SWARM ENGINEERING

IMPROVING NETWORK EFFICIENCY WITH AI

for Organizations in the Grain Industry

Overview

The global grain industry is a cornerstone of the world's food supply chain, playing a pivotal role in sustaining the nutritional needs of billions of people. As the demand for grain continues to grow at a compound annual growth rate of 8.8% from $1455 billion in 2023 to $2218 billion by 2028[1], the efficiency of grain industry networks becomes ever more critical. These networks encompass production, storage, and manufacturing, along with associated transportation, and are complex systems operating on a massive scale. However, they are not without their inefficiencies, which can have far-reaching implications on cost, environmental sustainability, and the reliability of the world's food supply. The major global companies have embraced data, and come a long way to eliminate waste, but there are still opportunities to get better, especially with advances in AI.

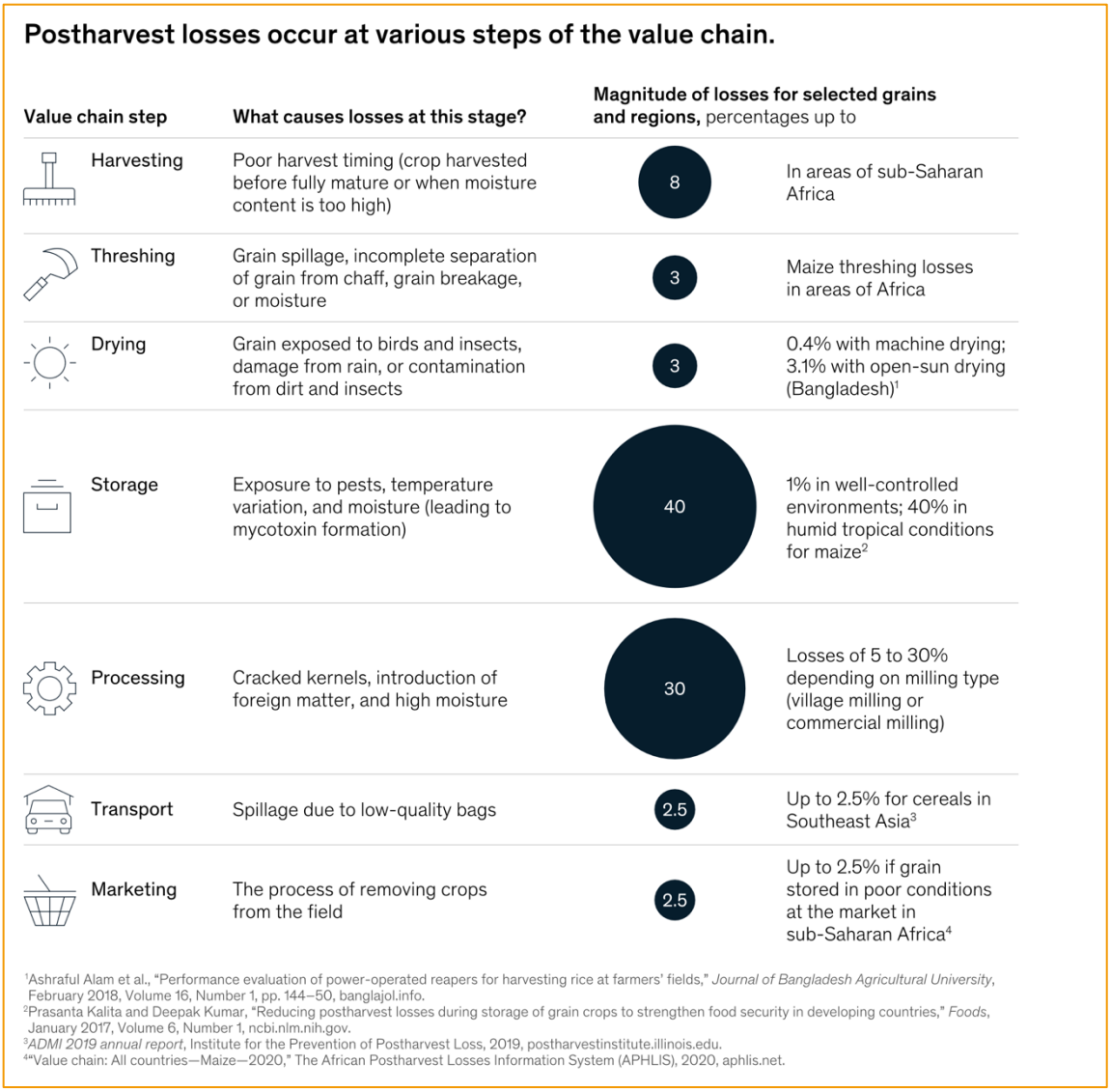
In recent years, the grain industry has faced a myriad of challenges, including logistical bottlenecks, geo-political issues, environmental pressures, and the need for digital transformation. These challenges underscore the necessity for continuous, strategic improvements across the network. Organizations must double-down on efficiency, as the risk of standing still is not only elevated operational costs but also exacerbates the industry's environmental footprint and compromises each organization's ability to meet the rapidly evolving demands.

This report outlines the primary network inefficiencies, their impact, and looks at key strategies organizations can deploy for improvement. We explore how sustainability practices can play into this model and may be opportunities for cost savings. Next, we investigate the challenges and barriers that need to be overcome in order to implement the latest technologies and consider how new concepts, such as the creation of a Challenge Center of Excellence, can contribute to closer alignment between business goals and innovation priorities. Finally, we offer some suggested areas which may be suitable for quick wins, highlighting AI use cases we have seen frequently deployed for significant cost savings.

[1] Source: The Business Research Company, Grain Farming Global Market Report 2024, published Jan 2024

Primary Inefficiencies

Most organizations in the grain industry participate in a multifaceted value chain that spans the globe, encompassing many interconnected stages. This extended supply chain is supported by a wide array of services, and transported via barges, trucking, rail, and maritime shipping. The largest loss of grain is frequently in **storage:** silos or warehouses face challenges related to capacity management, pest control, and maintaining optimal conditions to prevent spoilage or quality degradation. Inadequate storage infrastructure, especially in some regions, leads to significant post-harvest losses - up to 40% of grain is lost/wasted at this stage in developing countries. Next is **processing:** where inefficiencies stem from outdated equipment and technology, leading to lower yields and high energy consumption, with reported losses of 5-30%. Clearly, these numbers are far lower in North America, and inside the four large grain producers, who have deployed data and systems to eliminate as much waste as possible.



Postharvest losses occur at various steps of the value chain.

Value chain step	What causes losses at this stage?	Magnitude of losses for selected grains and regions, percentages up to	
Harvesting	Poor harvest timing (crop harvested before fully mature or when moisture content is too high)	8	In areas of sub-Saharan Africa
Threshing	Grain spillage, incomplete separation of grain from chaff, grain breakage, or moisture	3	Maize threshing losses in areas of Africa
Drying	Grain exposed to birds and insects, damage from rain, or contamination from dirt and insects	3	0.4% with machine drying; 3.1% with open-sun drying (Bangladesh)[1]
Storage	Exposure to pests, temperature variation, and moisture (leading to mycotoxin formation)	40	1% in well-controlled environments; 40% in humid tropical conditions for maize[2]
Processing	Cracked kernels, introduction of foreign matter, and high moisture	30	Losses of 5 to 30% depending on milling type (village milling or commercial milling)
Transport	Spillage due to low-quality bags	2.5	Up to 2.5% for cereals in Southeast Asia[3]
Marketing	The process of removing crops from the field	2.5	Up to 2.5% if grain stored in poor conditions at the market in sub-Saharan Africa[4]

[1]Ashraful Alam et al., "Performance evaluation of power-operated reapers for harvesting rice at farmers' fields," *Journal of Bangladesh Agricultural University*, February 2018, Volume 16, Number 1, pp. 144–50, banglajol.info.
[2]Prasanta Kalita and Deepak Kumar, "Reducing postharvest losses during storage of grain crops to strengthen food security in developing countries," *Foods*, January 2017, Volume 6, Number 1, ncbi.nlm.nih.gov.
[3]*ADMI 2019 annual report*, Institute for the Prevention of Postharvest Loss, 2019, postharvestinstitute.illinois.edu.
[4]"Value chain: All countries—Maize—2020," The African Postharvest Losses Information System (APHLIS), 2020, aphlis.net.

McKinsey & Company, How to reduce post-harvest crop losses in the agricultural supply chain, November 2021

While **Transportation** is only listed as a small loss of grain in the McKinsey report, it is one of the highest costs within the supply chain, in both developing regions and for the global producers. The movement of grain from fields to storage, on to processing facilities, warehouses, distribution centers, and customers, introduces its own set of inefficiencies. Logistical bottlenecks and inefficient planning can delay shipments or produce suboptimal results, leading to increased costs and reduced freshness of products. Additionally, the lack of integration between different stages of the supply chain can result in further operational inefficiencies, as processing may not be optimally located in relation to storage sites or end markets, resulting in yet more costs and environmental damage. Even companies that have tackled these issues can find their systems overwhelmed by frequent disruptions.

The Impact

Inefficiencies in storage, transportation, and processing directly translate to **higher operational costs** for grain industry stakeholders. This reduces profit margins for producers and elevates prices for consumers, affecting the overall affordability of grain products.

It also clearly affects **competitiveness**. Organizations, countries, or regions with more modernized, efficient supply chains can gain a competitive edge, accessing markets more effectively and offering lower-priced products. In contrast, those struggling with inefficiencies may find themselves at a disadvantage, unable to compete effectively on the global stage.

The **environmental impact** of these inefficiencies is significant. Wasteful practices, such as energy-intensive processing, or the loss of grains due to poor storage conditions, all contribute to both food waste and to an organization's carbon footprint. Transportation inefficiencies further exacerbate this situation, damaging both the environment and frequently a company's reputation, as consumers and business partners become more aware of critical ESG metrics.

Cost

In a 2019 survey, it was shown that the cost of exporting soybeans could vary from $9.40 to $64.60 per ton, based on transport inefficiencies alone.

USDA

Competition

"Since peaking in 1981, US wheat planted area has declined by nearly 39 million acres, and production has decreased by nearly 1 billion bushels."

USDA

Environment

The grains category of wheat, rice, maize, and other cereals, account for an estimated 69% of total inorganic fertilizer use for crops in the United States

International Fertilizer Association

Strategies for Improving Network Efficiency

Let's explore different approaches to improve network efficiency for grain organizations. Companies like Cargill, ADM, Bunge, and Louis Dreyfus have/are adopting many of these approaches, which makes it imperative for others to follow suit:

Leveraging Big Data and Analytics: the use of big data and analytics can significantly enhance demand forecasting and inventory management within the grain industry. By analyzing historical consumption patterns, weather data, and market trends, stakeholders can better predict demand fluctuations, optimizing inventory levels and reducing wastage. Advanced analytics can also identify inefficiencies within the supply chain, enabling more informed decision-making.

Adoption of Precision Agriculture: through technologies such as satellite imaging, GPS field mapping, and sensor networks, can optimize grain production by enabling more precise planting, fertilizing, and watering. These technologies help in maximizing yield while minimizing resource use, directly impacting the efficiency of the supply chain's initial stage. These technologies also feed the big data and analytics, providing more information which can be used to assist in decision-making.

IoT Devices for Real-Time Monitoring and Logistics Optimization: sensor networks are not just for the growing side of the business, Internet of Things (IoT) devices can revolutionize the monitoring and logistics aspects of the grain supply chain. Sensors placed in storage facilities can monitor temperature, humidity, and grain condition in real-time, allowing for proactive management of storage environments. In transportation, IoT devices can optimize routes, track shipments in real-time, and ensure the integrity of the grain during transit.

AI and Machine Learning: modern algorithms can analyze data from a multitude of sources to predict machinery failures before they occur, efficiently manage fleets of vehicles, labor, or both together, balance supply and demand, improve logistics operations, and much more. Additionally, these technologies can enhance quality control processes by identifying anomalies in grain quality faster and more accurately than traditional methods. The range of options increases every month and can transform the speed and effectiveness of operations.

Generative AI: is the new kid on the block, that everyone wants to talk about. This technology is moving very fast and can help with a range of different tasks such as summarization of other documents, translation, drafting reports, producing graphics, and even interaction in a human-like way with customers, suppliers, and employees. There are numerous ways to adopt this technology which could have an impact on grain network efficiency, but few established patterns that can be repeatably used, and still concerns over the bias, privacy, security, and applicability. This is a great technology to experiment with, and to see how it can fit into your processes. The potential value is high, but the exact fit depends on your specific needs, strengths, and weaknesses as an organization.

Sustainability Practices

In addition to the strategies outlined above, there are specific sustainability practices that can improve the grain network efficiency.

Renewable Energy Sources in Grain Storage and Processing Facilities: by harnessing solar or wind power, grain storage and processing facilities can not only significantly reduce their carbon footprint but also mitigate dependency on fossil fuels, thus enhancing energy security. Furthermore, integrating renewable energy solutions can lead to short or long-term cost savings through reduced energy expenses and potential incentives for adopting sustainable practices, fostering economic resilience.

Waste Reduction Techniques and Circular Economy Principles: strategies such as reusing grain by-products for animal feed or biofuel production and fostering partnerships with local communities to recycle packaging materials can further minimize environmental impact and contribute to a more sustainable supply chain. These initiatives not only reduce waste but also create additional revenue streams and strengthen relationships within the agricultural ecosystem, promoting a circular economy approach to production and distribution.

Regenerative Agriculture: can play a pivotal role in enhancing sustainability within the grain network, increasing yield and efficiency. Practices like cover cropping, crop rotation, and minimal tillage not only improve soil health and biodiversity but also sequester carbon from the atmosphere, mitigating climate change impacts. By restoring soil fertility and enhancing ecosystem resilience, regenerative agriculture not only promotes sustainable grain production but also fosters long-term environmental stewardship. Integrating these techniques into farming practices can lead to healthier ecosystems and increased crop yields. For organizations that purchase a large percentage of their crop, rather than growing it directly, it's important to sponsor, educate and reward suppliers who are progressing with regenerative programs.

Many organizations are working to manage not only direct emissions from their operations (Scope 1) but also indirect emissions from purchased electricity, heat, or steam (Scope 2), as well as (Scope 3) emissions along the entire value chain, including transportation, processing, and end-use of their products. Balancing multiple dimensions requires comprehensive strategies, but firms should recognize these are also opportunities for innovation and efficiency. We see many companies capturing ESG metrics, but few taking advantage of it in daily decision-making.

Case Study

We were engaged by a client to optimize their internal network of more than 100 locations that were supplying grain to a major port for international export orders. Each customer order had a specific set of quality criteria (e.g. protein content) and was large enough that in many cases, no single store of grain could meet the demand. Therefore, grain was transported from multiple locations to be combined at the port prior to shipping. More than $20M of orders were going through the specific port, which was one of many in the client's network.

Network of 100 grain facilities, funneling batches of grain to a single port.

The planner had to consider the transportation cost (train was preferred over truck), the availability of the grain (e.g. it could not be moved for a set period of days if it was undergoing fumigation treatment), and was essentially blending the grain to achieve the quality criteria in the order specification, e.g. if the protein content needed to be 11.5%, the planner could combine a 2 ton load with protein content of 10%, along with an 8 ton load of 12% to achieve an average of 11.5% protein content. There were also constraints based on the destination and journey time. For example, certain countries have differing import rules on the type and most recent timing of pesticide treatments.

Each customer order has specific quality criteria and multiple constraints, that must be met.

While the volume of data was not high in this example, the complexity of managing the constraints, and considering the 12 or so primary order criteria, meant that the decision was time-consuming, and mistakes were costly. On one occasion a vessel was turned around mid-journey because the calculations had been incorrectly applied, and the customer refused the order – resulting in a multi-million dollar loss. More frequently, the order was slightly over-spec, which over a year accumulated into higher costs and also missed opportunities for orders that could not be fulfilled as the quality of grain was no longer available.

Mistakes can cost $millions, so planner temptation is to over spec each order.

SWARM applied an AI algorithm to assist the planner, guiding the choice of where to source the grain for orders, and recommending the best mode of transportation and the plan timing (it was also costly to store grain at the port). This resulted in annualized savings of over 16%, and a reduction in planning time from several hours to a few minutes per order. At the same time, a machine learning algorithm could be deployed to look at the movement of grain through the network, ensuring that grain was more likely to be in the right location, at the right time – thereby taking advantage of pre-planned transportation and lowering both time for delivery, and the associated costs.

AI algorithm resulted in **16% annual savings** and planning reduced from **hours to mins.**

Challenges and Barriers

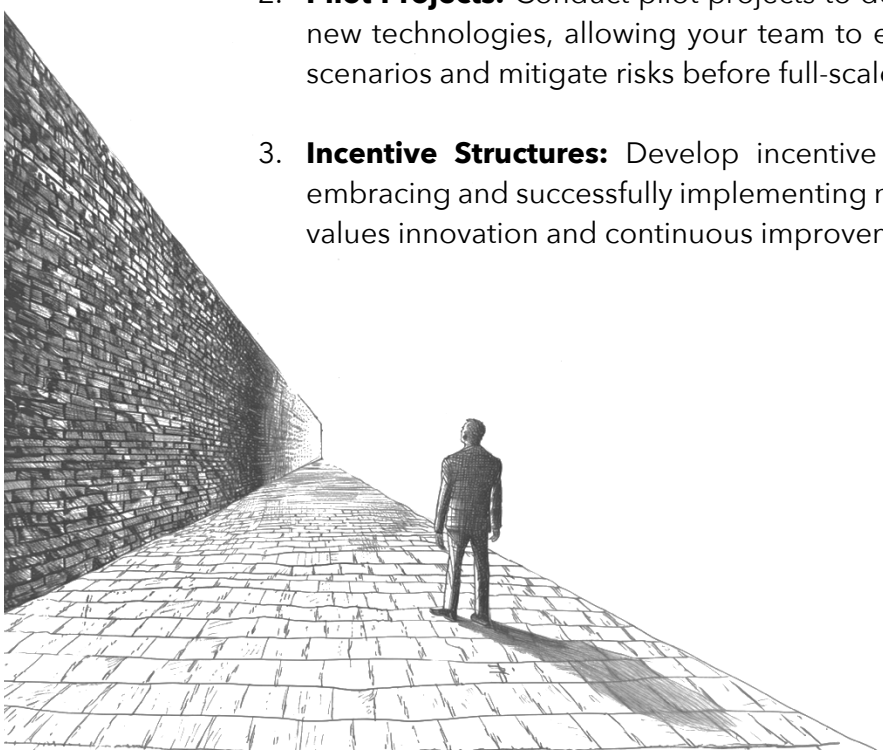
Grain companies often face significant issues when it comes to adopting new technologies. Without doubt, one of the primary obstacles is an organization's culture and established practices, which may resist change and innovation. As the magazine *Business Leadership Today* stated, "Culture change is perhaps the most challenging initiative a business leader will ever take on." Additionally, the upfront costs associated with implementing new technologies can be prohibitive, especially for companies operating on tight profit margins in competitive global grain markets. Furthermore, there may be a lack of technological expertise or resistance to certain technologies, such as AI, which can frequently be perceived as threatening to many with media stoked concerns over job security. Legacy infrastructure and equipment may also pose compatibility issues with modern technologies, requiring costly upgrades or retrofits. Moreover, risk aversion and uncertainty about the reliability and long-term benefits of new technologies can further deter adoption – as can the current pace at which it is evolving.

Despite these challenges, embracing innovation is crucial for grain companies to remain competitive in a rapidly changing industry, necessitating proactive strategies to overcome barriers and foster a culture of technological advancement. The grain network, as we have seen, is one of the primary areas where new technology can help make a rapid improvement. Here are our top five recommended approaches to implementing change successfully:

1. **Education and Training Programs:** implement training programs to familiarize employees with new technologies, emphasizing their benefits and providing hands-on experience to build confidence and competence. Give people access to new tools so they can learn in their day-to-day environment.

2. **Pilot Projects:** Conduct pilot projects to demonstrate the feasibility and efficacy of new technologies, allowing your team to evaluate their performance in real-world scenarios and mitigate risks before full-scale implementation.

3. **Incentive Structures:** Develop incentive structures that reward employees for embracing and successfully implementing new technologies, fostering a culture that values innovation and continuous improvement.



4. **Collaboration and Partnerships:** Forge partnerships with technology providers, industry experts, and research institutions to access resources, expertise, and support in navigating the adoption process, including guidance on selecting and customizing technologies to suit specific needs.

5. **Change Management Strategies:** Implement robust change management strategies to address resistance to change and overcome organizational inertia, involving stakeholders at all levels, communicating transparently, and providing ongoing support and encouragement throughout the transition process.

The Challenge Center of Excellence

Many companies have previously established a Center of Excellence focused on Innovation, Data Science, Process Improvement, and even AI. They have been a great tool for introducing and rolling-out new concepts into organizations, especially when the skills required have been in short supply and/or expensive.

We believe the Challenge Center of Excellence (CCoE) redefines the landscape of how tier-1 organizations will operate in the next 3-5 years, by focusing on discovering and then addressing specific business challenges. Through techniques that are centered on collaborative problem-solving, leveraging collective intelligence, and harnessing cutting-edge AI, the CCoE plays to the strengths of people and technology, enabling them to work together more effectively.

Unlike traditional innovation centers, which often rely heavily on internal ideation, or a good stream of external impetus, a Challenge CoE encourages cross-functional and interdisciplinary collaboration, both internally and externally, fostering a more open ecosystem for innovation. This approach ensures that solutions are directly applicable and tailored to real-world challenges in your organization, significantly enhancing their quality and impact. This ensures your efforts are aligned with strategic goals and effectively addressing the most pressing needs of the company.

As the first Challenge Engineering ™ platform in the market, SWARM has the expertise and tools to help you establish a CCoE. The latest developments include a free digital agent called AVA – the Agrifood Virtual Advisor, who can help guide you in managing your CCoE and has specialist skills to understand the most common challenges in grain network efficiency, allocation, logistics, and planning. You can learn more at our website https://swarm.engineering/ava

Conclusion

In the United States alone, there are over 10,000 grain elevators and storage facilities, according to the U.S. Department of Agriculture. Additionally, Canada also has a significant number of grain storage facilities, and while Mexico has fewer sites, it still possesses a notable number of grain storage facilities to support its agricultural industry. Overall, considering the extensive grain production in North America alone, the total number of grain storage facilities likely exceeds tens of thousands, and as we have seen there are still inefficiencies in storage, transportation, and processing which can be significant for individual organizations, even as the global players continue to invest in technology to minimize them.

While there are several well-known approaches to reducing costs and increasing efficiency, with new options rapidly emerging in AI and generative AI, the traditional barriers to change still exist and it takes concerted effort for organizations of all types to transform operations.

In the previous section we outlined some of the classic, most effective approaches to overcome obstacles to change, and also recommended the creation of a Challenge Center of Excellence to deliver innovation in a practical way to the organization, aligned with the goals of the business. Based on our experience, we would recommend exploring some of the following use cases as potentially 'low-hanging fruit' for piloting AI technology and getting quick-win validations to demonstrate cost savings in your grain network:

Supply/Demand balance	Taking both historical and predictive factors into account, AI can be used to make efficient choices to match grain supply on-hand with demand, driving an optimized fulfillment strategy. By successfully matching supply and demand, grain producers and distributors can maximize their profits and ensure customer requirements are met, while considering quality, transportation, and storage costs.
Network Optimization	In supply chain management, network optimization is a valuable tool for organizations seeking to improve their supply chain efficiency. By understanding potential challenges such as transportation, warehouse locations, production facilities, and distribution channels, network optimization seeks to streamline the flow of goods while minimizing costs. Its ultimate aim is to create a more efficient and cost-effective supply chain network. Networks can be reviewed in order to add new facilities, consolidate existing sites, or simply to determine the best location for manufacturing or storing inventory, based on historical customer demand.
Yield forecast, risk mitigation	This aims to identify potential risks and develop strategies to reduce the impact of different yield results by using machine learning and modeling billions of scenarios to determine optimal outcomes. Typical inputs include collecting and analyzing data on weather patterns, soil quality, and crop health, and using sensors to monitor crops. This can then

	inform decision-making related to production, marketing, and distribution.
Outbound Logistics	Is an area that varies significantly in quality between top percentile organizations and those that are under performing and is frequently one of the highest costs. The goal is well understood; to combine multiple sales orders into load plans, in order to fill trucks and deliver to customers in the most efficient manner. Planning must consider customer delivery windows, perishable products, and regional restrictions for both FTL and LTL while utilizing internal and third-party fleets. Every organization has this capability, and it must be operating to a certain degree or else they would not be in business, but in our experience, it is a frequent 'iceberg' of hidden inefficiencies and extraneous costs.
Sustainable Product Formulation	With multiple ingredients in a product specification, sourced from different suppliers and locations, there can often be choices that have a significant impact on ESG metrics. By embedding AI tools in the decision process, you can evaluate the pros and cons of switching ingredients, either by choice or through necessity based on inbound raw materials, to deliver products that meet health, taste, shelf-life, and cost criteria, while improving sustainability measures.

These are just a handful of suggestions based on projects we have seen executed successfully. By creating your own list of strategic challenges and defining the potential impact of solving them (before attempting to do so), you can evaluate the most valuable areas to tackle in your grain network to improve efficiency.

One final observation; **just because an operational area is achieving its goals, don't assume it is efficient**, or will continue to remain efficient. We have seen several examples of seemingly successful processes where the hidden inefficiencies were greater than $5M, and in one logistics example a process that cost $140M annually was shielding inefficiencies of $30M. It is a good idea to benchmark your most costly processes on a regular basis, to see if there are potential savings. As one C-level executive expressed it in a conversation with us recently '…this is supply chain operations, so it can never be a hundred percent efficient'. If you start from the assumption that your core processes are inefficient, and then look at how they can be improved you may be pleasantly surprised at the potential cost savings. If you start the other way around, assuming that your processes are good enough because they function every day, then you may be in for a shock in the future – especially if your competitors adopt AI.

We hope you enjoyed this report and found some concepts and actionable items to help improve your grain network's efficiency. Feel free to share any feedback or thoughts with us at SWARM Engineering, or to reach out and see how we can help you directly.

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