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The use of AI for demand forecasting

CASE STUDY:

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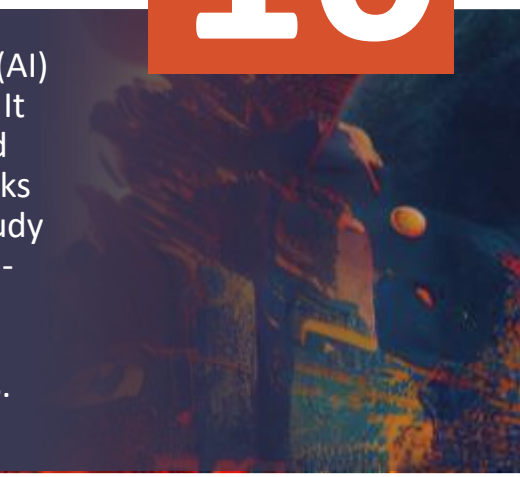


This case study explores the application of artificial intelligence (AI) in forecasting drug demand within the pharmaceutical industry. It focuses on how AI-driven tools enhance the accuracy of demand prediction, optimise supply chain management, and mitigate risks such as drug shortages and overproduction. Additionally, the study highlights ethical and reputational challenges associated with AI-based decision-making in health care. Through real-world applications, the case provides insights into the benefits and potential drawbacks of AI integration in pharmaceutical logistics.

Goal/Purpose

The primary objective of this case study is to analyse the effectiveness of AI in pharmaceutical demand forecasting as well as its broader implications for business strategy, operational efficiency, and ethical considerations. The study aims to provide a comprehensive understanding of how AI influences supply chain optimisation and decision-making in a highly regulated industry.

Expected Learning Outcomes

By engaging with this case study, learners will:

01 Understand the role of AI in improving forecasting accuracy and efficiency in the pharmaceutical industry;

02 Identify key challenges and limitations associated with AI-driven demand prediction, including ethical concerns and regulatory compliance;

03 Evaluate the impact of AI adoption on supply chain management, drug availability, and cost efficiency;

04 Develop critical thinking on how AI-based decision-making affects public trust and corporate reputation.

Suggested Methodological Approach

Case-Based Learning

Keywords

artificial intelligence in pharmaceuticals, drug demand forecasting, supply chain optimisation

One of the world's leading pharmaceutical companies, the organisation has been at the forefront of medical innovation for over a century.

With a strong presence in research, development, and the distribution of medicines and vaccines, the company has played a pivotal role in addressing global health challenges. Through its extensive network of research facilities, manufacturing plants, and partnerships, it continues to advance medical science and improve patient outcomes worldwide.

History and Growth

Founded in the late 19th century, the company began as a small chemical and pharmaceutical business focused on developing basic medicinal compounds. Over time, it expanded its research capabilities and introduced some of the most significant medical breakthroughs in history.

Key milestones in the company's history include:

01 Early 20th Century

Expansion into vaccine research and the development of antibiotics, helping combat infectious diseases;

02 Mid 20th Century

The introduction of breakthrough treatments in cardiology, oncology, and immunology;

03 Late 20th Century

Global expansion, acquisitions, and the establishment of major research hubs;

04 21st Century

Investment in biotechnology, personalised medicine, and large-scale vaccine production in response to emerging global health crises.

With a commitment to innovation, the company has become a trusted name in the pharmaceutical industry, known for its rigorous scientific approach and dedication to public health.

Business Profile

The company operates in over 100 countries, with headquarters in the United States of America and key regional offices in Europe, Asia, and Latin America. It maintains an extensive global research and development (R&D) network, supported by state-of-the-art laboratories and collaborations with academic institutions, health care providers, and government agencies

Its business model is based on three core pillars:

01 Pharmaceuticals

The development and commercialisation of prescription medications covering a wide range of therapeutic areas, including oncology, cardiology, neurology, and infectious diseases;

02 Vaccines

A world leader in vaccine research, the company produces vaccines for influenza, pneumococcal disease, HPV, and other life-threatening illnesses;

03 Consumer Health Care

Division focused on over-the-counter (OTC) medications, supplements, and personal health products.

With multiple manufacturing facilities worldwide, the company ensures efficient production and distribution, meeting the health care needs of millions of patients.

Innovation is at the heart of the company's success. It invests billions annually in R&D to develop new therapies, improve the existing treatments, and explore cutting-edge medical technologies

The company's research teams specialise in:

01 Molecular and genetic research to develop targeted therapies;

02 Clinical trials to ensure the safety and efficacy of new drugs;

03 Biotechnology to enhance vaccine development and biologic treatments.

Strategic partnerships with universities, biotech companies, and health care organisations further strengthen its research pipeline, ensuring continuous medical advancements.

One of the key challenges that the company faced was accurate demand forecasting across its global operations. Due to the complexity of pharmaceutical supply chains, long production lead times, and fluctuating demand influenced by seasonal trends and public health crises, the company struggled to align supply with actual market needs. This often resulted in inefficiencies such as drug shortages, surplus inventory, or delayed deliveries. This case highlights how the company addressed this challenge by implementing advanced AI-driven forecasting systems.

Sector Overview

The global pharmaceutical industry is one of the most critical sectors in health care, responsible for the research, development, production, and distribution of medicines and vaccines.

It plays a fundamental role in disease prevention, treatment, and improving the quality of life. The industry is highly regulated, requiring rigorous clinical testing and approval from regulatory bodies such as the US Food and Drug Administration (FDA) and the European Medicines Agency (EMA) before bringing new drugs to market. This sector is innovation-driven, with companies investing heavily in research and development (R&D) to create breakthrough treatments.

It encompasses various sub-sectors, including:

01 Biopharmaceuticals

Focusing on complex, biologically-derived drugs and therapies;

02 Generic Pharmaceuticals

Producing lower-cost alternatives to branded drugs after patents expire;

03 Over-The-Counter (OTC) Medications

Non-prescription drugs available directly to consumers;

04 Vaccines

A critical area focused on immunisation against infectious diseases.

> *The industry is characterised by long development cycles, high investment costs, and intense competition, with companies competing in innovation, pricing, and market access.*

Market Size and Growth Trend

The pharmaceutical industry is a multi-trillion-dollar global market. In 2023, the global pharmaceutical market was valued at over 1.5 trillion USD, and it continues to grow due to several key factors.

Key Factors:

01 Ageing Population

An increasing number of elderly individuals require long-term treatment for chronic diseases such as cancer, diabetes, and cardiovascular disorders;

02 Rising Health Care Expenditure

Governments and private institutions worldwide are investing more in health care infrastructure and drug accessibility;

03 Advancements in Biotechnology

Breakthroughs in genetic engineering, personalised medicine, and biologics are driving innovation in new treatment options;

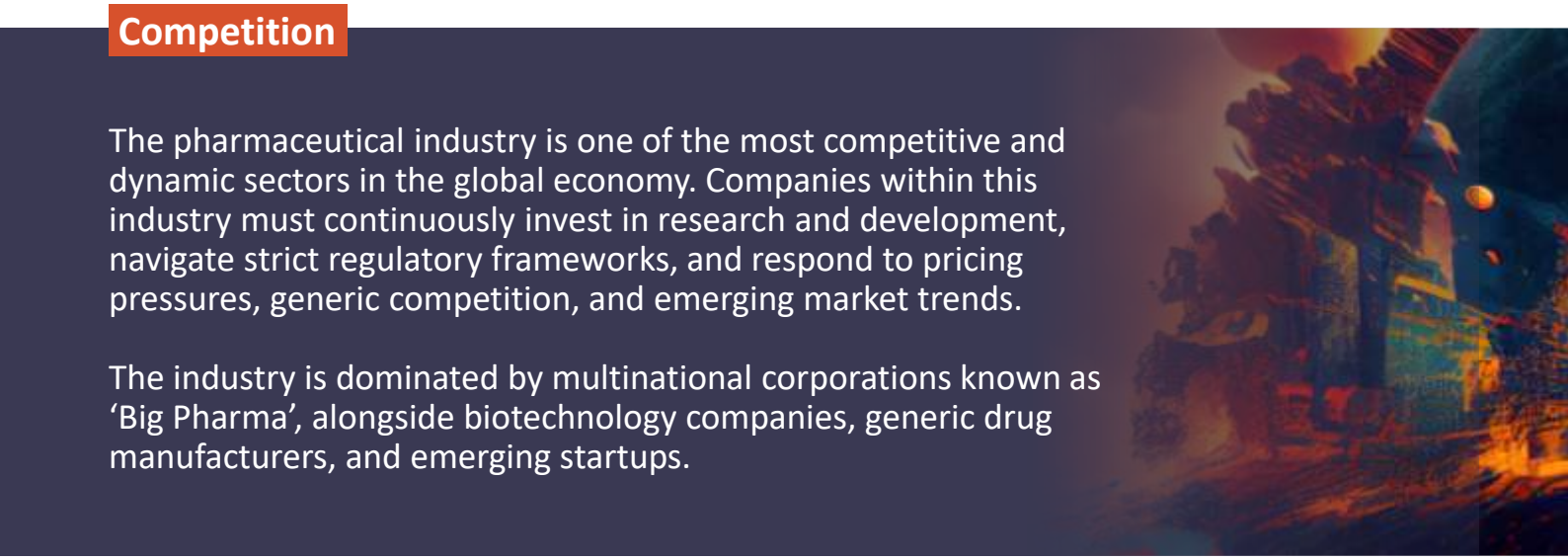
04 Emerging Markets

Rapid health care development in countries such as China, India, and Brazil is contributing to increased pharmaceutical demand;

05 Pandemic Preparedness

The COVID-19 pandemic accelerated investments in in vaccine research, antiviral drugs, and mRNA technology, highlighting the industry's role in global health security.

Competition



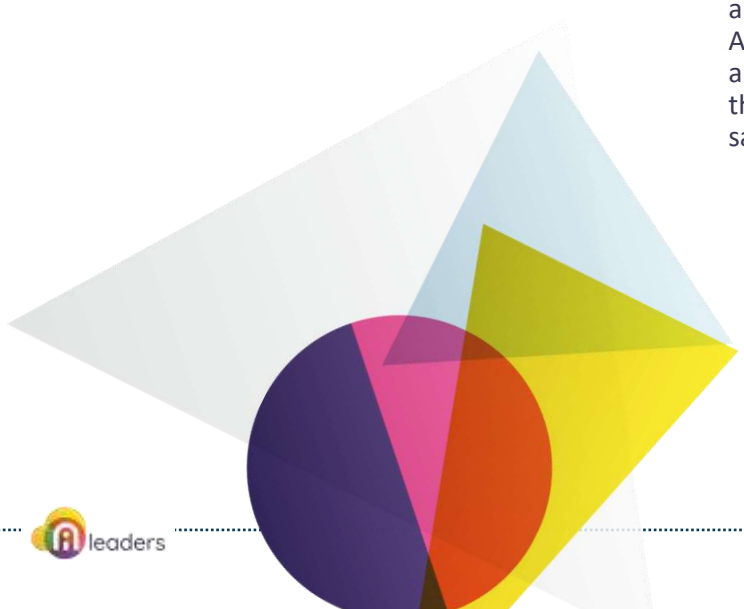
The pharmaceutical industry is one of the most competitive and dynamic sectors in the global economy. Companies within this industry must continuously invest in research and development, navigate strict regulatory frameworks, and respond to pricing pressures, generic competition, and emerging market trends.

The industry is dominated by multinational corporations known as 'Big Pharma', alongside biotechnology companies, generic drug manufacturers, and emerging startups.

The global pharmaceutical market is highly concentrated, with a small number of dominant corporations holding a significant share. These multinational pharmaceutical companies operate globally, with extensive research and development facilities, manufacturing plants, and distribution networks. Some of the largest players in the industry include Pfizer, Johnson & Johnson, Merck & Co., Roche, Novartis, Sanofi, AstraZeneca, and GlaxoSmithKline. These companies specialise in the development of prescription drugs, vaccines, and biologics, often competing in similar therapeutic areas such as oncology, cardiology, neurology, and infectious diseases. In addition to traditional pharmaceutical corporations, biotechnology companies play an increasingly significant role in drug innovation. Companies such as Moderna, BioNTech, Regeneron, and Amgen focus on cutting-edge medical research, including mRNA vaccine development, monoclonal antibody treatments, gene therapy, and personalised medicine. Unlike traditional pharmaceutical companies – which rely on chemical-based drug formulations – biotechnology companies develop biologics and cell-based therapies, creating a highly specialised competitive landscape.

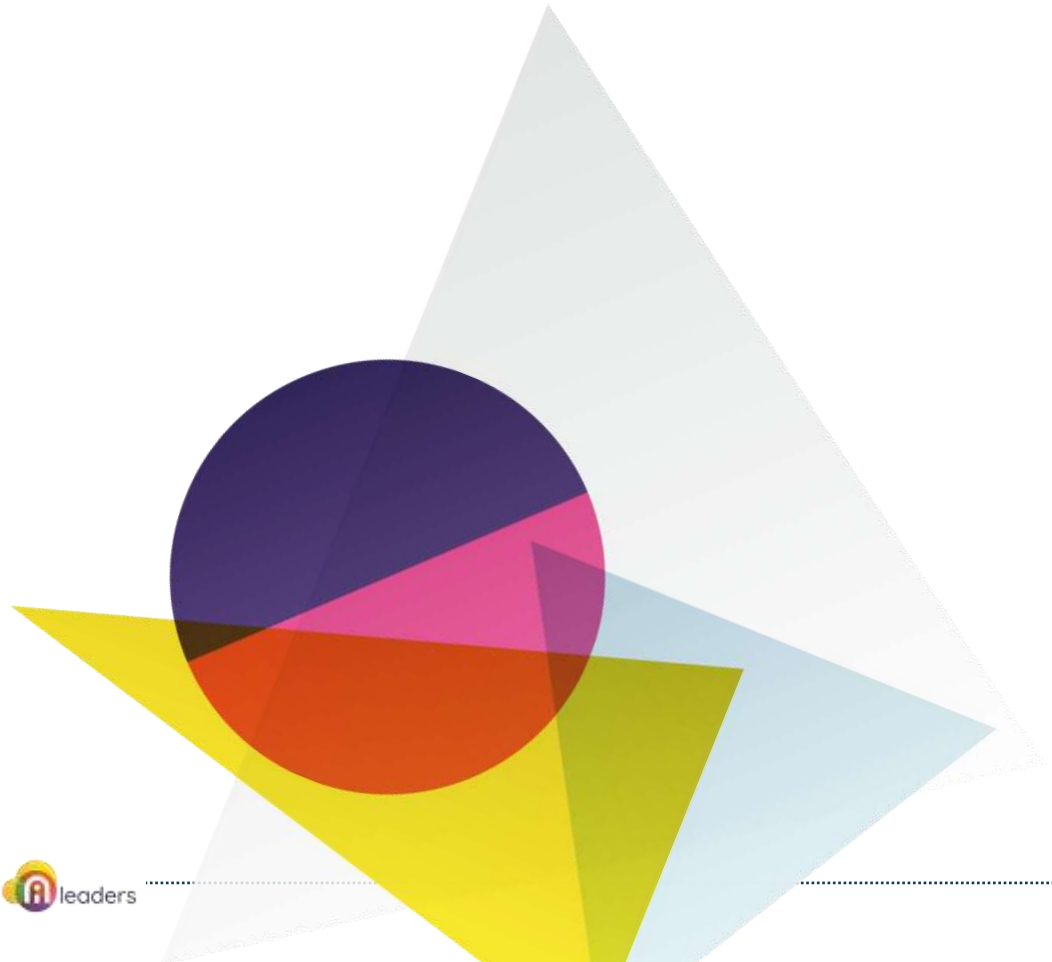
Companies in the pharmaceutical industry compete across multiple dimensions, including drug innovation, regulatory approval, patent exclusivity, market expansion, and health care provider relationships. One of the most significant areas of competition is drug innovation as well as research and development. Pharmaceutical companies engage in an ongoing race to develop and commercialise groundbreaking drugs. The first company to successfully bring a new treatment to market secures patent protection and gains exclusivity, allowing it to establish a dominant position. However, the drug development process is highly risky and expensive, with only a small fraction of drug candidates making it through clinical trials and regulatory approval. To strengthen their pipelines, many companies acquire or partner with biotechnology firms, integrating emerging innovations into their portfolios.

Regulatory approval and market access are also key competitive factors. Companies must navigate complex regulatory frameworks in different countries, with approval from agencies such as the US Food and Drug Administration (FDA), the European Medicines Agency (EMA), and the World Health Organization (WHO), which is essential for commercial success. Delays in obtaining regulatory approval can significantly impact a company's market position, allowing competitors to gain an advantage. Additionally, some companies benefit from fast-track approval programmes for critical or breakthrough therapies, giving them a temporary monopoly in life-saving drug markets.



Relationships with health care providers and institutions also influence competitive positioning. Pharmaceutical companies invest heavily in building relationships with hospitals, clinics, and prescribing physicians to encourage the adoption of their products. This is achieved through marketing campaigns, medical education programmes, and financial incentives. However, concerns about ethical practices and conflicts of interest have led to stricter regulations on the industry–physician interactions in many countries. Despite their dominant position, pharmaceutical companies face numerous challenges that threaten their market leadership. One of the most significant disruptions in the industry is the rise of artificial intelligence in drug discovery. AI-driven startups are accelerating drug research and reducing development costs, challenging traditional pharmaceutical R&D models. As a result, large pharmaceutical companies must integrate AI into their operations to remain competitive.

The growing market for biosimilars is also changing the competitive landscape. Biosimilars are highly similar alternatives to biologic drugs and provide cost-effective options for patients. As patents for biologic drugs tend to expire, pharmaceutical companies must compete with biosimilar manufacturers, leading to lower prices and reduced profitability. Regulatory and pricing pressures continue to pose challenges for the pharmaceutical industry. Governments worldwide are implementing policies to control drug prices and improve patient access to affordable medications. This trend has forced pharmaceutical companies to rethink pricing strategies while balancing the need for profitability and continued investment in R&D. Shifts in consumer behaviour and health care preferences are also influencing competition. There is a growing focus on preventive health care, personalised medicine, and digital health solutions. Companies that adapt to these trends by developing targeted therapies, diagnostic tools, and digital health platforms are likely to gain a competitive advantage in the evolving pharmaceutical landscape, pricing pressures, patent expirations, and regulatory hurdles.



The Company's Current Situation

Current Situation

The company is currently one of the world's largest and most influential pharmaceutical corporations, with strong global presence in the research, development, and distribution of life-saving drugs and vaccines.

Its portfolio includes treatments for a wide range of diseases, including in oncology, cardiology, immunology, infectious diseases, and neurology. The company operates in over 100 countries, with research and manufacturing facilities strategically located across North America, Europe, and Asia. In recent years, the company has faced challenges typical of the pharmaceutical industry, including increasing competition from biotech companies, regulatory pressures on drug pricing, and the growing presence of generic drug manufacturers.

Despite these challenges, the company continues to dominate the market through strategic acquisitions, investments in research and development, and the adoption of cutting-edge technologies. One of the company's most significant areas of focus is improving demand forecasting for drugs. The pharmaceutical supply chain is complex, and predicting drug demand is essential to ensuring that the right medications are available at the right time and in the right quantities.

Forecasting Drug Demand using AI

One of the company's critical areas of focus is improving the accuracy and efficiency of drug demand forecasting. The pharmaceutical supply chain is notoriously complex, and ensuring that the right medications are produced and distributed to meet demand is a challenging task. Historically, companies used to rely on traditional forecasting methods, such as sales data analysis, seasonal trends, and physicians' prescribing patterns. These models, while helpful, often resulted in inefficiencies such as drug shortages, overproduction, or financial losses.[1]

To address these issues, the company has embraced artificial intelligence (AI) as a key tool in optimising demand forecasting processes. AI and machine learning technologies have enabled the company to create a sophisticated forecasting system that integrates a vast array of data to predict the demand for medications with unprecedented accuracy. By using advanced algorithms, real-time data, and big data analytics, the company can optimise production schedules, reduce waste, and ensure that life-saving drugs are available when and where they are needed most.

1 Shukar, S., Zahoor, F., Hayat, K., Saeed, A., Gillani, A. H., Omer, S., ... & Yang, C. (2021). Drug shortage: causes, impact, and mitigation strategies. Frontiers in pharmacology, 12, 693426.

Forecasting Drug Demand using AI

AI-powered demand forecasting starts with the collection of data from diverse sources. These include historical sales records, electronic health records (EHRs), hospital and pharmacy inventories, disease outbreak information, environmental conditions, and even social media trends. The integration of data from these various sources allows AI to identify patterns and correlations that would be difficult or impossible for human analysts to discern.

This comprehensive data aggregation is the foundation for making highly accurate predictions. Once the data is collected, machine learning models are used to analyse and predict future demand. The company's AI system employs various advanced techniques, such as time-series forecasting, deep learning, and reinforcement learning. These models help identify long-term trends, detect complex patterns, and adjust forecasts based on new data. The models are constantly refined to improve prediction accuracy, especially in response to unpredictable events such as pandemics or geopolitical disruptions.

Unlike traditional forecasting methods, the company's AI system continuously monitors real-time data and adjusts predictions as new information becomes available. This dynamic capability allows the company to react quickly to changes in demand. For example, if an outbreak of flu is detected in a particular region, the AI system can predict an increased need for antiviral medications, and production can be ramped up accordingly. The system also adjusts for changes in government policies, market conditions, and supply chain challenges, ensuring that production remains aligned with actual demand.

AI's impact extends beyond forecasting into production and distribution. By predicting demand with greater precision, the AI system helps optimise production schedules, ensuring that drugs are manufactured in the right quantities without excessive waste. The AI system also optimises logistics, streamlining distribution routes to ensure timely delivery to health care providers and pharmacies. Additionally, by analysing factors such as raw material availability and shipping delays, the AI system can anticipate potential supply chain bottlenecks, helping to mitigate disruptions before they occur.

To sum up, before the implementation of AI, the demand forecasting process in the company had heavily relied on traditional methods. These included manual analysis of historical sales data, seasonal trends, market research, and physicians' prescribing patterns. Forecasts were often created by analysts or planners using spreadsheets or basic statistical models. While this approach offered a basic understanding of demand, it was limited in its ability to account for real-time variables, unexpected shifts in market behaviour, or complex interdependencies across global markets. As a result, forecasts were often less accurate and could lead to inefficiencies such as drug shortages, overproduction, or missed sales opportunities.
After AI had been introduced into the forecasting process, the system became significantly more dynamic and data-driven. AI models are now able to process vast amounts of structured and unstructured data, including supply chain information, epidemiological trends, patient behaviour, weather patterns, and even social media signals. These models use machine learning algorithms to detect patterns and adjust forecasts in real time as new data becomes available. This has improved the accuracy and agility of demand planning, allowing the company to respond more quickly to changes in the market. AI also supports scenario-planning and risk assessment, enabling more informed decision-making and reducing the likelihood of costly forecasting errors.

Key Aspects to be Analysed

Key Aspects

01 The Effect of Using AI for Demand Forecasting

The company's investment in AI-driven forecasting has already yielded significant benefits. One of the most notable improvements has been in forecasting accuracy, with predictions now more than 30% more accurate than traditional methods. This has led to better inventory management, reduced instances of drug shortages, and minimised financial impact of overproduction. AI has also enabled the company to allocate resources more efficiently, resulting in cost savings across manufacturing, logistics, and supply chain operations. Furthermore, the dynamic nature of AI-driven forecasting allows the company to respond more rapidly to market changes. For instance, the system can quickly adjust production schedules in response to sudden changes in prescription patterns or disease outbreaks. This faster reaction time has proven invaluable during public health crises, where demand for certain medications can spike unexpectedly.

02 Challenges and Future Outlook

Despite its success, the company faces several challenges in its AI-driven forecasting efforts Data privacy concerns – such as ensuring compliance with regulations such as GDPR and HIPAA – are always a consideration when working with sensitive patient information. Additionally, while AI can improve forecasting accuracy, it is not infallible, and unforeseen global events such as pandemics or geopolitical conflicts can still disrupt the predictions. Integrating AI into the existing legacy systems presents another challenge, as does addressing potential biases in AI models that could disproportionately impact certain populations or regions. Looking into the future, the company plans to continue enhancing its AI capabilities. It intends to incorporate even more real-time data sources – including data from wearable health devices – and explore blockchain technology to improve transparency in drug distribution. The company is also focused on investing in next-generation AI models that could predict individual patient needs, moving towards personalised treatment forecasts that anticipate demand on a much more granular level.

03 Key Aspects to be Analysed

One of the key tasks for those working with the case is to explore the data sources that could further enhance the accuracy of drug demand forecasting. While the company already uses a wide variety of data, there is always room for improvement. Those working with the case should critically evaluate these data sources, their reliability, and the challenges of integrating them into an AI-powered demand forecasting system. The next area for analysis involves the ethical considerations tied to AI-driven demand forecasting in the pharmaceutical industry. Given that AI relies heavily on vast amounts of data, ethical dilemmas can arise. Another key consideration involves understanding the potential public relations and reputation challenges linked to AI-based demand forecasting. Predicting drug demand is not just a logistical task; it also has significant implications for how the company is perceived by both the public and its stakeholders. By exploring these areas, those working with the case will gain a deeper understanding of the complexities and challenges in integrating AI into the pharmaceutical demand forecasting process, while also considering the broader societal implications of such technologies. .

Questions to Consider

Ethical Challenges in Predicting Demand

- **Data privacy and consent** - How should the company handle patient data to ensure compliance with data privacy regulations (e.g. GDPR, HIPAA)? What steps should be taken to ensure that the use of health data, especially sensitive information, is ethical and transparent to the public?
- **Bias in AI models** - Is there a risk that AI algorithms might inadvertently favour certain populations or regions in their demand predictions? How can AI systems be designed to ensure they don't perpetuate health disparities or lead to an underrepresentation of marginalised groups in forecasting models?
- **Transparency and accountability** - In situations where AI-driven forecasts lead to an overproduction or an underproduction of critical medications, who is responsible? What safeguards need to be in place to ensure accountability when AI models are making important decisions that affect global health?

Reputation and Public Perception

- **Trust in AI** - How might patients, health care professionals, and the general public react to the use of AI in predicting drug demand? Could there be scepticism about the company's reliance on AI for such a sensitive aspect of health care? How can the company ensure that its AI systems are transparent and trustworthy to stakeholders?
- **Drug shortages or overproduction** - If demand forecasts are inaccurate, it could result in drug shortages or overproduction. What are the potential reputational risks if critical medications are unavailable when needed, or if excess stockpiling leads to waste? How can the company communicate its efforts in improving demand forecasting to mitigate concerns and protect its public image?
- **Equitable access** - How might stakeholders perceive the fairness of the company's distribution strategies? Could there be a backlash if it is claimed that some regions or populations are receiving preferential treatment in terms of drug availability? How does the company ensure that its AI-driven decisions do not disproportionately affect certain groups?
- **AI transparency and communication** - How should the company communicate its AI-driven forecasting methods to the public? Should they disclose the algorithms or provide a level of transparency to alleviate public concerns about the fairness and accuracy of AI predictions?

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