for the pharmaceutical companies to maintain a balance between under-stocking and overstocking. Demand analysis through data analytics involves the examination of demand patterns, production schedules, and shipment data to establish optimal inventory levels (Govindan et al., 2015). Predictive analytics help manufacturers in preparing for the demand uncertainty, thereby reducing costs arising from stockout and excess inventory (Choi et al., 2017).

3. Assuring Regulatory Compliance

Regulatory agencies like the FDA and EMA enforce strict compliance in the pharmaceutical setting (Gogtay et al., 2017). Data-driven solutions help organizations maintain compliance by ensuring the tracking of manufacturing processes, documentation of quality control measures, and automation of related reporting requirements (Ying et al., 2019). Digital records will allow transparency and easy auditing, thus minimizing the risk of regulatory contravention (McKinsey & Co., 2020).

Figure 1: Role of data in the pharmaceutical supply chain

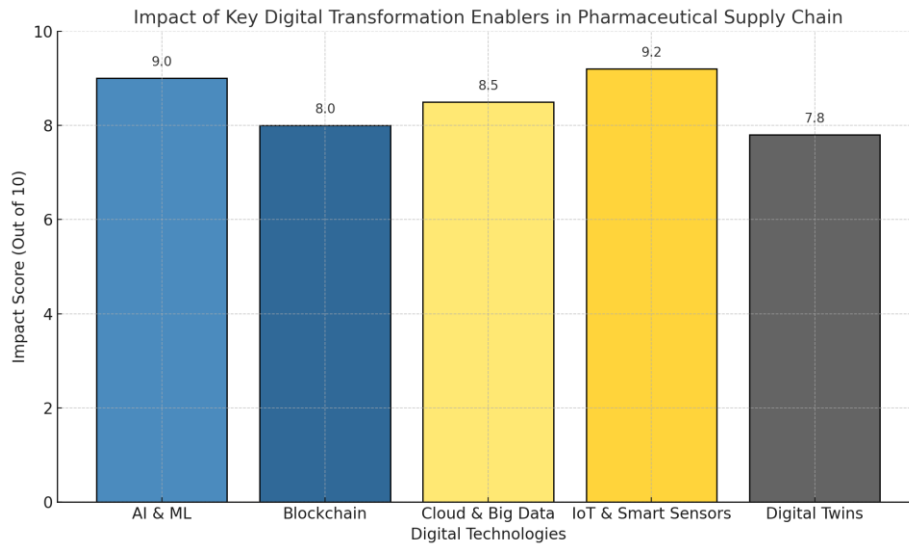
3D Pie Chart: Role of Data in Pharmaceutical Supply Chain



Key digital transformation enablers that drive transformation in pharmaceuticals:

The implementation of digital technologies in the pharmaceutical supply chain makes smart manufacturing a reality. By employing digital enablers, suppliers, manufacturers, retailers and end customers can stay connected through data and information interactions.

Figure 2: Impact of key digital transformation enablers on supply chains



1. Artificial Intelligence & Machine Learning

Demand forecasting, producing optimal production schedules, and detect anomalies in the supply chain are some applications of AI and ML algorithms (Dutta et al., 2020). Integrating historic data with real-time inputs improves the decision-making processes involving lesser human errors and increased operational efficiency of the technologies (Shukla et al., 2021).

2. Blockchain Transparency and Secured

With blockchain technology, the integrity of the pharmaceutical products is secured through an unbreakable platform for truly tracking drugs from production to the end users (Kshetri, 2018). This decentralized system denies opportunities for more clear security and fraud reduction and compliance enhancement (Hölbl et al., 2018). Smart contracts further streamline supplier agreements and thus reduce administrative burden and facilitate cooperation among those involved (Casino et al., 2019).

3. Cloud Computing and Big Data Analytics

Cloud integration permits different stakeholders to cooperate seamlessly by providing the means of collecting all data toward individual nodes in a supply chain (Hashem et al., 2015). It is possible through big data analytics to afford the organization insights into its operational inefficiencies for proactive resolution (Raghupathi & Raghupathi, 2014). Analyzing large amounts of data in real time further provides informed decision-making, hence reducing risks and optimizing workflow (Mikalef et al., 2018).

4. Internet of Things (IoT) and Smart Sensors.

IoT devices and smart sensors prove important to work on the product integrity throughout supply (Wortmann & Flüchter, 2015). Temperature-sensitive drugs, including biologics and vaccines, need strict storage conditions (Moeuf et al., 2018). Through direct real-time alerts of temperature, humidity, and other environmental factors that synchronize usage with deviations (Atzori et al., 2010). This increases quality assurance and greatly minimizes the risk of compromised products reaching patients.

5. Digital Twins for Predictive Maintenance

With Digital twin technology, creation of a virtual copy of physical resources in the supply chain assets is planned to allow companies the simulation and prediction of their operational outcomes (Tao et al., 2018). Maintenance can be timed in the nick of time to be proactive, thus decreasing downtime and failure of equipment through real-time data input in digital twins (Boschert & Rosen, 2016). This technology increases manufacturing efficiency while ensuring the seamless functioning of supply chain processes (Schleich et al., 2017).

Shift of the pharmaceutical sector towards value based pricing and its implications:

a. Adopting Value-Based Pricing Models Rather than Volume-Based Pricing Models

Pharmaceutical companies have always relied on volume-based pricing for sale revenue: the more the unit amounts sold, the more revenue earned (Kaplan & Porter, 2011). The industry is now fast advancing to value-based pricing, i.e., prices will be on account of the drug being efficacious and effective patient experienced outcomes (Neumann et al., 2018). Such a pricing strategy will refrain from selling for a month and would require pharmaceutical companies to show the real-world impact of their products (Husereau et al., 2013).

b. Measurement of Outcomes Based on Data

Measuring and tracking patient outcomes best determines the success of value-based pricing (Mestre-Ferrandiz et al., 2012). Advanced analytics and real-world evidence (RWE) platforms collect real-world evidence from electronic health records, patient monitoring systems, and clinical trials (Makady et al., 2017). Insights like those enable the justification of pricing models in the view of pharma companies and improvement in drug formulations based on real-world efficacy (Hughes-Wilson et al., 2012).

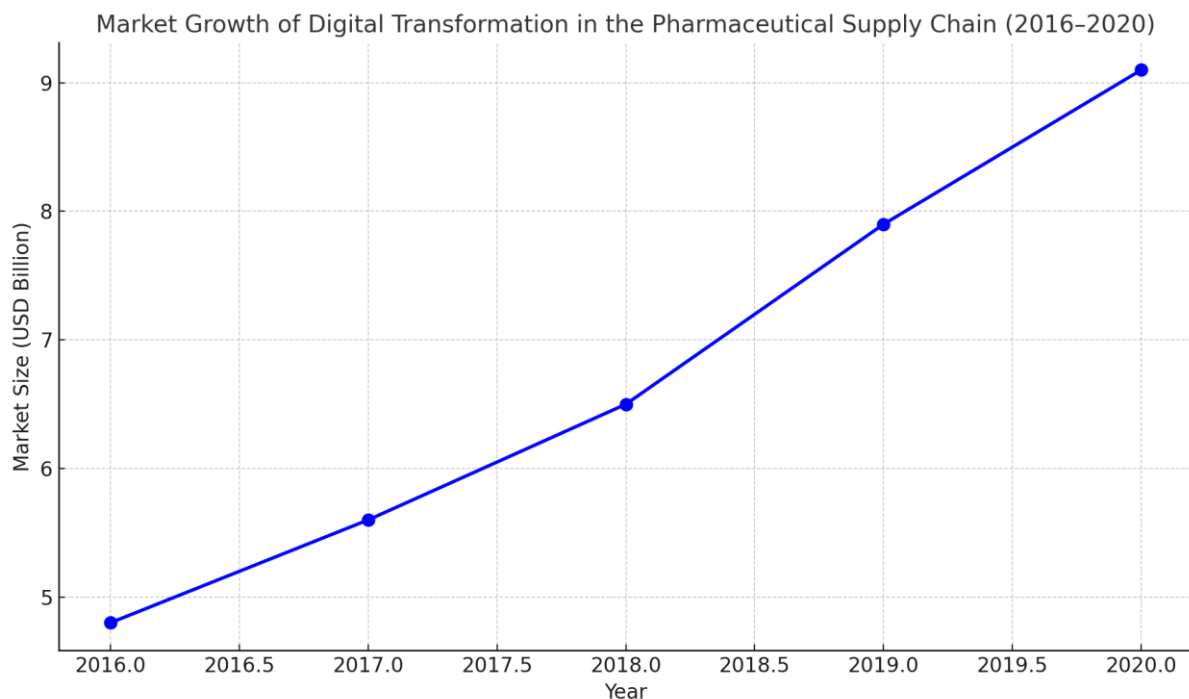
c. The Effect of Value-Based Pricing on Supply Chain Strategies

An influence of value-based pricing towards the pharmaceutical supply chain strategies is being greater demands on transparency, efficiency, and adaptability (Garrison et al., 2017). Drug distribution must be matched to patient needs while causing as little wastage as possible and using the most effective logistics (Simoens, 2011). Then, agility within the supply chains becomes essential in dealing with changing market demands and reimbursement models (Lakdawalla et al., 2018).

Market Growth of Data-Driven Digital Transformation in Pharmaceutical Supply Chain

The market growth of the pharmaceutical company that has adopted digital transformation was valued at approximately USD 29.4 billion in the year 2020. It is expected to reach USD 56.6 billion by the year 2025. The industry is expected to adopt a CAGR of 13.3% and the increasing demand of traceability, efficiency, and resilience in supply chains will catalyze this growth rate.

Figure 3: Market growth of digital transformation in pharmaceutical supply chains



The key growth drivers of the market are the impact of the Pandemic, which accelerated the urgency in digital technologies to manage supply disruptions, and rising drug complexities. The pressure from regulatory

compliance and the demand for visibility and transparency across the supply chains also fueled the market growth.

Among the adopted digital technologies, big data analytics consumed about 60% share in enhancing forecasting and production efficiency, followed by AI, 40% and IoT and blockchain 30% and 15% respectively.

Recommendations:

- Future research should investigate the long-term effects of digital transformation on pharmaceutical supply chain resilience, sustainability, and patient outcomes.
- The exploration of how emerging technologies such as quantum computing and federated learning could be implemented into supply chain management would warrant additional studies.
- Furthermore, empirical studies on cross-border data interoperability and global standardization challenges would highly benefit multinational pharmaceutical companies.
- Examining the ways in which digital transformation could enhance sustainable practices, such as waste and energy conservation, would in no small measure help with the enhancement of social and environmental capability of the profession.
- Lastly, interdisciplinary research bridging healthcare, data science, and operations management will be important for systemic innovation and delivery system improvement.

CONCLUSION

Data-driven transformations fuel pharmaceutical supply chains by improving their efficiency, security, and compliance (Sharma et al., 2021). The application of AI and big data analytics in blockchain makes organizations prepared for future needs in the industry (Tang & Veelenturf, 2019). Value-based pricing reaffirms an organization's importance in taking advantage of real-world data to make strategic decisions (Kaplan & Porter, 2011). Growing competitive strength and luxury in pharmaceutical industries would depend on advanced studies and investment in digitalization and transformation with technological advancement.

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