1st World Congress on Industrial Engineering and Operations Management
October 9-11, 2024
Publisher: IEOM Society International, USA DOI: 10.46254/WC01.20240108
Published: October 09, 2024

Automated Inventory Management for a Regional Fireworks Company: Boosting Efficiency and Cutting Costs

Karii Gribanov, Blade Beaubouef, Nabin Sapkota, Shahriar Hossain
Department of Engineering Technology,
Northwestern State University
Natchitoches, Louisiana, USA
Kgautreauxgrib349958@nsula.edu, bbeaubouef213081@nsula.edu,
sapkotan@nsula.edu, hossains@nsula.edu

Abstract

The team designed a fully automated, user-friendly inventory management system for a small fireworks business active in the southern United States region. The company decided to update its inventory management system to save time and money on the receiving and giving end of sales. Employing MS Excel with macro extensions, the team combined client, supplier, and transaction data to optimize operations. This system boosted efficiency by approximately 50% and saved the company $30,990 annually by cutting labor, software, and system maintenance. This offered the team hands-on experience, allowing them to hone their technical skills in a real-world problem-solving environment.

Keywords:

Automated, VBA Editor, MS Excel, Inventory, Businesses

1. Introduction

The company operates throughout the southern region of the US, specializing in organizing firework displays for various events. Each display is carefully synchronized with curated music selections. Both micro and medium-sized businesses require clear financial statements that are accurately recorded in bookkeeping, which cannot be overlooked (Nino et al. 2019). Since the company sells class C fireworks they must adhere to governmental safety regulations. Automated inventory systems assist businesses in staying compliant with regulations by delivering accurate, real-time inventory data and supporting traceability across the supply chain (Okotie 2023).

Inventory management is vital for most companies, but it's particularly important for small businesses, as they typically have fewer resources and less bargaining power than larger companies, which can negatively impact their ability to manage inventory effectively (Bai and Zhong 2008). The company partnered with the Department of Engineering Technology at Northwestern State University to enhance its inventory system by transitioning to an automated solution (Svetsomboon and Savatsomboon 2013). To maintain continuity with its previous inventory management processes and minimize subscription expenses, the company opted to continue using MS Excel. Since macros offer a flexible and perhaps underutilized tool for assisting researchers in obtaining clean, analyzable datasets (Bauzon *et al.* 2021). The team developed a system in MS Excel that operates using macros within the Microsoft Windows environment. To efficiently handle data related to customer orders, suppliers, and products, a tailored system was designed to meet the company's specific requirements. This approach aligns with the methodology described by Ovezmyradov, B., Meuthia, Y., & Kurata, H. (2016).

This inventory system is important for the company to efficiently fulfill government requirements. By swiftly locating and tracking past customer orders, the company will be well-prepared for the annual audit. Additionally, the system enhances customer satisfaction by expediting the ordering process through order tracking. Another benefit of adopting a fully automated inventory system is achieving precise inventory tracking (Apolonio and Norona 2021). Automation provides accurate inventory management, decreasing the likelihood of errors like overstocking or stockouts. This method supports maintaining optimal inventory levels and prevents costly mistakes. Consequently, it enhances customer satisfaction by ensuring quicker and more accurate order fulfillment. Timely and correct deliveries lead to positive customer feedback and greater loyalty to the business.

1.1 Objective

The objective of this project is to design a cost-effective, user-friendly computerized inventory management system that allows the company to efficiently manage its inventory without the need for additional staff, while ensuring compliance with city, state, and federal regulations. To address this, the team utilizes MS Excel to develop an automated and user-friendly inventory system.

2. Literature Review

The palm oil industry is a vital sector of Malaysia's economy, playing a significant role in both its exports and economic growth. As the world's second-largest producer of palm oil, Malaysia faces growing demands that necessitate efficient operations, particularly in inventory management. Ismail and Al-Hadi (2021) highlight the importance of an effective inventory control system to manage the complexities of the palm oil supply chain. One of the major challenges stems from the varying ages of palm oil trees, as they have a distinct production lifecycle—yielding the highest fruit output between the ages of 7 and 24 years, with productivity diminishing thereafter. This variation in tree age complicates inventory control and underscores the need for systems that can track and forecast production cycles, ensuring that supply aligns with consumer demand. To address these challenges, the introduction of computerized inventory control systems has emerged as a solution. MS Excel Macro application systems have been adopted as a practical alternative to manual inventory management, providing a more organized and efficient approach. These systems leverage automation tools, such as the Economic Order Quantity (EOQ) model, which helps optimize order quantities and reduce costs. Ismail and Al-Hadi (2021) argue that such automated systems not only streamline processes but also facilitate quicker decision-making by enabling companies to access real-time data, track inventory levels, and forecast demand more accurately.

Beyond industry applications, the role of simulation games in engineering and supply chain education demonstrates the growing integration of technology into inventory management practices. Ovezmyradov et al. (2016) describe the use of the beer distribution game, a popular tool in teaching supply chain management, which has faced limitations in multiplayer scenarios due to its complexity. To overcome these issues, the Supply Chain Competition Game, a spreadsheet-based system compatible with MS Excel, has been introduced. This game offers enhancements such as multiplayer support, improved usability, and real-time performance monitoring, making it a valuable educational tool. The parallels between the game's ability to simulate supply chain dynamics and the real-world application of inventory management systems in industries like palm oil suggest a shared emphasis on efficiency, real-time data analysis, and practical, intuitive tools for decision-making. Overall, the adoption of automated inventory management systems, particularly through user-friendly platforms like MS Excel, has proven essential in managing the complexities of industries such as palm oil. By integrating advanced tools like EOQ models and simulation-based learning, these systems enhance operational efficiency and contribute to better-informed decision-making in dynamic supply chain environments.

3. Methods

The development of the proposed automated inventory management system for this project is implemented through 18 distinct steps, outlined in Table 1 and Table 3.

Figure 1. Screenshot of Macros

Table 1. Steps to develop the proposed automated inventory management system on Excel

Steps	Activity	Description
1	Admin Access	Begin by organizing the workspace into two columns designated for administrative purposes, as shown in Table 2. Later, hide these columns to streamline the interface for users.
2	Add Title	Use a text shape tool to add a bold, centered title "Inventory Management System" for consistency and clarity.
3	*Introduce Button Sets*	Create button sets for various categories, starting with "Customers." Design these buttons to have no fill or outline for a clean appearance.
4	*Apply Background*	Enhance the visual appeal of the worksheet by applying a background from a stored file.
5	*Create Menu*	Insert additional shapes filled with the same color as the title to maintain coherence. Remove outlines and adjust their size. Label each menu option, including "Customers," with a font size of 18 for easy readability.

Table 2. Admin Access

Admin Uses	
Sel. Tab	PURCHASES
Order Load	TRUE/FALSE
Order Row	
Next Order #	
Sel. Order Row	
Search Order Row	
Cust/Supplier Row	
Sel. Cust Row	
Next Cust. ID	
Sel. Supp Row	
Next Supp ID	
Sel. Product Row	
Next Prod ID	

Search Customer

Add New Customer

CUSTOMER LIST

Cust ID	Cust. Name	Address	City	State	ZIP	Phone	Email
1	John Doe	Insufficient	Natchitoches	LA	71457	000-000-0000	jdoe@me.com
3	**John Doe**	**Insufficient**	**Natchitoches**	**LA**	**71459**	**000-000-0002**	**jdoe@me.com**
4	John Doe	Insufficient	Natchitoches	LA	71460	000-000-0003	jdoe@me.com
5	John Doe	Insufficient	Natchitoches	LA	71461	000-000-0004	jdoe@me.com
6	John Doe	Insufficient	Natchitoches	LA	71462	000-000-0005	jdoe@me.com
7	John Doe	Insufficient	Natchitoches	LA	71463	000-000-0006	jdoe@me.com
8	John Doe	Insufficient	Natchitoches	LA	71464	000-000-0007	jdoe@me.com
9	John Doe	Insufficient	Natchitoches	LA	71465	000-000-0008	jdoe@me.com
10	John Doe	Insufficient	Natchitoches	LA	71466	000-000-0009	jdoe@me.com
11	John Doe	Insufficient	Natchitoches	LA	71467	000-000-0010	jdoe@me.com

Figure 2. Screenshot of Customer List

Table 3. Steps to develop the proposed automated inventory management system on Excel (Continued…)

Steps	Activity	Description
6	Adjust Alignment and Margins	Make alignment and margin adjustments to ensure uniformity among menu items. Duplicate items for each button, label accordingly and rename for easy identification.
7	Add Connector Lines and Icons	Insert connector lines between menu items, matching their color and adjusting weight. Add icons to menu items and align them vertically.
8	Ensure Clarity and Consistency	Give all menu items and icons unique names and group them. Adjust properties to prevent resizing cells. Allocate administrative columns for essential data [Figure 1].
9	Apply Conditional Formatting	Improve data visibility and organization by applying conditional formatting for alternating row colors and highlighting selected or new rows.
10	Utilize Formulas	Use formulas to determine the row associated with selected suppliers/customers and order details. Copy relevant information from other sheets and paste it into the inventory manager sheet, making necessary adjustments Jelen and Syrstad (2022).
11	Create Macros	In the Visual Basic for Applications (VBA) editor, create macros to change the appearance of selected menu tabs. Ensure these macros reset the appearance of all menu tabs and modify the appearance of the selected tab based on predefined criteria (Ji and Hu 2024)
12	Implement Event Handlers	Save changes and implement event handlers to call macros when menu tabs are selected, ensuring a seamless user experience.
13	Refresh Customer List	Initiate a process to refresh the customer list when clicking on the "Add New" button to ensure real-time updates.
14	Determine Selected Row	Identify the next available row for new customer entries to maintain data integrity.
15	Store Information and Enhance Navigation	Store selected row information for reference and add visual indicators for new records. Adjust the scroll window to display newly added customer entries for enhanced navigation.
16	Enable Input and Update List	Allow users to input new customer details directly into the spreadsheet. Confirming the entry triggers the addition of the new customer to the list, which dynamically updates to include the new entry [figure 2].
17	Extend Functionality	Extending similar functionality to managing suppliers and products, ensuring consistency across different categories within the inventory management system.
18	Implement Delete Functionality	Assign dedicated macros to delete buttons for each category. Display confirmation prompts before proceeding with deletion. Retrieve selected row information and handle the deletion process securely and reliably. Refresh the list after successful deletion to maintain data integrity [Figure 3]

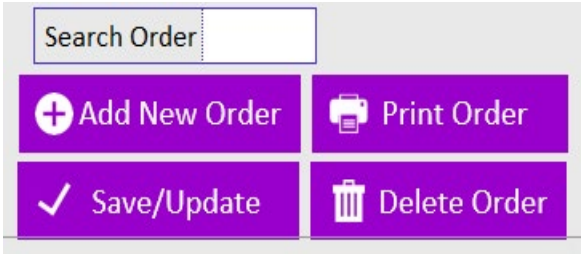

Figure 3. Screenshot of Delete Button

4. Data Collection (12 font)

A fully automated inventory management system enhances efficiency and effectiveness by updating inventory control processes. With organized workflows and a user-friendly interface, it simplifies operations and improves usability. The introduction of button sets and a cohesive menu design improves navigability and accessibility, with uniform icons and adjustments ensuring easy identification and intuitive user interaction. The data in this section has been simulated by the team to protect the privacy of the company and its customers [figure 1]..

The system's use of conditional formatting and dynamic updates enhances inventory management by improving data visibility and organization. [Figure 4]. Real-time updates ensure users always have access to the most current information.

Figure 4. Screenshot of monthly profits

The automated system simplifies the process of updating customer lists and adding scrolling functionality. With automated refresh and intuitive row selection, users can efficiently add new entries while ensuring data integrity and minimizing errors.

Sales Order #55	SALES ORDER			Order Date	9/17/2024
Customer	John Doe			Subtotal	$ 756.00
	Insufficient			Tax	$ 75.60
	Natchitoches, LA, 71459			Total	$ 831.60
Product	**Description**	**Qty**	**Sales Price**		**Total**
2.5" Dominator Dun Pai B1 Assortment (24/4) American		4	$189.00		$ 756.00

Figure 5. Screenshot of new customer entry.

The system's delete functionality [Figure 6] ensures secure record removal, preventing accidental data loss. Confirmation prompts and data refresh procedures give users confidence in managing inventory data effectively

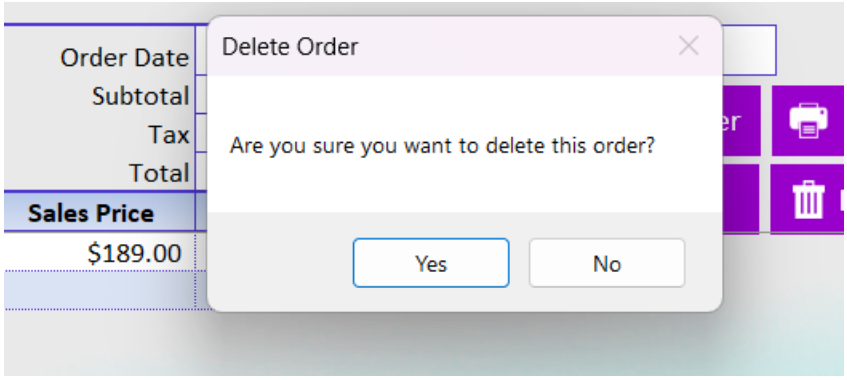

Figure 6. Screenshot of delete function on new customer entry.

The fully automated inventory management system boosts efficiency, accuracy, and user satisfaction. By using automation and intuitive design, it helps users manage complex tasks more easily, enhancing overall productivity.

5. Results and Discussion

Implementing a fully automated inventory management system improves the efficiency and effectiveness of inventory control by organizing the workspace into streamlined columns and a user-friendly interface. The addition of

categorized button sets, a cohesive menu design, and visually consistent elements like icons and margin adjustments enhance navigability, accessibility, and intuitive user interaction.

The system enhances inventory management efficiency by integrating conditional formatting, dynamic data updates, and real-time information. Features like alternating row colors and highlighted entries improve data visibility and organization, ensuring users always have access to the most up-to-date information. The automated system streamlines updating customer lists and implementing scrolling functionality with automated refresh mechanisms and intuitive row selection algorithms. This allows users to efficiently add new entries while maintaining data integrity, improving usability, and reducing the risk of errors. The system's delete functionality ensures secure and reliable record deletion, with confirmation prompts and data refresh procedures preventing accidental data loss. Overall, the fully automated inventory management system improves efficiency, accuracy, and user satisfaction. By combining automation with intuitive design, it empowers users to handle complex inventory tasks easily, enhancing productivity.

5.1 Equations

Listed below are the following equations that involve forecasting future demand for products or services and using that insight to plan ideal production levels, inventory quantities, and material purchases (Opara 2023).

Managing Inventory Systems

$$X_{i+1} = X_i + X_j - d$$

where *X* represents the quantity of the item, where the subscript *i* denotes the beginning quantity, and *j* indicates the purchased quantity, and where *d* denotes the consumption. For instance, if the company is preparing for the Natchitoches City of Lights Christmas Festival show and the customer orders six 2.5" FK Green Glitter Fireworks, the program would automatically adjust the inventory to reflect that there are now 90 left in stock [figure 7].

11	2.5" FK Green Glitter Wolverine				96
12	2.5" GalaStar Two Break Canister Shells Wolverine				96
13	2.5" FB Solid Cases-All colors Orange/Silver/Assorted Wolverine				96

11	2.5" FK Green Glitter Wolverine				90
39	3.0" USD Glitterinf gold to blue Wolverine				72
75	4.0" FK Glittering Green Pistil Waterfall Dahlia Wolverine				36

Figure 7. Comparison of a quantity of 2.5" FK Glitter Fireworks

Reorder Point (ROP)

$$ROP = (d_\tau * \tau) + S_r$$

Where $S_r = Saftey\ Stalk$

The reorder point is the inventory level at which a new order should be placed. It is calculated based on the expected demand during the lead time, the time between placing an order and receiving it, and the desired safety stock level.

Economic Order Quantity (EOQ)

$$EOQ = \sqrt{\frac{2DP}{C}}$$

where, D Denotes the Demand, P denotes the Ordering Cost, and C denotes the Holding Cost per Unit. EOQ represents the optimal order quantity that minimizes the total inventory costs, including ordering costs and holding costs. It balances the cost of ordering against the cost of holding inventory.

Safety Stock

$$S_r = \left(Z_s core \times \sigma_{d_\tau}\right) \times \sqrt{\tau}$$

Where σ_{d_τ} represents the standard deviation during lead time, and τ represents the lead time. Safety stock is a buffer of extra inventory maintained to mitigate the risk of stockouts due to variability in demand or lead time. The Z-score corresponds to the desired level of service level or probability of not stocking out.

Service Level

$$Service\ Level = 1 - P_{Stockout}$$

Where $P_{Stockout}$ represents the probability of stock outs occurring. Service level represents the probability that demand will not exceed supply during the lead time. It is often used in conjunction with safety stock calculations to determine the appropriate level of inventory to maintain.

Inventory Turnover

$$Inventory\ Turnover = \frac{Cost\ of\ Goods\ Sold}{Average\ Inventory}\text{L}$$

Inventory turnover measures how efficiently inventory is being managed by indicating how many times inventory is sold and replaced within a given period. A higher turnover rate generally indicates better inventory management.

Lead Time

$$Lead\ Time = Time\ Between\ Placing\ an\ Order\ and\ Receiving\ it$$

Lead time can be deterministic (fixed) or stochastic (variable). Understanding lead time is crucial for accurately determining reorder points and safety stock levels.

These equations have been integrated into the algorithm that manages the inventory automatically, ensuring efficient replenishment and stock management without human intervention. Additionally, various optimization techniques and algorithms such as dynamic programming, linear programming, or simulation can be employed to improve inventory management further.

6. Conclusion

In conclusion, since Excel is commonly accessible software for small businesses, it serves as an effective tool for doing quantitative analysis in statistics (Herkenhoff and Folgi 2013). The development of a fully automated inventory management system using MS Excel presents a valuable opportunity to transform the company's inventory control processes and achieve its operational goals. Material planning is viewed as the tactical phase of the overall planning process, focusing on the demand and supply of goods. It involves initiating, controlling, and monitoring purchase orders (Kalwar and Khan 2020). While the current results are based on a sample test run, they demonstrate significant potential benefits, including streamlined administrative tasks, improved user interface design, and dynamic data updates, all in line with the project's objectives of cost-effectiveness, user-friendliness, and regulatory compliance.

The system's capacity to analyze historical data and identify customer behavior patterns supports informed decision-making and inventory optimization, like the work of Ravichandran and Kumar (2015) in managing consumables inventory in the pressure vessel manufacturing industry using Excel. By automating repetitive tasks and integrating with other business systems, the proposed solution can improve operational efficiency, optimize resource allocation, and enhance cross-departmental coordination. The next crucial phase involves rigorous testing, verification, and validation to ensure the system's effectiveness and reliability. Testing will involve real data to validate the system's accuracy in real-world scenarios. The inventory replenishment module will undergo thorough checks to confirm its ability to forecast demand, optimize stock levels, and manage timely orders. Likewise, the inventory consumption module will be tested for its ability to track usage, monitor trends, and generate actionable insights. Comprehensive testing of each component will ensure the system meets its goals of efficiency, accuracy, and regulatory compliance, ultimately leading to successful implementation and operational excellence

Although the system has yet to be fully implemented, the insights gained from the sample test run highlight its transformative potential. By leveraging technology to streamline processes, improve decision-making, and enhance operational performance, the company can better position itself for success in a competitive market landscape.

Acknowledgments

The team would like to express their gratitude to Kenyetta Jackson (administrative assistant of the Department of Engineering at NSU) and Craig George (Graduating Senior student of the Department of Engineering Technology at NSU) for their invaluable wisdom, guidance, and support throughout the development of this system.

References

Bai, L., & Zhong, Y. , *Improving inventory management in small business: A case study*. (Unpublished Master's Thesis), Jönköping International Business School, Jönköping University, Sweden, pp. 55,2008.

Bauzon, J., Murphy, C., & Wahi-Gururaj, S. (2021). Using macros in Microsoft Excel to facilitate cleaning of research data. *Journal of Community Hospital Internal Medicine Perspectives*, Vol. 11, Issue 5, pp. 653-657.

Herkenhoff, L., & Fogli, J. , *Applied statistics for business and management using Microsoft Excel*. New York: Springer, pp. 60,2013.

Ismail, S. Z., & Al-Hadi, A. K. A. (2021). Developing palm oil inventory control system using MS Excel macro. *Journal of Modern Manufacturing Systems and Technology*, Vol. 5, Issue 1, pp. 51-55.

Jelen, B., & Syrstad, T. , *Microsoft Excel VBA and Macros (Office 2021 and Microsoft 365)*. Microsoft Press, pp. 58,2022

Ji, X., & Hu, B. , Macros in Excel. In *E3S Web of Conferences* (Vol. 522, p. 01040). EDP Sciences, pp 4,2024.

Kalwar, M. A., & Khan, M. A. , Optimization of Procurement & Purchase Order Process in Footwear Industry by using VBA in MS Excel. *International Journal of Business Education and Management Studies (IJBEMS)*, Vol. 5, Issue 2, pp. 81,2020.

Nino, I. J., Manafe, J. D., & Setyorini, T. , Simple bookkeeping model using Microsoft Excel for culinary micro-business in East Nusa Tenggara, *Proceedings of the International Conference on Economics, Business, Social, and Humanities (ICEBSH)* pp. 29-41,2019.

Okotie, P. M. (2023). Automation of an inventory system, *Journal of Information Technology and Engineering* (Manuscript in preparation), pp. 7.

Opara, U. J. (2023) Automating Forecasting using Excel VBA, *Journal of Business and Data Analytics*, pp. 1

Ovezmyradov, B., Meuthia, Y., & Kurata, H. , Modeling and teaching inventory management in a multiplayer supply chain competition game using Excel and Google Sheets. *Asia Pacific Industrial Engineering and Management Systems Conference*, December 7-10,2016, Taipei, Taiwan.

Apolonio, S. D., & Norona, M. I. (2021). Automating inventory management in distribution centers of a leading fast-moving consumer goods (FMCG) industry player in the beverage market: A supply chain 4.0 journey. In *Proceedings of the Second Asia Pacific International Conference on Industrial Engineering and Operations Management*, Indonesia, September 14-16, pp. 1602-1614,2021.

Ravichandran, V., & Kumar, N. G. , "Establishing Control on Consumables Inventory in a Pressure Vessel Manufacturing Industry Using Microsoft Excel (A Case Study)," *International Journal of Research in Engineering and Technology,* Vol. 04, Issue 04, pp. 288-292,2015.

Svetsomboon, S., & Savatsomboon, G. A. (2013) Case Study: Improving Business Operations at Wongpanit Donmuang Using Microsoft Excel, The 2nd IBSM, International Conference on Business and Management, 2 – 4 October, Chiang Mai – Bangkok.

Biographies

Karii Gribanov is a graduating senior at Northwestern State University working on her bachelor's degree in industrial engineering technologies. Since starting at Northwestern, she has been founding president of the ATMAE student chapter where she and other members assisted the department with all academic and fundraising events. Karii is currently an intern at Roy O Martin working underneath the quality control department as a research assistant.

Blade Beaubouef is a graduating senior at Northwestern State University. He has been working on his bachelor's degree in industrial engineering technology and going for a minor in electrical engineering technology. Blade is currently a co-op at an international paper in mechanical maintenance.

Dr. Shahriar Hossain is the Department Head and Associate Professor of Engineering Technology at Northwestern State University. With over 15 years of experience, he specializes in manufacturing systems optimization. He has published extensively, earned multiple awards, and holds certifications in industrial robotics and PLC systems.

Dr. Nabin Sapkota is an Associate Professor of Engineering Technology at NSU. He holds a B.E. in Production from India and an M.S. and Ph.D. in Industrial Engineering from the University of Central Florida. His expertise includes operations research, simulation, and nonlinear dynamical systems.