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THE IMPACT OF ARTIFICIAL INTELLIGENCE ON THE U.S. GRAIN STORAGE CHAIN

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ABSTRACT

The application of artificial intelligence (AI) in the grain storage chain in the United States has led to significant changes in the operational and financial efficiency of the agricultural sector. AI-based solutions, such as machine learning algorithms for stock forecasting and transportation route optimization, have enabled managers to reduce costs and maximize profitability. Accurate grain demand forecasting and logistical optimization allow for more agile adaptation to market fluctuations, making companies more competitive globally. Furthermore, AI has proven essential in automating processes that prevent losses and improve the quality of stored grains. Intelligent monitoring of storage conditions, such as temperature and humidity, helps prevent deterioration and enhances product preservation. Technologies like computer vision and big data analysis have also contributed to improving both production and financial management by providing valuable insights into operational costs, profit margins, and opportunities to reduce expenses. AI not only optimizes operational processes but also shapes the business models of the agricultural sector. As more companies adopt these technologies, they become more resilient to external crises, such as the COVID-19 pandemic. Technological advancement, combined with the growing demand for more sustainable agricultural practices, opens up new possibilities for the future of farming. Emerging trends in AI promise to further expand the transformative potential, creating a smarter, safer, and more sustainable agricultural sector.

Keywords: Artificial Intelligence (AI). Grain Storage. Machine Learning. Agricultural Efficiency. Supply Chain Optimization.

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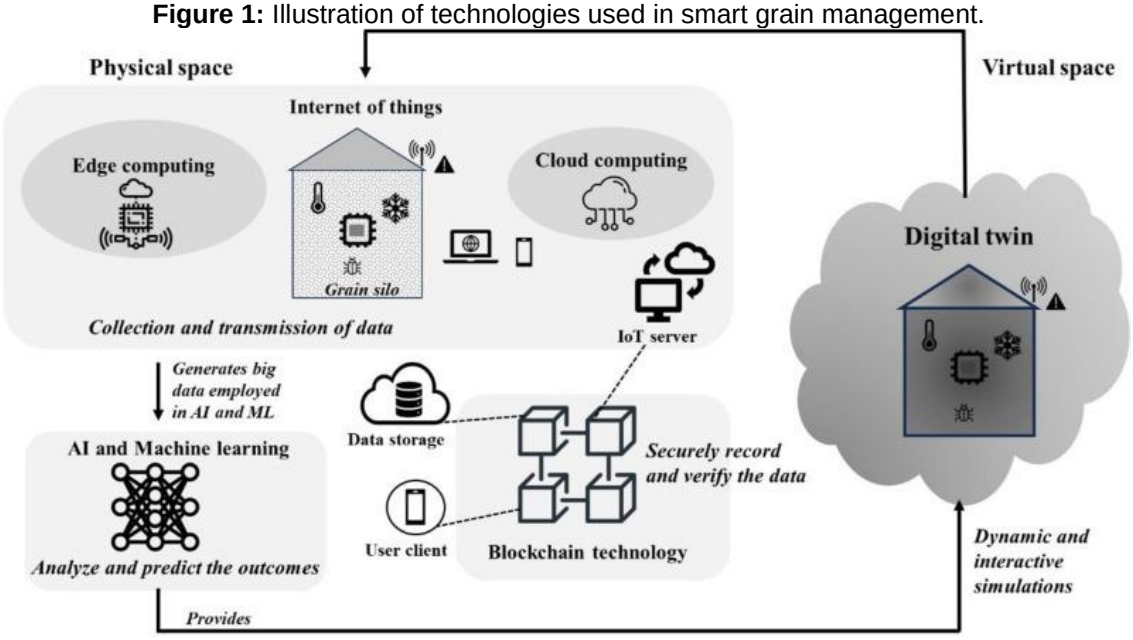
INTRODUCTION

The grain storage chain in the United States is crucial for the global agricultural sector, encompassing multiple stages from harvest to market delivery. Managing large volumes of grain production, along with transportation, storage costs, and risks, is complex. Financial optimization of this process is essential for enhancing operational efficiency and profitability. Artificial intelligence (AI) has emerged as a transformative tool to address the operational and financial challenges faced by this industry. One key area where AI has made a significant impact is in inventory forecasting and management. By utilizing machine learning algorithms, more accurate predictions of grain demand can be made, factoring in variables such as market trends, weather conditions, and historical data. These forecasts allow managers to optimize stock levels, reducing costs associated with overstocking or product shortages, and identifying the best times to sell to maximize profit.

Figure 1: Illustration of technologies used in smart grain management.



Source: Anukiruthika and Jayas (2025).

Additionally, AI improves transportation logistics by optimizing delivery routes, accounting for factors like weather, traffic, and fuel costs, leading to reduced transportation expenses and greater efficiency. AI also helps in monitoring storage conditions such as temperature and humidity, preventing losses and ensuring the quality of the grain, which directly contributes to revenue. Furthermore, AI plays a crucial role in financial management, as it can analyze vast amounts of financial data,

identifying patterns and offering insights into operational costs, profit margins, and areas for cost reduction. This analysis enables businesses to make more informed decisions, adapt to market fluctuations, and implement strategies to manage financial risks effectively. In summary, AI is reshaping the grain storage chain in the U.S., improving both operational and financial aspects, and allowing agricultural and storage companies to become more efficient, cost-effective, and competitive in the global market.

The study by Di Vaio et al. (2020) explores AI's role in the agri-food industry, focusing on its impact on operational processes and the challenges AI brings to new business models from a sustainable perspective. It emphasizes how supply chain stakeholders can contribute to value creation depending on their environmental awareness. This research stresses the need to redesign business models in sectors like agri-food, where adopting AI technologies requires substantial adjustments. The study utilized a two-phase methodology, including an extensive review of literature from scientific databases, followed by an analysis of selected articles. The findings underscore the significance of AI in achieving sustainable and responsible business models, especially in light of the COVID-19 pandemic, offering both theoretical and practical insights for further developments.

Patrício and Rieder's (2018) study highlights the vital role of grain production in the global economy, emphasizing the need for efficient and safe food production methods. The research focuses on the application of computer vision combined with AI algorithms, particularly in precision agriculture for the production of the world's five most produced grains: maize, rice, wheat, soybean, and barley. By reviewing 25 studies from the last five years, the paper identifies areas like disease detection, grain quality, and phenotyping where AI is making significant contributions. The study reveals the potential for advancements in precision agriculture, particularly through the use of Graphics Processing Units (GPU) and advanced AI techniques such as Deep Belief Networks (DBN), improving computer vision methods in agriculture.

Lei, Qiaoming, and Tong (2023) examine AI's role in the evolving financial technology landscape and its impact on supply chain operations. The study proposes an AI-based financial-risk-prevention (FRP) model to help businesses make informed decisions in uncertain environments, such as the COVID-19 pandemic. By applying machine learning algorithms like the chaotic grasshopper optimization algorithm (CGOA) and support vector machine (SVM), the model optimizes data to predict the

likelihood of business failure, enhancing decision-making and operational efficiency. The empirical results show that this model outperforms others in predicting and preventing financial risks, proving its effectiveness in mitigating financial uncertainties within supply chains.

Alomar's (2022) research focuses on AI's role in optimizing supply chain management, particularly in non-livestock supply chains. It examines how factors like increasing family income, rising female workforce participation, and technological advancements influence supply chain performance. AI helps improve capacity planning, productivity, quality, and safety in supply chains. The study identifies AI strategies that have already been applied and explores those with potential for future use, demonstrating how AI-driven improvements can enhance logistics, marketing, and manufacturing performance, with the proposed model achieving a performance metric of 94.12%.

Fadiji et al. (2023) analyze research trends on AI in postharvest agriculture, identifying advancements and gaps in the field. The study, based on 586 articles published between 1994 and 2022, highlights significant growth in AI research, particularly in the last decade. The leading countries in this field include China, the United States, and India, with a substantial portion of the publications coming from these countries. The research identifies key areas such as the Internet of Things, cold chain logistics, big data, and real-time monitoring that require further development. The study underscores AI's role in reducing postharvest losses, enhancing food quality and nutrition, and addressing food insecurity, offering valuable insights for future research in the field.

Finally, Oliveira and Silva's (2023) review of AI technologies in agriculture highlights the growing need for innovative solutions due to the increasing global population. Analyzing 906 relevant papers and selecting 176 for bibliometric analysis, the study identifies over 20 AI techniques used in agriculture, including machine learning, IoT, and robotics. The research emphasizes the role of AI in crop management and pest control, with countries like India, China, and the USA leading in AI applications. The study identifies emerging trends and challenges that will shape the future of AI in agriculture, offering crucial insights for advancing the field.

In conclusion, the application of artificial intelligence (AI) in the grain storage chain in the United States has shown a significant impact on improving the operational

and financial efficiency of the agricultural sector. AI-based solutions, such as the use of machine learning algorithms for inventory forecasting and transportation route optimization, have enabled managers to reduce costs and maximize profitability. By predicting grain demand more accurately and optimizing logistics processes, companies can better adapt to market fluctuations, ensuring greater competitiveness in the global market.

Furthermore, AI has excelled in automating processes aimed at preventing losses and improving the quality of stored grains. Intelligent monitoring of storage conditions, such as temperature and humidity, has helped prevent deterioration and optimize product conservation. The use of technologies such as computer vision and big data analysis has also contributed to enhancing production and financial management, providing valuable insights into operational costs, profit margins, and opportunities for cost reduction.

Finally, the impact of AI is not limited to the optimization of operational processes but is also shaping business models in the agricultural sector. As companies adopt these technologies, they not only improve their efficiency but also become more resilient to external crises, such as those generated by the COVID-19 pandemic. The combination of technological advances with the growing need for more sustainable and efficient agricultural practices opens up new possibilities for the future of the sector. Emerging AI trends promise to further expand the potential for transformation, paving the way for a smarter, safer, and more sustainable agricultural industry.

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