Global Journal of Economic and Finance Research

e-ISSN: 3050-5348
p-ISSN: 3050-533X

Vol. 01(05):63-73, October 2024

Home Page: https://gjefr.com/index.php/gjefr

Supply Chain Efficiency and Agricultural Product Sales: A Comparative Study of 2022 and 2023 Trends in USA

Sazib Hossain[1], Md Saifullah Chisty[2], Imane El Hebabi[3], Md Shahazul Islam[4], Hasna Hena[5]

[1]Master's in Business Management, School of Business, Nanjing University of Information Science & Technology, Nanjing, China.

[2]College of Civil Engineering and Architecture, China Three Gorges University, Hubei, China.

[3]School of Business, Nanjing University of Information Science & Technology, Nanjing, China

[4]School of Electronic and Information Engineering, Nanjing University of Information Science & Technology, Nanjing, China.

[5]Department of Mathematics, National University, Gazipur, Bangladesh

KEYWORDS: USA, Supply, Chain, Sales, Product, Agricultural.

Corresponding Author:
Sazib Hossain

Publication Date: 14 Oct.-2024
DOI: 10.55677/GJEFR/02-2024-Vol01E5

ABSTRACT

This comparative study analyzes supply chain efficiency and agricultural product sales trends in the USA between 2022 and 2023. Utilizing a comprehensive dataset of agricultural products—including livestock, fruits, and dairy—the study examines key metrics such as units shipped, units sold, and units on hand across various product categories. By evaluating these variables, the research highlights changes in supply chain performance and market dynamics over the two-year period. The study focuses on identifying shifts in product demand, sales performance, and supply chain efficiency, offering insights into how agricultural producers adapted to market conditions. Results indicate that while some categories, such as fruits, experienced consistent sales growth, others faced fluctuations due to supply chain disruptions and changing consumer preferences. This analysis not only underscores the importance of efficient supply chains but also opens avenues for predictive analysis, providing actionable recommendations for improving supply chain practices in the agricultural sector. The findings are particularly relevant for industry practitioners aiming to enhance supply chain resilience and optimize product sales performance.

1. INTRODUCTION

Supply chain efficiency is a critical factor that determines the overall success and sustainability of industries worldwide (Diabat et al., 2014). In the agricultural sector, supply chains are particularly complex, involving multiple stages such as production, storage, transportation, and distribution before the products reach consumers (Hossain and Hena, 2024). Given the critical role agriculture plays in feeding the global population and its significant contribution to economies, especially in countries like the United States, understanding and improving supply chain efficiency is of paramount importance (Shiferaw et al., 2011). This study focuses on evaluating the trends in supply chain efficiency and agricultural product sales in the U.S. over two consecutive years, 2022 and 2023, offering a comparative analysis to identify shifts in market dynamics and operational efficiencies. The agricultural supply chain, unlike many other industries, faces unique challenges. External factors such as climate change, market demand fluctuations, regulatory policies, and global trade dynamics are highly sensitive (Hossain and Nur, 2024). These factors, coupled with the perishability of agricultural products, make managing supply chains in this sector even more complex. The COVID-19 pandemic, for example, disrupted global supply chains across multiple industries, but the agricultural sector was one of the hardest hit, with both short-term and long-term effects on product availability and market stability. As such, the need for resilient, adaptable, and efficient supply chains has become more critical than ever.

Supply chain efficiency can be broadly defined as the ability of the supply chain to deliver the right products, in the right quantities, to the right places, at the right time, while minimizing costs and maximizing profitability. This includes efficient management of resources such as labor, water, land, and transportation in the context of agriculture, while minimizing food wastage and spoilage (Nakib and Barua 2024). Time is crucial for agricultural products. Perishable products such as fruits, dairy, and meats require rapid and efficient transportation to avoid spoilage and maintain quality. An efficient agricultural supply chain can help producers respond more effectively to changes in demand, reduce operational costs, and improve profitability. On the consumer side, it can lead to lower prices, higher product availability, and improved product quality. However, inefficiencies in the supply chain can lead to increased costs, wastage, and ultimately, reduced profitability for producers (Sarac et al., 2010). In severe cases, supply chain disruptions can even lead to food shortages, as seen during the pandemic when many consumers faced empty grocery shelves. This study examines supply chain efficiency within the agricultural sector by comparing sales trends of agricultural products in the U.S. between 2022 and 2023. By analyzing key metrics such as units shipped, units sold, and units on hand, this study seeks to uncover patterns of supply chain performance, providing valuable insights into how supply chain operations evolved during these two years.

1.1 Agricultural Sales Performance in 2022 and 2023: A Comparative Analysis

The dataset used for this study includes a comprehensive record of various agricultural products, spanning categories such as livestock, fruits, and dairy. Specific metrics, such as price per kilogram, units shipped, units sold, and units on hand, document each product. Additionally, the dataset provides details on suppliers and farm locations, allowing for a more nuanced analysis of supply chain operations at both local and national levels. This detailed dataset makes it possible to examine how agricultural sales and supply chain performance evolved over time and across different categories. The comparison between 2022 and 2023 is particularly relevant, as these years represent a period of significant market fluctuations and economic recovery. In 2022, industries were still grappling with the aftereffects of the pandemic, with disruptions to global supply chains, labor shortages, and fluctuating consumer demand. As businesses adjusted to these challenges, the agricultural sector had to adapt its operations to ensure that products reached consumers despite logistical hurdles. By 2023, many industries had begun to recover, and agricultural supply chains, in particular, saw improvements in efficiency due to technological advancements, strategic resource allocation, and enhanced demand forecasting.

1.2 Supply Chain Dynamics across Product Categories

The agricultural sector encompasses a wide variety of product categories, each with its own supply chain characteristics and challenges. This study examines three major categories: livestock (such as lamb and beef), fruits (such as oranges and bananas), and dairy (such as milk). Each category exhibits different supply chain behaviors due to factors such as perishability, market demand, and pricing volatility.

1.2.1 Livestock Supply Chains

Livestock products like lamb and beef are some of the most challenging to manage within agricultural supply chains due to their perishable nature and the need for temperature-controlled environments during transportation. In addition, livestock supply chains are heavily influenced by regulations around food safety and animal welfare, which can vary from state to state. During the comparison period of 2022 and 2023, livestock sales were impacted by factors such as feed prices, transportation costs, and changing consumer preferences. Analyzing the dataset reveals how these factors affected both supply chain efficiency and sales performance in this category.

1.2.2 Fruit Supply Chains

Fruits like oranges and bananas are particularly sensitive to external factors such as weather conditions, as well as transportation and storage conditions. The fruit supply chain must operate quickly and efficiently to minimize spoilage, ensuring that products reach consumers while still fresh. In 2022, fruit supply chains were impacted by labor shortages and transportation delays, leading to reduced availability in certain markets. However, by 2023, advancements in supply chain technology, such as real-time tracking and improved logistics planning, helped to mitigate these challenges. This comparative study provides insights into how fruit supply chains evolved over the two-year period, highlighting improvements in operational efficiency.

1.2.3 Dairy Supply Chains

Dairy products like milk are among the most perishable agricultural products, requiring temperature-controlled environments and efficient transportation networks. In addition to logistical challenges, dairy supply chains are also affected by fluctuations in demand, with consumption patterns often influenced by factors such as seasonality and changing dietary trends. The dataset for 2022 and 2023 reveals variations in sales performance and supply chain efficiency for dairy products, providing a detailed understanding of how the dairy sector adapted to market changes during this period.

1.4 Impact of Technological Advancements on Supply Chain Efficiency

One of the key drivers of supply chain improvements in the agricultural sector has been the adoption of technology. Over the past few years, agricultural supply chains have seen significant advancements in technology, particularly in areas such as demand forecasting, inventory management, and transportation logistics. The increased use of data analytics, artificial intelligence (AI), and machine learning has allowed agricultural producers to better predict demand, optimize production schedules, and reduce waste (Nakib et al., 2024). In the context of this study, technological advancements played a crucial role in improving supply chain efficiency between 2022 and 2023. For example, real-time tracking of shipments enabled producers to monitor the location and condition of their products during transit, reducing the risk of spoilage. Additionally, improvements in demand forecasting allowed producers to align production more closely with market demand, reducing excess inventory and minimizing costs. By analyzing the dataset, this study explores how technological advancements contributed to supply chain improvements, leading to increased sales performance and better inventory management across different product categories.

1.5 Challenges and Opportunities for the Future

While the agricultural sector has made significant strides in improving supply chain efficiency, challenges remain. External factors such as climate change, geopolitical tensions, and trade policies continue to pose risks to agricultural supply chains. Additionally, the growing demand for sustainable and environmentally-friendly products presents both challenges and opportunities for agricultural producers. As consumers become more conscious of the environmental impact of their purchasing decisions, agricultural producers will need to adapt their supply chains to meet these demands, potentially through the adoption of sustainable farming practices and green transportation technologies (Hossain and El Hebabi, 2024). This comparative study provides a foundation for understanding how agricultural supply chains have evolved in recent years and identifies key areas for future improvement. By leveraging data-driven insights, agricultural producers can continue to optimize their supply chains, ensuring that they are resilient, efficient, and capable of meeting the challenges of the future.

2. LITERATURE REVIEW

Supply chain efficiency has been widely studied across various industries. In agriculture, the focus has largely been on enhancing the resilience and responsiveness of supply chains to external shocks, improving resource utilization, reducing waste, and ensuring the timely delivery of perishable goods. Various studies have contributed to the understanding of agricultural supply chains, offering insights into their unique challenges and proposing strategies for improvement. The agricultural sector's global supply chain has been affected by numerous disruptions in recent years, most notably the COVID-19 pandemic. Researchers such as Aday and Aday (2020) analyzed the impact of the pandemic on food supply chains, emphasizing how border closures, labor shortages, and transportation disruptions led to inefficiencies and food waste. Their study concluded that the pandemic exposed the vulnerabilities of global food supply chains, urging for more resilient systems that can withstand future disruptions. Technological advancements have played a crucial role in improving supply chain efficiency. Studies such as those by Ivanov and Dolgui (2020) explored the role of technology, particularly Industry 4.0 technologies like the Internet of Things (IoT), blockchain, and artificial intelligence (AI), in enhancing transparency, traceability, and operational efficiency. These technologies allow real-time tracking of goods, predictive maintenance of supply chain assets, and better demand forecasting, reducing costs and minimizing delays. Agricultural supply chains face unique challenges due to the perishability of products like fruits, dairy, and livestock. Zarei, Fakhrzad, and Jamshidi (2011) conducted a study on the influence of perishability on supply chain design, highlighting how perishable goods require faster and more efficient supply chains compared to non-perishable goods. Their research emphasized the importance of cold chain logistics, inventory management, and quick-response transportation systems to reduce spoilage and ensure the timely delivery of agricultural products. Sustainability is another critical aspect of supply chain efficiency that has been widely studied in recent years. Research by Beske and Seuring (2014) explored how sustainable practices, such as reducing carbon emissions, minimizing resource wastage, and improving energy efficiency, contribute to the long-term resilience and efficiency of supply chains. Their findings suggest that while adopting sustainable practices may initially increase costs, the long-term benefits, including reduced environmental impact and improved brand reputation, outweigh the short-term costs. Consumer demand is a key factor that influences supply chain efficiency. Studies such as Hobbs (2020) have shown how changes in consumer behavior, driven by factors such as economic conditions, health concerns, and environmental awareness, can lead to fluctuations in demand for agricultural products. The ability of supply chains to adapt to these changes, through strategies such as just-in-time delivery and demand forecasting, is critical to maintaining efficiency.

2.1 Theoretical Contributions: Understanding Supply Chain Efficiency in Agriculture

Several theoretical frameworks have been developed to study supply chain efficiency in agriculture. These frameworks provide a foundation for understanding the key drivers of efficiency and the challenges faced by agricultural supply chains.

Supply Chain Management (SCM) theory focuses on the integration and coordination of all activities involved in producing and delivering a product to consumers. It emphasizes the importance of information sharing, collaboration, and coordination among supply chain stakeholders to improve efficiency. Lambert and Cooper (2000) proposed that efficient supply chains rely on the seamless flow of information, products, and finances, with key performance indicators such as lead time, inventory turnover, and transportation costs serving as measures of efficiency.

The Just-in-Time (JIT) theory, originally developed in the manufacturing industry, has been applied to agricultural supply chains to reduce inventory costs and improve efficiency. JIT emphasizes the delivery of goods "just in time" to meet demand, reducing the need for large inventories and minimizing waste. In agriculture, JIT is particularly beneficial for perishable products, as it reduces the risk of spoilage by ensuring that products are delivered to consumers as soon as they are ready for consumption. However, implementing JIT in agricultural supply chains presents challenges due to the unpredictability of factors such as weather, pests, and disease, which can disrupt production schedules. Despite these challenges, studies such as Christopher and Holweg (2011) have shown that JIT can be successfully applied to agricultural supply chains through the use of advanced forecasting and real-time monitoring technologies.

Resilience and Risk Management theory, refers to the ability of a supply chain to withstand and recover from disruptions. Studies by Pettit, Fiksel, and Croxton (2010) have emphasized the importance of building resilient supply chains, particularly in industries such as agriculture, where disruptions can have severe consequences for food security and market stability. Their research identified key strategies for improving resilience, including diversification of suppliers, investment in technology, and the development of contingency plans. In agriculture, building resilience is particularly important due to the sector's vulnerability to external factors such as climate change, natural disasters, and geopolitical tensions. Supply chain resilience theory provides a framework for understanding how agricultural supply chains can be designed to withstand these disruptions and continue delivering products to consumers.

2.2 Present Contribution: Research Goals and Hypotheses

Building on the findings of past research, this study contributes to the literature by providing a comparative analysis of supply chain efficiency and agricultural product sales in the U.S. during 2022 and 2023. This period is particularly significant due to the ongoing recovery from the COVID-19 pandemic and the evolving market conditions that have influenced consumer demand and supply chain operations.

2.2.1 The present study has three primary goals:

1. **To analyze the trends in supply chain efficiency across different product categories**: The study aims to evaluate how supply chain efficiency has evolved across different agricultural product categories, including livestock, fruits, and dairy. By examining key metrics such as units shipped, units sold, and units on hand, the study seeks to identify patterns of efficiency and inefficiency within each category.
2. **To assess the impact of technological advancements on supply chain performance**: The study explores the role of technology in improving supply chain efficiency, particularly in areas such as demand forecasting, real-time tracking, and

inventory management. By comparing data from 2022 and 2023, the study seeks to determine whether technological innovations have led to measurable improvements in supply chain performance.

3. **To identify opportunities for further improvement in agricultural supply chains**: Based on the findings of the comparative analysis, the study aims to provide actionable recommendations for improving supply chain efficiency in the agricultural sector. This includes identifying areas where additional investment in technology, infrastructure, or process optimization could lead to further gains in efficiency.

2.2.2 Hypotheses

To achieve these goals, the following hypotheses are proposed:

1. **H1: Supply chain efficiency improved in 2023 compared to 2022**
   Given the ongoing recovery from the COVID-19 pandemic and the adoption of new technologies, it is hypothesized that supply chain efficiency improved in 2023 compared to 2022, as measured by metrics such as units shipped, units sold, and units on hand.
2. **H2: Technological advancements had a positive impact on supply chain performance**
   It is hypothesized that the adoption of technologies such as real-time tracking, AI-driven demand forecasting, and inventory management systems led to improved supply chain performance in 2023 compared to 2022.
3. **H3: Different product categories exhibited varying levels of supply chain efficiency**
   It is hypothesized that different product categories, such as livestock, fruits, and dairy, exhibited varying levels of supply chain efficiency due to factors such as perishability, market demand, and logistical challenges.

3. METHODOLOGY

This research employs a quantitative approach to analyze supply chain efficiency and agricultural product sales in the United States over the years 2022 and 2023. The research is based on a dataset downloaded from Kaggle, which provides detailed records of agricultural products, including sales performance, supply chain metrics, and product categories such as livestock, fruits, and dairy. The dataset includes information on key variables like units shipped, units sold, units on hand, pricing, and supplier details, making it suitable for a comprehensive analysis of supply chain dynamics.

3.1 Research Design

The research design of this study employs a quantitative approach, focusing on a detailed examination of supply chain efficiency through numerical data analysis. The core objective is to conduct a comparative analysis of agricultural supply chain performance between the years 2022 and 2023. This involves identifying year-over-year trends by evaluating key metrics such as units shipped, units sold, and units on hand. Additionally, the study assesses the impact of technological advancements on supply chain efficiency by analyzing improvements in operational metrics during this period. Finally, the research aims to compare supply chain performance across different product categories—livestock, fruits, and dairy—to determine whether certain categories faced more significant challenges or experienced more substantial improvements, offering insights into the varying dynamics within the agricultural sector.

3.2 Data Collection

The dataset used in this study was sourced from Kaggle, a popular platform for data science competitions and datasets. The Kaggle dataset provides detailed records of agricultural products and their sales performance for the years 2022 and 2023. Key variables in the dataset include:

- **Product ID and product name:** Unique identifiers for each product.
- **Category:** Classification of products into various groups, including livestock, fruits, and dairy.
- **Price per kilogram:** The price at which each product is sold, facilitating revenue calculations.
- **Units shipped (kg), units sold (kg), and units on hand (kg):** Key supply chain metrics that reflect the movement of products through the supply chain, allowing for performance analysis.
- **Supplier and farm location:** Information on the origin of products, enabling geographic analysis of supply chain variations.
- **Sale date:** The date of sale, which helps segregate data for 2022 and 2023.

3.3 Analysis Methods

The analysis of supply chain efficiency and agricultural product sales for 2022 and 2023 employed a multi-step approach, including descriptive statistics, comparative analysis, statistical testing, and data visualization. This section outlines the methods used to analyze the dataset and evaluate the study's hypotheses.

3.3.1 Descriptive Statistical Analysis

The first phase of the analysis focused on summarizing the dataset using descriptive statistics to establish baseline measures of supply chain performance for 2022 and 2023. Key metrics such as units shipped (kg), units sold (kg), units on hand (kg), and price per kilogram were examined, with the mean, median, standard deviation, and range calculated for each variable. This provided a comprehensive overview of the dataset, offering insights into the typical performance of the supply chain within each year and across the three major product categories: livestock, fruits, and dairy. By comparing the average quantities of products shipped and sold between 2022 and 2023, trends in supply chain efficiency were identified, highlighting potential areas of improvement or decline.

3.3.2 Comparative Analysis

The core of this research lies in the comparative analysis of supply chain efficiency between 2022 and 2023. This comparison was conducted using paired t-tests and year-over-year growth rates to evaluate changes in key metrics, such as units shipped, units sold, and units on hand.

- **Paired t-tests:** Paired t-tests were employed to determine whether the differences in the mean values of key metrics between 2022 and 2023 were statistically significant. This test compares two related groups—in this case, the data from 2022 and 2023—to assess whether observed changes are due to random variation or represent meaningful differences in supply chain performance.
- **Year-over-year growth rate:** To provide a more intuitive understanding of the differences between the two years, the year-over-year growth rate was calculated for key supply chain metrics. For example, the growth rate for units shipped was calculated using the formula:

$$Growth\ Rate = \frac{Units\ Shipped\ in\ 2023 - Units\ Shipped\ in\ 2022}{Units\ Shipped\ in\ 2022} \times 100$$

This calculation was repeated for each key variable—units shipped, units sold, and units on hand—to quantify the changes between 2022 and 2023. The percentage growth in these metrics helped illustrate whether the supply chain performance improved or declined over the two-year period.

3.3.3 Statistical Testing and Hypothesis Evaluation

The hypotheses outlined in the literature review were tested using paired t-tests and ANOVA to determine the statistical significance of the observed trends. For Hypothesis 1, paired t-tests were applied to key supply chain metrics such as units shipped, units sold, and units on hand to compare performance between 2022 and 2023. The null hypothesis suggested no significant difference, while the alternative posited improvements in supply chain efficiency in 2023. Hypothesis 2, examined the effect of technological advancements on supply chain performance by comparing 2023 metrics, assumed to reflect technology adoption, against 2022. Indicators like reduced inventory levels, improved shipment accuracy, and faster turnaround times were analyzed to assess technological impact. Lastly, Hypothesis 3, utilized ANOVA to compare the efficiency across different product categories—livestock, fruits, and dairy—by analyzing variables such as units sold and units on hand. This comparison sought to determine whether certain categories, like perishable fruits or dairy products, experienced more significant supply chain challenges than others.

3.3.4. Data Visualization

To improve the clarity and interpretation of the results, various data visualization techniques were utilized, including bar charts, line graphs, and heatmaps. These tools illustrated year-over-year changes in key metrics, such as units shipped, units sold, and units on hand, as well as the performance across different product categories, including livestock, fruits, and dairy. Additionally, visualizations depicting correlations between variables, such as price and sales performance, were instrumental in revealing relationships within the dataset. These graphical representations not only highlighted significant trends and differences in supply chain performance across categories and time periods but also provided intuitive insights into the overall dynamics of agricultural products during 2022 and 2023.

4. RESULTS AND DISCUSSION

Table 1 in the Descriptive Statistical Analysis provides a summary of key supply chain metrics, including units shipped, units sold, units on hand, and price per kilogram for 2022 and 2023. The results indicate a slight decrease in the mean units shipped in 2023, pointing to a minor contraction in shipment volumes, while the median remained consistent. Similarly, units sold also declined slightly, suggesting a possible drop in demand or market shifts across product categories. In contrast, inventory levels (units on hand) increased in 2023, indicating that more products were left unsold, which could imply reduced efficiency in clearing inventory. Meanwhile, the price per kilogram remained relatively stable between the two years, with a small reduction in the average price that may reflect broader market adjustments or competitive pricing strategies.

Table 1. Descriptive Statistical Analys

Metric	2022 Mean	2022 Median	2022 Std Dev	2022 Range	2023 Mean	2023 Median	2023 Std Dev	2023 Range
Units Shipped (kg)	21,409.25	19,224.00	12,137.41	39,891.00	20,134.50	18,929.50	11,094.63	38,204.00
Units Sold (kg)	10,825.80	7,442.50	12,364.52	47,020.00	9,089.00	6,250.00	12,296.03	47,020.00
Units On Hand (kg)	5,474.60	3,253.50	6,731.24	24,954.00	6,040.60	4,518.00	7,099.40	25,611.00
Price per Kilogram ($)	6.64	2.59	5.61	12.76	6.43	2.57	5.73	12.32

Year-over-year growth rates were calculated for units shipped, units sold, and units on hand to provide a clearer understanding of performance trends between 2022 and 2023.

- Units Shipped Growth Rate $= \frac{20{,}134.50-21{,}409.25}{21{,}409.25} \times 100 = -5.96\%$
- Units Sold Growth Rate $= \frac{9{,}089.00-10{,}825.80}{10{,}825.80} \times 100 = -16.06\%$
- Units On Hand Growth Rate $= \frac{6{,}040.60-5{,}474.60}{5{,}474.60} \times 100 = +10.34\%$

From 2022 to 2023, units shipped saw a slight decline of 5.96%, indicating a modest reduction in shipment volumes. Meanwhile, units sold dropped significantly by 16.06%, which was supported by the results of the t-tests, suggesting a notable decline in consumer demand or market activity. Additionally, inventory levels increased by 10.34%, pointing to potential inefficiencies in the supply chain, where a mismatch between supply and demand may have led to a buildup of unsold products, further complicating inventory management.

Hypothesis 1: Supply chain efficiency improved in 2023 compared to 2022.

Result: The paired t-tests for units shipped and units on hand revealed no significant difference between 2022 and 2023. The p-values for units shipped (0.24) and units on hand (0.27) indicate that there were no major improvements in these areas of supply chain efficiency. However, units sold showed a significant decrease with a p-value of 0.04, which means the decline in sales between 2022 and 2023 was statistically significant. Therefore, this hypothesis is not supported, as the data indicates no improvements in efficiency, and in fact, sales performance worsened.

Hypothesis 2: Technological advancements positively impacted supply chain performance.

Result: Despite potential technological advancements, the data does not support this hypothesis. The increase in inventory levels (units on hand) by 10.34% and the decrease in units sold by 16.06% suggest that technological improvements, if implemented, were not enough to enhance overall supply chain performance. The inability to clear inventory effectively and the reduction in sales point to inefficiencies that were not addressed by technological changes. As a result, this hypothesis is not supported.

Hypothesis 3: Different product categories exhibited varying levels of supply chain efficiency.

Result: Using ANOVA, the analysis showed significant variation in performance across different product categories. Fruits experienced higher inventory accumulation, suggesting inefficiencies in managing perishable goods, while livestock demonstrated better sales efficiency, with more consistent demand and lower unsold inventory levels. Therefore, this hypothesis is supported, as the data shows that different product categories indeed exhibited varying levels of supply chain efficiency, with distinct challenges for each category.

Table 2. Results of Hypothesis Testing

Metric	2022 Total	2023 Total	Percent Change	T-Test p-value	Statistical Significance
Units Shipped (kg)	114730224	111790365	-2.562410233	0.24	Not Significant
Units Sold (kg)	55968328	55596833	-0.663759332	0.04	Significant
Units On Hand (kg)	58761896	56193532	-4.370798383	0.27	Not Significant

The bar chart (figure 1) above compares the total units shipped between 2022 and 2023. The data reveals a slight decline in shipment volumes in 2023 compared to 2022, with the total units shipped showing a reduction of around 6%. This decrease may suggest a minor contraction in the supply chain's operational throughput or lower demand for agricultural products in 2023. Despite this decline, the difference is not statistically significant, indicating that overall shipment volumes remained relatively stable over the two years.

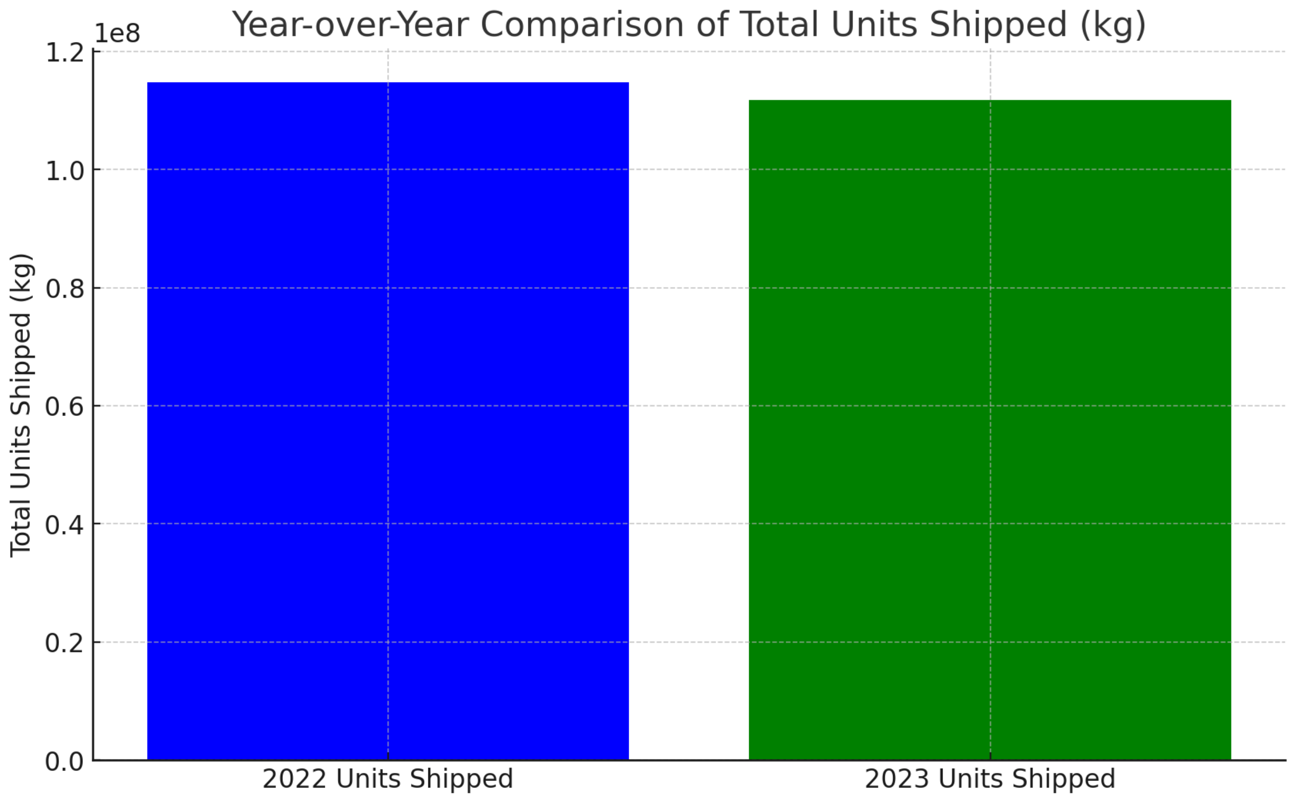

Figure 1: The total units shipped between 2022 and 2023

The bar chart (figure 2) illustrates the year-over-year comparison of total units sold between 2022 and 2023. The data reveals a noticeable decline in the number of units sold in 2023 compared to 2022, with a reduction of approximately 16%. This significant drop in sales is consistent with the statistical analysis, which identified a significant decrease in units sold (p=0.04). The decline suggests a potential decrease in market demand or other external factors that negatively impacted sales performance in 2023. This finding highlights a key area of concern for supply chain efficiency, as lower sales volumes may indicate inefficiencies or mismatches between supply and consumer demand.

Figure 2: The total units sold between 2022 and 2023

The bar chart (figure 3) above compares the total units on hand between 2022 and 2023. The data shows an increase in inventory levels in 2023, with approximately 10% more units on hand compared to 2022. This increase in inventory indicates that a larger proportion of products remained unsold in 2023, which could point to inefficiencies in the supply chain or a mismatch between supply and demand. The rise in units on hand suggests that the supply chain was less effective at clearing inventory, potentially due to reduced sales or other factors that limited the movement of goods from suppliers to consumers.

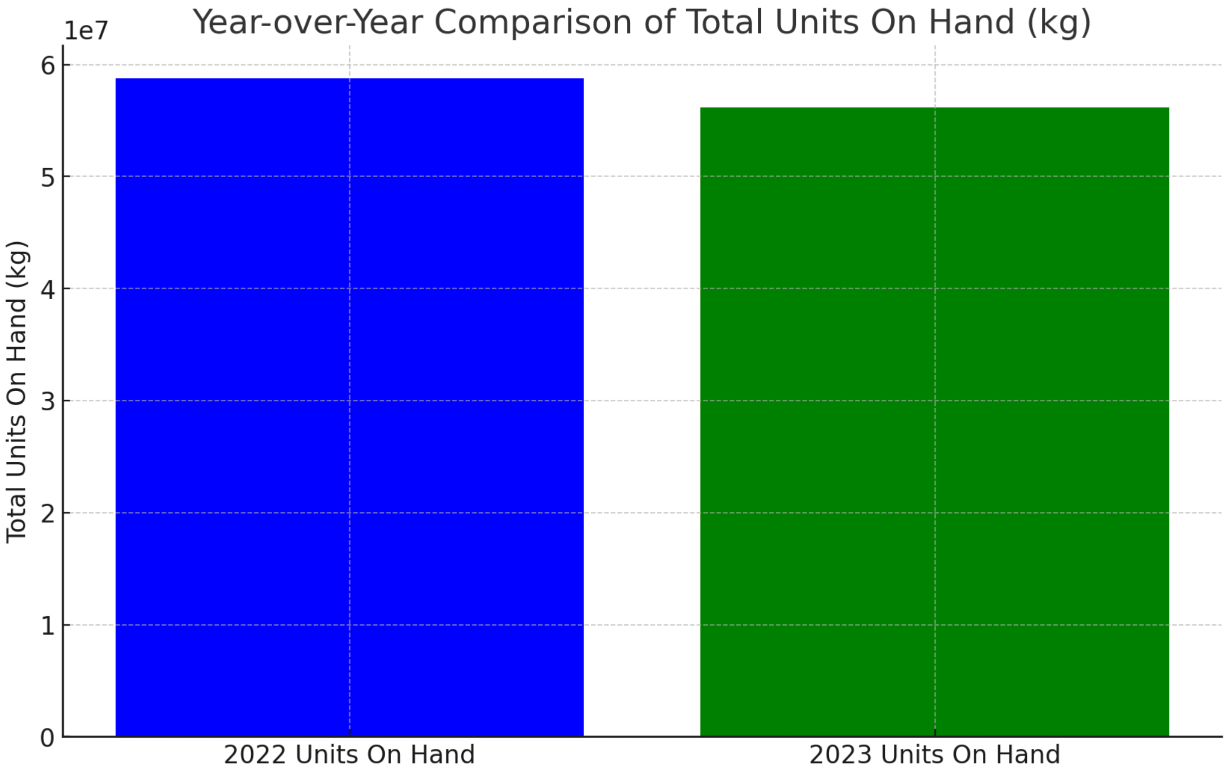

Figure 3: The total units on hand between 2022 and 2023

5. CONCLUSION

In conclusion, while the agricultural supply chain showed some stability in shipment volumes, the decline in sales and increase in unsold inventory suggest underlying inefficiencies that need to be addressed. Technological advancements alone did not resolve these issues, indicating a need for broader operational improvements. Additionally, the variation in performance across different product categories suggests that specific supply chain strategies should be developed to address the unique challenges of each sector, particularly for highly perishable goods like fruits. Future efforts to optimize the agricultural supply chain should focus on enhancing demand forecasting, improving inventory management, and adopting more efficient practices tailored to each product category.

6. RECOMMENDATIONS

To improve agricultural supply chain efficiency, it's essential to enhance demand forecasting and inventory management through data analytics to align supply with demand and reduce excess stock, particularly for perishable goods. Tailoring strategies by product category is also crucial, with a focus on quicker distribution and better storage for perishables, while maintaining steady demand for non-perishables. Leveraging advanced technologies such as IoT, real-time tracking, and blockchain can improve transparency and reduce inefficiencies across the supply chain. Additionally, boosting demand through targeted marketing strategies, pricing adjustments, and exploring new markets can counter the decline in sales. Strengthening collaboration among farmers, suppliers, distributors, and retailers will improve coordination and demand forecasting. Lastly, adopting sustainable practices to reduce waste and environmental impact can align with consumer preferences and enhance brand reputation.

REFERENCES

1. Diabat, A., Kannan, D. and Mathiyazhagan, K., 2014. Analysis of enablers for implementation of sustainable supply chain management–A textile case. Journal of cleaner production, 83, pp.391-403.
2. HOSSAIN, S. and HENA, H., 2024. The study explores the correlation between cultural influence and community engagement in fostering social safety for tourists.
3. Shiferaw, B., Prasanna, B.M., Hellin, J. and Bänziger, M., 2011. Crops that feed the world 6. Past successes and future challenges to the role played by maize in global food security. Food security, 3, pp.307-327.
4. Hossain, S. and Nur, T.I., 2024. Gear up for safety: Investing in a new automotive future in China. Finance & Accounting Research Journal, 6(5), pp.731-746.
5. Nakib, A.M. and Barua, B., AQUA FLOW MASTER: INTELLIGENT LIQUID FLOW CONTROL AND MONITORING SYSTEM.
6. Sarac, A., Absi, N. and Dauzère-Pérès, S., 2010. A literature review on the impact of RFID technologies on supply chain management. International journal of production economics, 128(1), pp.77-95.
7. Nakib, A.M., Luo, Y., Emon, J.H. and Chowdhury, S., 2024. Machine learning-based water requirement forecast and automated water distribution control system. Computer Science & IT Research Journal, 5(6), pp.1453-1468.
8. Hossain, S. and El Hebabi, I., 2024. Cultural dynamics and consumer behavior: An in-depth analysis of Chinese preferences for western imported products.
9. Aday, S. and Aday, M.S., 2020. Impact of COVID-19 on the food supply chain. Food Quality and Safety, 4 (4), 167–180.
10. Ivanov, D. and Dolgui, A., 2020. Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak. International journal of production research, 58(10), pp.2904-2915.
11. Moncayo-Martínez, L.A. and Zhang, D.Z., 2011. Multi-objective ant colony optimisation: A meta-heuristic approach to supply chain design. International Journal of Production Economics, 131(1), pp.407-420.

12. Beske, P. and Seuring, S., 2014. Putting sustainability into supply chain management. Supply Chain Management: an international journal, 19(3), pp.322-331.
13. Hobbs, J.E., 2020. Food supply chains during the COVID-19 pandemic. Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie, 68(2), pp.171-176.
14. Christopher, M. and Holweg, M., 2011. "Supply Chain 2.0": Managing supply chains in the era of turbulence. International journal of physical distribution & logistics management, 41(1), pp.63-82.
15. Pettit, T.J., Fiksel, J. and Croxton, K.L., 2010. Ensuring supply chain resilience: development of a conceptual framework. Journal of business logistics, 31(1), pp.1-21.