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Proposed Production Scheduling at Bottle King Solutions Services Inc.

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Abstract
Bottle King Solutions Services Inc., a plastic bottle manufacturing company, faces inefficiencies in production scheduling, leading to overproduction and excess inventory. This study aims to develop a production scheduling system that is optimized by reviewing two years of sales data, resource availability, and production limitations. The company typically generates around 97,580 bottles each day, which is higher than the actual requirement of 83,768 units, causing excess inventory and inefficient resource allocation. By utilizing production scheduling methods such as demand forecasting and resource allocation analysis, the study uncovers inefficiencies in labor efficiency, raw material consumption, and equipment usage. Results suggest that synchronizing production schedules with market demand could decrease overproduction by roughly 15%, reduce raw material waste, and enhance machine utilization. The suggested scheduling framework advises adopting a demand-focused strategy, optimizing batch sizes, and improving workforce distribution to boost productivity. These enhancements aim to shorten lead times, decrease storage expenses, and increase operational efficiency, thereby ensuring sustainable growth and profitability for the organization.

Keywords: Production Scheduling, Resource Optimization, Overproduction Management

1. Introduction

Effective production scheduling relies on a thorough grasp of market possibilities and the expenses related to production, sourcing, inventory, and distribution throughout the planning period. Traditionally, manufacturing systems that produce multiple products often struggled with the challenge of efficiently distributing limited resources across each production line to reduce costs (Kim, 2020). This issue became even more pressing for companies like Bottle King Solutions Services Inc., which is situated in Sitio Pamutungan Jubay, Liloan, Cebu. As a manufacturer focused on large-scale production of plastic bottles, Bottle King held an important position in its field, recognized for its wide range of products that met various market demands. Its product offerings spanned from 250ml, 350ml, and 500ml bottles to 1-liter, 4-liter, and 5-gallon containers, including slim bottle varieties designed for specific applications. This broad product assortment allowed the company to serve a diverse clientele, comprising Bottled Water

Companies, Beverage Manufacturers, and the Food Sector. Furthermore, Bottle King strategically engaged with Retailers, Distributors, and Government Contracts, thereby ensuring a consistent stream of business opportunities and a varied revenue source. The company's capacity to address the needs of both individual customers and businesses illustrated its adaptability in navigating market complexities. Nevertheless, as its operations expanded in both scale and range, the necessity for effective resource distribution and production scheduling grew increasingly vital for maintaining its position in the industry.

Despite achieving significant success, Bottle King Solutions Services Inc. encountered substantial challenges in enhancing its operational efficiency. A major concern was overproduction, which led to an overflow of inventory in its warehouse, with total output reaching 97,580 units while overall demand was only 83,768 units. This excess production resulted from ineffective production scheduling, as production rates failed to match the actual demand trends. Consequently, units that remained unsold cluttered the warehouse as part of the routine process, creating a cycle of persistent overstocking. This surplus not only consumed valuable storage space but also tied up resources that could have been used more effectively. Adding to the complexity were unpredictable customer demands, poor raw material utilization, and the lack of a robust production capacity planning system, which made it hard for the company to synchronize supply and demand. To address this issue, the company needed to adopt a more precise production scheduling system that would better align production rates with real demand, thereby ensuring optimized inventory levels and more efficient use of resources.

The purpose of this study was to develop an improved production scheduling system at Bottle King Solutions Services Inc. By analyzing the company’s historical production methods, resource distribution practices, and scheduling limitations, the research sought to offer practical recommendations for enhancing resource efficiency and streamlining production processes. The emphasis was on synchronizing production schedules with market needs to minimize both overproduction and excess inventory, guaranteeing that production levels aligned with real sales demands.

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2. Theoretical Framework

Figure 1: Theoretical Framework of the Study

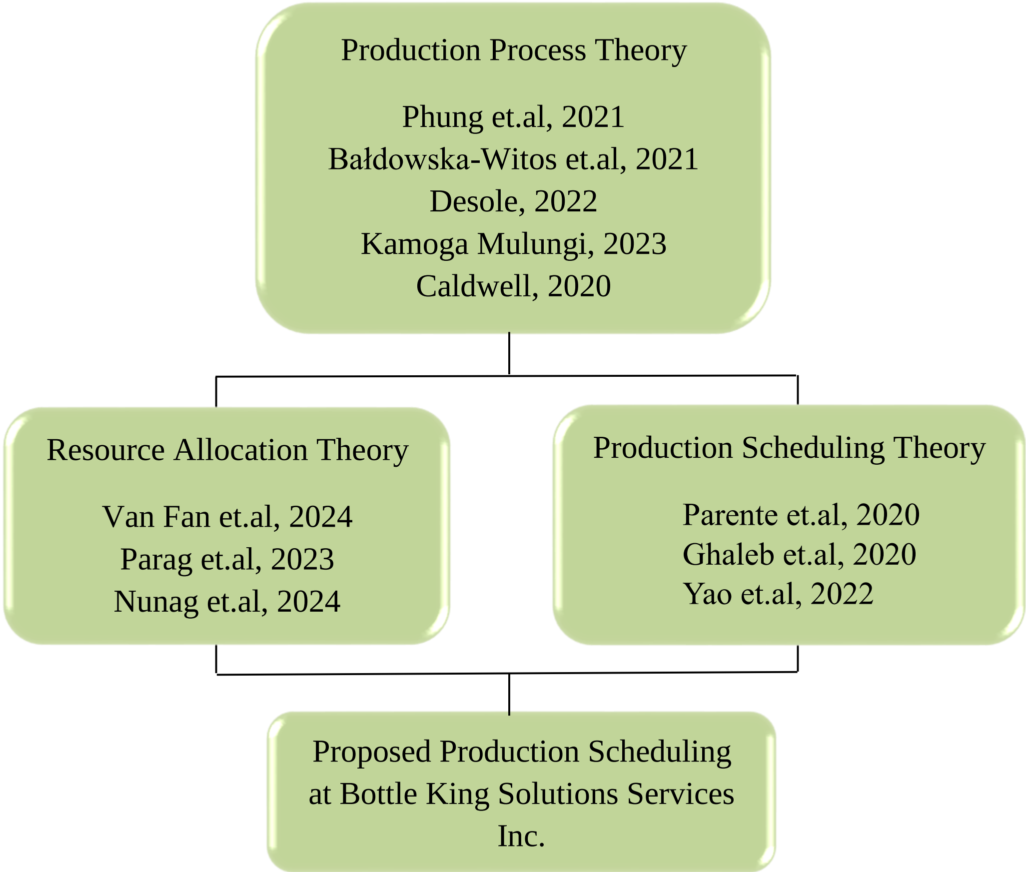


Figure 1 illustrates the theoretical framework employed in this research, which aimed to merge established theories to improve production scheduling practices at Bottle King Solutions Services Inc. This framework is based on three fundamental theoretical principles: Production Process Theory, Resource Allocation Theory, and Production Scheduling Theory. The Production Process Theory emphasized the sequence of activities and transformations that took place from the initial raw materials to the completion of finished goods. A vital aspect of this theory was to ensure a seamless production process from material procurement to the production and distribution of the end product. As noted by Phung et al. (2021), the complexity of the production process varied depending on the product type and the operational scale. For example, straightforward manufacturing processes consisted of only a few steps, such as assembly, whereas more intricate processes involved stages like material handling, quality inspections, and packaging. Regardless of the level of complexity, the primary objective remained to eradicate inefficiencies such as delays, waste, or bottlenecks that could hinder the production flow.

In this context, Bałdowska-Witos et al. (2021) emphasized that comprehending the flow of materials and labor was crucial in production management. The effective coordination of labor, equipment, and materials facilitated the achievement of production objectives within the targeted timeframe. The implementation of modern technologies, including automation and lean principles, improved this flow by minimizing the chances of bottlenecks or disruptions that could result in delays or increased expenses.

Furthermore, optimizing the flow required balancing different production components such as labor, machinery, and materials, ensuring that no step in the process was overstaffed or underutilized, thus contributing to more reliable and efficient production cycles (Desole, 2022).

In addition, Kamoga Mulungi (2023) highlighted that a production process needed to be crafted with both scalability and flexibility in consideration. In today's rapidly changing market, businesses had to swiftly adapt to variations in consumer demand or shifts in the supply chain. A rigid production process resulted in inefficiencies when demand surged or declined, as the company may have struggled to modify its capacity in response. By creating a process that could easily scale up or down, companies could better respond to market fluctuations, reduce waste, and sustain high levels of efficiency despite uncertainty (Caldwell, 2020). This level of adaptability ensured that businesses could meet customer expectations without overwhelming their production capabilities.

The Resource Allocation Theory played a vital role in managing production effectively by concentrating on the strategic distribution of limited resources—such as workforce, materials, machinery, and capital—across different production processes. The objective of resource allocation was to utilize resources efficiently, fulfilling both production targets and strategic business aims while reducing costs and minimizing waste.

A fundamental concept of resource allocation, as highlighted by Van Fan et al. (2024), was the necessity for organizations to effectively prioritize their resources in alignment with their strategic objectives. This required making choices about where to direct limited resources to achieve optimal outcomes, taking into account both immediate demands and future goals. For instance, when a company encountered restrictions on labor hours or raw materials, decisions regarding resource allocation aimed to ensure that these resources were focused on the most essential or high-value activities. By prioritizing the most profitable or critical products over those of lesser importance, it ensured that resources were utilized in a way that significantly contributed to the organization's success. This strategic alignment avoided the improper distribution of resources, guaranteeing that production efforts consistently matched the company's overarching vision and objectives.

Additionally, Parag et al. (2023) asserted that successful resource distribution necessitated decision-making that took into account both internal and external limitations. Internal limitations encompassed aspects like the existing workforce, production capacities, and internal workflows, while external constraints included supply chain issues, market changes, or regulatory demands. Organizations factored in these limitations when determining how to allocate their resources.

In practice, resource distribution sought to enhance the productivity of available assets while reducing inefficiencies such as downtime and underutilization. Nunag et al. (2024) underscored the significance of managing resource usage to prevent both overexploitation and underexploitation. Overexploitation could lead to resource exhaustion and increased wear on machinery, whereas underexploitation caused inefficiencies and elevated operational expenses. For instance, machinery that was not fully utilized or idle labor incurred costs without contributing to output. Resource allocation strategies aimed to achieve the most effective use of all assets, ensuring that each resource was placed where it would yield the greatest benefit.

A vital element of resource allocation theory was the idea of balancing competing needs. In manufacturing, numerous demands for limited resources often arose simultaneously. For example, various production lines or departments might require access to the same equipment or workforce concurrently. Efficient resource allocation prioritized these needs and distributed resources in a manner that reduced conflict and ensured that the most critical tasks were addressed first. This became particularly difficult when demand changed or when unexpected disruptions, such as supply chain holdups or workforce shortages, arose. In such instances, the capacity to swiftly modify resource allocation to align with evolving demands was crucial for sustaining production continuity and minimizing losses.

Production Scheduling Theory was a crucial element in manufacturing and operations management that concentrated on structuring and planning tasks as well as resource distribution to maximize efficiency and ensure that production targets were achieved. It served as an essential part of the overall production process by making certain that the appropriate resources—such as labor, equipment, and materials—were deployed at the correct times to reach the intended output without unnecessary delays or shortages of resources.

An important aspect of production scheduling was optimizing the resources at hand while adhering to tight deadlines. As noted by Parente et al. (2020), successful scheduling enabled businesses to assign tasks effectively, reducing downtime and avoiding both underutilization and overutilization of resources. By thoroughly assessing the availability of resources, the demands of the tasks, and the time required for various operations, production schedulers developed balanced strategies that ensured heightened productivity while keeping costs low. The objective was to guarantee that each phase of the production process was executed punctually, without delays, and using the minimum necessary resources, while also being adaptable to unforeseen changes or disruptions.

As highlighted by Ghaleb et al. (2020), production scheduling included aligning demand with the available capacity. The process was overseen in such a manner that companies could satisfy customer demand without surpassing their resource constraints. This involved coordinating production capacity, labor hours, and material availability with demand projections. Additionally, scheduling took into account external variables like supplier lead times, variations in demand, and potential disruptions in the supply chain, all of which had a significant effect on a company's capability to reach production objectives. Techniques such as the Just-in-Time (JIT) system, Capacity Requirements Planning (CRP), and Materials Requirements Planning (MRP) were frequently employed to navigate these complexities.
In accordance with this, Yao et al. (2022) highlighted that an effectively organized production schedule not only maximized resource efficiency but also improved collaboration among different departments, including procurement, production, and distribution. A comprehensive schedule made certain that each department was aware of when to deliver materials, when to start production, and when to get ready for shipping, thereby decreasing the likelihood of miscommunication or delays. Scheduling also played a crucial role in overseeing inventory levels, making sure that raw materials and finished products were

accessible when required, while avoiding the buildup of excess stock that could incur storage costs or lead to inventory obsolescence.

Furthermore, scheduling contributed to minimizing downtime, which is one of the most significant challenges in production settings. Downtime may arise from various issues, such as maintenance requirements, supply delays, or lack of sufficient labor. By planning tasks and resources ahead of time, production managers could ensure that required resources were ready when needed and that equipment maintenance was carried out during off-peak production hours, thus reducing interruptions to the entire production process.

In addition, an efficient production schedule promoted adaptability and responsiveness in manufacturing. The production environment was frequently subject to change, with product demand varying, new orders being placed, and unexpected situations occurring. Scheduling systems that possess the flexibility to respond to these alterations, such as by employing real-time data for on-the-fly adjustments, enabled businesses to satisfy customer demands without overwhelming resources or causing delays.

3. Review of Related Literature

Analyzing sales performance is essential for manufacturing firms, as it directly impacts strategic choices and the distribution of resources. (Missbauer & Uszoy, 2020) point out that sales evaluations help businesses recognize products with high demand, streamline inventory management, and adapt promptly to market shifts. Research conducted by (Lapide, 2021) underlines that keeping track of sales for different sizes of plastic bottles enables manufacturers to customize their production strategies, thus fulfilling customer preferences while maximizing profits. Additionally, (Dittfeld et al., 2020) discovered that accurate sales forecasting is vital for synchronizing production plans with consumer demand, ultimately improving operational effectiveness.

This methodology is closely associated with production scheduling. By precisely assessing sales performance, companies can predict demand more accurately and coordinate their production timelines with anticipated sales. Production scheduling ensures that the required resources—such as workforce, machinery, and raw materials—are at hand to meet production goals without overwhelming or underusing the system (Lee et al., 2024). Effective scheduling enables manufacturers to allocate resources optimally, preventing delays and assuring that production operates smoothly in response to market needs. In this manner, data on sales performance directly influences production scheduling decisions, refining production flow and boosting overall operational efficiency.

The current status of resource availability—comprising raw materials, labor, and machinery—is vital for sustaining production scheduling in manufacturing. (Parente et al., 2020) highlight that efficient management of these resources reduces production holdups and facilitates timely customer deliveries. A study by (Bakke & Hellberg, 2021) reinforces that having a thorough comprehension of input availability allows companies to enhance their production schedules, minimize waste, and improve overall output. Furthermore, (Permana et al., 2021) found that businesses with a comprehensive awareness of their resource availability are better prepared to make well-informed decisions regarding resource allocation and necessary operational adjustments.

The management of raw materials is essential for effective production scheduling. According to Chandra et al. (2021), strategically managing raw material supplies can lead to a significant decrease in production delays and budget excesses. Accessing high-quality raw materials consistently is vital to fulfilling production timelines and meeting customer needs, as shown by Tineo et al. (2023). Reliable raw material sourcing guarantees that production can continue uninterrupted, which is essential for efficient scheduling, as stated by Missbauer & Uzsoy (2020).

The availability of labor is similarly important for ensuring smooth production operations. Alamgir Hossain (2020) points out that optimizing labor distribution reduces downtime and boosts overall productivity. Flexible scheduling, as highlighted by Chandra et al. (2021), enables companies to adjust their workforce according to changing demand, ensuring production requirements are met without overextending resources. Furthermore, Ertogal & Öztürk (2020) underscore the significance of cross-training staff, which enhances workforce flexibility and promotes effective labor utilization, benefiting production scheduling.

Equipment availability is also critical for production scheduling. Yao et al. (2022) illustrate that properly maintained machinery lowers the likelihood of downtime and enhances production efficiency. Investing in modern machinery, as emphasized by Owens (2023), improves production scheduling and ensures more consistent operations. Regular maintenance and timely upgrades, as suggested by Lohmer & Lasch (2021), are vital for averting unexpected equipment failures and maintaining continuous production flow. By ensuring both the availability and reliability of equipment, companies can prevent delays and improve their scheduling accuracy.

Assessing the current inefficiencies and limitations within a manufacturing firm is essential for identifying areas that need improvement and streamlining production processes. Research by (Parente et al., 2020) indicates that such inefficiencies can increase operational costs and decrease profits, underscoring the importance for companies to analyze their production capabilities. (Lohmer & Lasch, 2021) argue that recognizing constraints in factors like raw material availability, labor hours, and production capacity enables manufacturers to devise strategies focused on enhancing production scheduling and ensuring prompt product delivery. Furthermore, (Fu et al., 2021) points out that companies that regularly assess and address inefficiencies are more likely to maintain a competitive advantage in fast-evolving markets.

This assessment is closely linked to production scheduling. By uncovering inefficiencies and limitations, manufacturers can plan and modify schedules more effectively in accordance with the resources at hand. Evaluating raw material availability, labor hours, and capacity constraints facilitates the creation of more feasible production plans, ensuring that manufacturers can satisfy customer needs without overextending their resources.

The access to raw materials is crucial for efficient production scheduling. (Mohammadi, 2020) illustrates that inconsistent access to high-quality raw materials can lead to production setbacks and increased expenses. Studies by (Teerasoponpong & Sopadang, 2021) show that supply chain disruptions can considerably affect raw material availability, compelling manufacturers to pause operations or opt for less efficient alternatives, thus exacerbating capacity limitations. Poor management of raw materials can hinder a company's ability to scale its production, which directly affects production scheduling, as highlighted in the findings of (Trebuna et al., 2022).

Labor hours are a key element that affects production scheduling. (Ghaleb & Taghipour, 2020) indicate that inadequate labor allocation can result in idle time and failure to meet production objectives. (Liu et al., 2022) emphasize that companies may find it difficult to adapt to fluctuating production demands without strong workforce management strategies, making scheduling even more challenging. Rigid labor hour policies, as mentioned by (Berry & Vollman, 2020), can pose challenges in responding to market changes, ultimately hindering the optimization of production schedules and timely delivery.

Equipment capacity limitations significantly restrict the ability to diversify product offerings or satisfy market demand. (Mateljak & Mihanović, 2020) note that constraints in equipment capacity can impede a company's capability to broaden its product line, resulting in lost revenue opportunities and diminished customer satisfaction. (Yao et al., 2022) indicate that production bottlenecks often force manufacturers to prioritize high-margin products over variety, negatively affecting their responsiveness to customer preferences. (Sunday et al., 2021) emphasize that poor production scheduling leads to longer lead times and decreased responsiveness to customer needs, which highlights the necessity of precise scheduling to prevent these challenges and maintain market competitiveness.

Production scheduling is a vital aspect of successful manufacturing operations. A refined production scheduling strategy specifies the required resources, including raw materials, labor, and equipment, to meet anticipated demand. It ensures that a company can manufacture goods at the appropriate time and in the correct quantity without overwhelming the system. According to (Li & Ierapetritou, 2021), effective production scheduling is crucial for companies to satisfy customer demand while reducing downtime and operational inefficiencies. By aligning production scheduling with demand forecasts, businesses can evade both overproduction and stockouts, enhancing overall workflow.

Furthermore, production scheduling concentrates on resource allocation to achieve production goals within designated timeframes. A well-organized production schedule guarantees that tasks are completed in the most efficient order, reducing delays and optimizing resource utilization. (Chen et al., 2023) point out that production scheduling is essential for addressing capacity constraints, such as machine availability or labor shortages, by strategically arranging production activities to avoid bottlenecks. Production scheduling allows manufacturers to meet demand effectively. As indicated by (Danket et al., 2024), aligning this process is vital for improving production timelines, lowering costs, and increasing overall production efficiency. By consistently assessing and refining production scheduling, manufacturers can ensure a seamless operational flow and remain competitive in evolving markets.

4. Statement of the Problem

This study aims to develop a production capacity planning and scheduling system for Bottle King Solutions Services Inc.

Specifically, this study seeks to answer the following questions:

1.What were the sales of Bottle King Solutions Services Inc. products over the past two years in terms of:

1.1 250 ml;
1.2 350 ml;
1.3 500 ml;
1.4 1 Liter
1.5 4 Liter;
1.6 5 Gallon;
1.7 Slim;

2. What is the current availability status of Bottle King Solutions Services Inc. in terms of:
2.1 Raw Materials;
2.2 Labor Hours;
2.3 Equipment;

3. What are the current inefficiencies and constraints within Bottle King production processes in terms of:
3.1 Availability of Raw Materials;
3.2 Limited Labor Hours;
3.3 Equipment Capacity;

4. What production scheduling strategies can be implemented at Bottle King Solutions Services Inc. to improve resource utilization, mitigate overproduction and align production with market demand?

5. Based on the findings, what recommendations can be made to improve Bottle King's production processes and profitability?

5. Significance of the Study

This study held considerable significance for various stakeholders involved with Bottle King Solution Services Inc. by providing actionable insights and solutions to optimize its production processes through improved capacity planning and scheduling. The primary beneficiaries of this study included:

Owner and Management of Bottle King Solution Services Inc. The research delivered an in-depth assessment of production inefficiencies and limitations, allowing the owner and management team to refine their production workflows. This strategy improved resource utilization, optimized production scheduling, and facilitated more informed decision-making, ultimately enhancing the company's capacity to fulfill demand while managing expenses effectively.

Employees. Employees experienced advantages from enhanced production processes and resource management, resulting in a more orderly workplace. The improved production scheduling lessened workloads, boosted job satisfaction, and reduced interruptions, contributing to smoother daily operations and a more efficient work environment.

Customers. Customers enjoyed the benefits of more dependable product availability and timely delivery. By better aligning production with demand through efficient scheduling, Bottle King was able to fulfill customer requirements and expectations more effectively, which led to increased customer satisfaction and loyalty.

Suppliers. Suppliers encountered a more organized and predictable ordering process. As Bottle King fine-tuned its production scheduling, it resulted in more consistent and prompt procurement of raw materials, strengthening relationships with suppliers and ensuring seamless production operations.

Investors and Financial Stakeholders. Investors and financial stakeholders reaped the benefits of enhanced financial performance and profitability at Bottle King. Improved operational efficiency through superior scheduling heightened the company's attractiveness as an investment and contributed to a healthier financial outlook.

The Local Community. As Bottle King became more efficient and profitable, it positively impacted the local community by potentially expanding operations, creating additional job opportunities, and supporting local economic development.

Future Researchers. Future researchers gained from this study by obtaining insights into the practical application of production capacity planning and scheduling. The research provided a real-world case that serves as a reference for similar investigations, presenting a methodological framework and data that could be utilized to explore further optimization techniques and strategies across various industries.

6. Scope and Limitations

This study established a proposed production scheduling system for Bottle King Solutions Services Inc., analyzing two years of sales data across seven product categories and evaluating available resources, including raw materials, workforce, and equipment. By pinpointing inefficiencies and constraints, it suggested strategies to enhance resource use and synchronize production schedules with demand. The research offered practical recommendations aimed at improving production flow, decreasing overproduction, and aligning with actual sales needs, resulting in a system customized to the company's requirements.

This study faced several limitations that may have influenced the findings and recommendations for the proposed production scheduling system at Bottle King Solutions Services Inc. The ever-changing nature of the industry, encompassing shifts in consumer preferences, regulatory changes, and economic volatility, might not have been entirely considered. Furthermore, practical obstacles such as resistance to change, the need for staff training, and possible disruptions during the implementation phase could influence feasibility. Additionally, the research primarily centered on historical data and existing practices, which may limit responsiveness to sudden market changes or supply chain issues. Inventory management aspects, including safety stock and reorder thresholds, were not comprehensively examined, which could affect how well production aligns with demand. Despite these limitations, the suggestions lay a groundwork for enhancing production efficiency and resource allocation.

7. Research Methodology

Research Design

This study used a quantitative case study approach to develop a production scheduling system for Bottle King Solutions Services Inc. By examining two years' worth of data, it uncovered inefficiencies and suggested improvements to enhance scheduling, minimize overproduction, and make better use of resources, all while maintaining data validity and adhering to ethical standards.

Research Process Flow

Figure 2: Research Process Flow

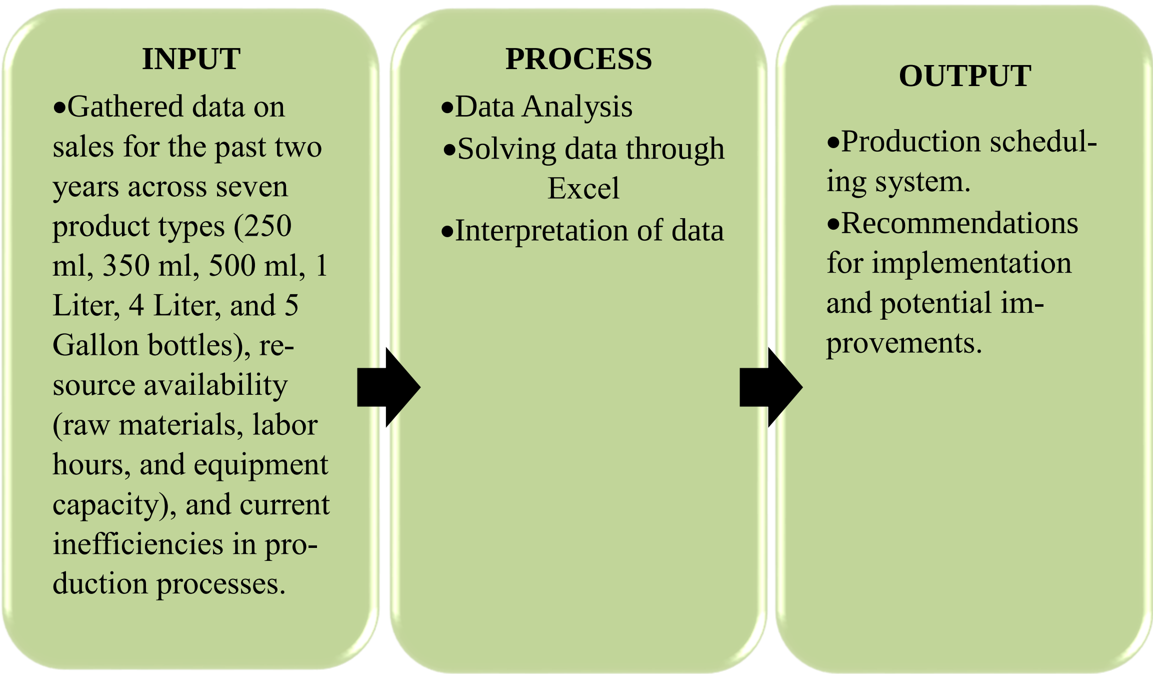
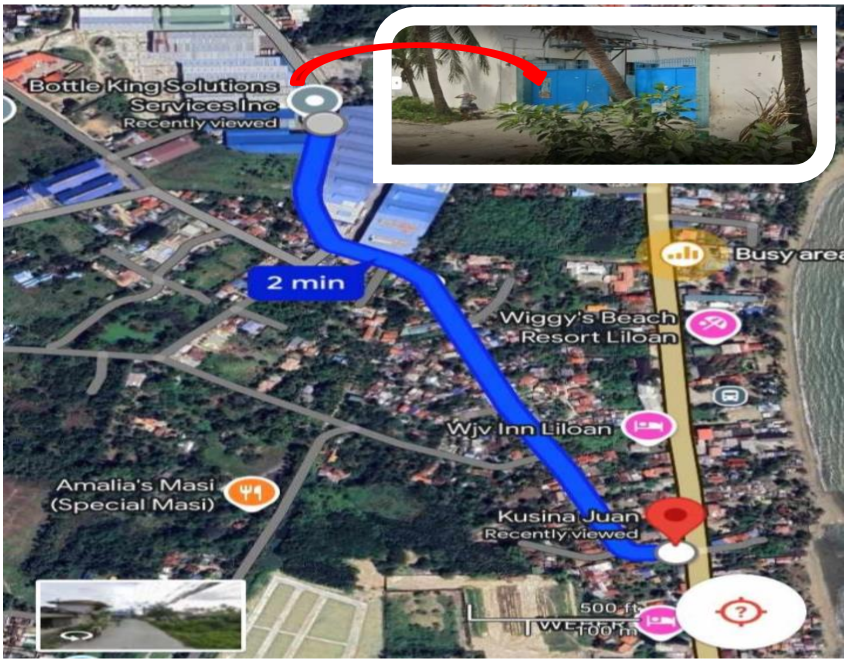


Figure 2 depicts the workflow of the research, detailing the procedures employed to establish a production scheduling model for Bottle King Solutions Services Inc. The investigation commenced with gathering data, emphasizing sales, raw materials, labor hours, equipment capabilities, and production limitations, which were crucial for forming the model. The Process stage entailed assessing these limitations to devise a production strategy that matched output with demand, tackling challenges such as excessive production and inventory. In the Output phase, the results were compiled into a proposal for a new production system, accompanied by suggestions for its implementation.

Research Environment

Figure 3 depicted a map of Bottle King Solutions Services Inc., which was found in the semi-rural region of Liloan, Cebu, more specifically in Purok Manga, Sitio Pamutungan. This site could be reached by a 900-meter pathway, taking about 12 minutes to walk from Fatima Road in Liloan, Cebu. Adjacent to Bottle King was Homman Builders and Development Corporation, a nearby entity that played a role in the local economic environment. The study was carried out at Bottle King Solutions Services Inc., a manufacturer and supplier of plastic bottles that had been delivering high-quality and safe plastic bottles to consumers for almost 8 years.

Figure 3: Research Environment of the Study



Research Instruments

To gather sales data for the past two years, the researchers analyzed compiled sales summaries and inventory records, concentrating on sales quantities and pricing approaches for the seven types of plastic bottles. Additionally, they utilized a Production Data Collection Form to record essential information such as production capacity, raw material usage, labor hours, machine operation time, variable costs, selling prices, and projected demand.

Procedures of Data Gathering

The process commenced with securing the company owner's consent via a formal request letter, highlighting the study's aim to tackle inefficiencies and enhance the production capacity planning system. Once approved, the researchers developed a Production Data Collection Form to systematically collect essential inputs, including the availability of raw materials, labor hours, production capacity, current units produced, variable costs, selling prices, estimated monthly demand, and sales data from the previous two years. Following that, a scheduled observation of the production process was conducted to document the details of workflows, raw material consumption, labor distribution, and machine operations.

The collected data underwent meticulous verification through cross-referencing production records with staff feedback to identify and rectify any discrepancies. Quantitative metrics, such as daily production capacity, labor hours per unit, and machine time per unit, were analyzed to assess production limitations and inefficiencies. The historical sales data was utilized to develop a production scheduling plan aimed at mitigating overproduction problems that resulted in excessive stock in the warehouse while synchronizing production scheduling with market demand.

Treatment of Data

The researchers gathered sales information from Bottle King Solutions Services Inc. over the last two years to examine sales figures and customer preferences regarding seven varieties of plastic bottles. This information was taken from sales records and reports, concentrating on critical metrics such as sales figures, pricing strategies, and fluctuations in seasonal demand. The data was systematically organized and scrutinized to recognize sales patterns, serving as a foundation for creating production scheduling strategies that align with market requirements. To evaluate resource availability, the researchers employed a customized Production Data Collection Form to obtain information on raw materials, labor hours, and equipment supply. This information was analyzed to comprehend resource usage and to identify potential areas for enhancement. In recognizing production inefficiencies, direct observations of workflows, machine operation durations, and raw material consumption were performed. The observational data was evaluated to identify operational bottlenecks and inefficiencies, guiding the creation of strategies to refine production scheduling. The collected data was examined to formulate scheduling strategies focused on improving resource use, addressing inefficiencies, and aligning production with demand. The recommendations were derived from data insights, ensuring their relevance and optimizing operations.

8. Definition of Terms

- **Production Data Collection Form**- The Production Data Collection Form was a detailed document created to gather essential production-related information for the seven kinds of plastic bottles produced by Bottle King Solutions Services Inc. This included details on production capacity, raw material consumption, labor and equipment time needs, variable costs, selling prices, and projected monthly demand. The form facilitated organized data gathering for analysis and the creation of a linear programming model focused on optimizing the product mix to minimize costs.

9. Presentation, Analysis, and Interpretation of Data

This chapter applied an empirical approach to address the issues of overproduction and overstocking at Bottle King Solutions Services Inc. By analyzing data on sales, resource availability, and cost frameworks, it pinpointed inefficiencies and emphasized opportunities for enhancement. The chapter concentrated on creating a production scheduling strategy that aligns production with genuine demand, reduces surplus stock, and optimizes resource utilization. It also described the execution of the scheduling solution and provided insights into how it lowered costs while improving operational efficiency.

Past Sales of Bottle King

Table 1: Quantity Demand Data Bottles of Bottle King Products for Year 2022

Month	Product						
	250ml	**350ml**	**500ml**	**1 Liter**	**4Liter**	**5 Gallon**	**Slim**
	Monthly Demand /Pack	Monthly Demand /Pack	Monthly Demand /Pack	Monthly Demand /Pack	Monthly Demand /Pack	Monthly Demand /Pack	Monthly Demand /Pack
January	900	2230	2880	2000	650	3750	3345
February	980	2260	2800	2000	690	3670	3220
March	1000	2450	2700	2200	780	3670	3425
April	995	2300	2830	1900	660	3560	3400
May	990	2400	2900	2100	700	3000	3260
June	975	2375	2760	1900	650	3700	3200
July	1100	2400	2800	2210	695	3560	3000
August	1020	2350	2780	2050	705	3407	3105
September	965	2220	2875	1990	635	3540	3245
October	1070	2290	2950	1800	725	3780	3465
November	1090	2375	2600	2350	700	3560	3320
December	1015	2360	2670	2240	635	3565	3125

Table 1 presented the "Quantity Demand Data Bottles of Bottle King Products for the Year 2022," offering a comprehensive analysis of monthly demand patterns for the different categories of bottles produced by Bottle King. The months were listed from January to December, giving a complete view of how demand fluctuated over the year for each bottle category. The table included seven varieties of bottles: 250ml, 350ml, 500ml, 1 Liter, 4 Liter, 5 Gallon, and Slim bottles, each demonstrating distinct demand trends. Starting with the 250ml bottles, the demand showed moderate variations, ranging from a low of 900 packs in January to a peak of 1,100 packs in July. This suggested that demand increased during the middle of the year, possibly due to seasonal consumption patterns or market preferences. In contrast, the demand for the 350ml bottles remained relatively high and stable compared to the 250ml bottles, with its highest demand recorded in March at 2,450 packs. Though there were slight decreases in April and September, the overall demand throughout the year was steady, indicating a consistent customer preference for this particular size.

The demand for 500ml bottles fluctuated throughout the year, ranging from 2,600 packs in November to 2,950 packs in October. October represented the peak demand, suggesting a seasonal tendency for this bottle size, potentially influenced by market trends or consumer behavior. The 1 Liter bottles experienced more noticeable fluctuations, reaching a peak demand of 2,350 packs in November, which was significantly higher than its lowest point of 1,800 packs in October. This surge in November indicated an increased demand for larger bottles as the year came to a close. The demand for 4 Liter bottles remained the lowest among all bottle types, varying from 635 packs in September and December to a maximum of 780 packs in March. The slight rise in March might have been driven by specific market factors; however, overall, the demand for this size was rather limited throughout the year. The 5 Gallon bottles showed strong demand, with monthly figures ranging from 3,000 packs in May to 3,780 packs in October.

October's peak demand aligned with the trends seen in other bottle types, pointing to a general rise in demand during that month. The Slim bottles experienced consistent demand as well, with levels varying from 3,000 packs in July to 3,465 packs in October. In keeping with the trends of the 5 Gallon and 1 Liter bottles, October marked the peak demand for Slim bottles, further reinforcing the observation that various bottle types saw increased demand during this month. Seasonal and monthly trends highlighted high-demand months such as March, October, and November, when there was a surge in demand across several bottle types, indicating that these months were significant for production and inventory management. Conversely, months like January and September, which had lower demand, reflected decreased consumption and could present opportunities for optimizing production or focusing on other operational tasks. Certain bottle types, like the 350ml and Slim bottles, demonstrated more stable demand, showing a steady customer preference throughout the year.

From a business perspective, scheduling production should prioritize increasing output during peak demand months such as March, October, and November to guarantee sufficient supply. In contrast, production during lower-demand months, like January and May, could have been allocated

Table 2: Quantity Demand Data Bottles of Bottle King Products for Year 2023

	Product						
	250ml	**350ml**	**500ml**	**1 Liter**	**4Liter**	**5 Gallon**	**Slim**
Month	Monthly Demand /Pack	Monthly Demand /Pack	Monthly Demand /Pack	Monthly Demand /Pack	Monthly Demand /Pack	Monthly Demand /Pack	Monthly Demand /Pack
January	1000	2800	3300	2500	800	3300	3600
February	900	2500	3100	2200	700	3180	3400
March	1100	2850	3450	2500	830	3340	3430
April	1095	2900	3610	2600	840	3280	3320
May	1130	3000	3800	2730	980	3360	3615
June	980	2950	3885	2700	780	3200	3350
July	985	2995	3875	2720	805	3050	3200
August	800	2180	3370	2590	793	3080	3180
September	910	2780	3400	2243	920	3100	3310
October	1050	2850	3330	2230	820	3120	3220

November	1100	3200	3450	2560	810	3430	3150
December	1010	3370	3700	2430	850	3270	3050

In Table 2, the monthly demand statistics for different Bottle King products during 2023 are categorized by size: 250ml, 350ml, 500ml, 1 Liter, 4 Liter, 5 Gallon, and Slim bottles. Demand fluctuated throughout the year, indicating seasonal changes and evolving consumer preferences. Each size exhibited unique demand patterns that influenced production and inventory management. The 250ml size showed fairly consistent demand, with a slight uptick in March (1,100 packs) and a notable drop in August (800 packs). The 350ml bottles experienced their highest demand in December (3,370 packs), while the lowest occurred in August (2,180 packs), pointing to increased consumer interest during the holiday season. Likewise, the 500ml size saw its peak in July (3,875 packs) and its minimum in February (3,100 packs), suggesting steady popularity throughout the year with minor fluctuations. For the 1 Liter size, demand was generally stable, reaching its highest in May (2,730 packs) and its lowest in October (2,223 packs). The 4 Liter size maintained the most stable demand pattern, exhibiting only minor changes; however, demand peaked in May (980 packs) and fell to its lowest in February (700 packs). The 5 Gallon size also followed a consistent trend, with demand peaking in November (3,430 packs) and declining in July (3,050 packs).

Finally, Slim bottles demonstrated strong demand, reaching their peak in January (3,600 packs) and dropping to their lowest in December (3,050 packs). These demand patterns revealed notable dynamics in consumer preferences. Larger sizes, particularly the 4 Liter and 5 Gallon, exhibited stable demand, likely driven by bulk or institutional buyers. In contrast, smaller sizes like the 250ml and 350ml showed more pronounced seasonal fluctuations, which could reflect individual consumer preferences. The Slim bottles indicated consistently high demand, showcasing their broad appeal.

Table 3: Sales Data of Bottle King Products by Size for Year 2022

Month	**Product**							**TOTAL Year 2022**
	250ml	**350ml**	**500ml**	**1 Liter**	**4 Liter**	**5 Gallon**	**Slim**	
Jan	₱731,250	₱1,349,150	₱1,584,000	₱997,500	₱101,920	₱412,500	₱2,090,625	**₱7,266,945**
Feb	₱796,250	₱1,367,300	₱1,540,000	₱997,500	₱108,192	₱403,700	₱2,012,500	**₱7,225,442**
Mar	₱812,500	₱1,482,250	₱1,485,000	₱1,097,250	₱122,304	₱403,700	₱2,140,625	**₱7,543,629**
Apr	₱808,438	₱1,391,500	₱1,556,500	₱947,625	₱103,488	₱391,600	₱2,125,000	**₱7,324,151**
May	₱804,375	₱1,452,000	₱1,595,000	₱1,047,375	₱109,760	₱330,000	₱2,037,500	**₱7,376,010**
Jun	₱792,188	₱1,436,875	₱1,518,000	₱947,625	₱101,920	₱407,000	₱2,000,000	**₱7,203,608**

Jul	₱893,750	₱1,452,000	₱1,540,000	₱1,102,238	₱108,976	₱391,600	₱1,875,000	**₱7,363,564**
Aug	₱828,750	₱1,421,750	₱1,529,000	₱1,022,438	₱110,544	₱374,770	₱1,940,625	**₱7,227,877**
Sept	₱784,063	₱1,343,100	₱1,581,250	₱992,512	₱99,568	₱389,400	₱1,028,125	**₱6,218,018**
Oct	₱869,375	₱1,385,450	₱1,622,500	₱897,750	₱113,680	₱415,800	₱2,165,625	**₱7,470,180**
Nov	₱885,625	₱1,436,875	₱1,430,000	₱1,172,063	₱109,760	₱391,600	₱2,075,000	**₱7,500,923**
Dec	₱824,688	₱1,427,800	₱1,468,500	₱1,117,200	₱99,586	₱392,150	₱1,953,125	**₱7,283,049**
TOTAL	**₱9,831,250.00**	**₱16,946,050.00**	**₱18,449,750.00**	**₱12,339,074.50**	**₱1,289,698.00**	**₱4,703,820.00**	**₱23,443,750.00**	**₱87,003,392.50**

Table 3 provided a comprehensive overview of Bottle King's sales performance in 2022 across various bottle sizes, showcasing significant trends in consumer purchasing behavior. The smaller bottle formats, including 250ml, 350ml, and 500ml, consistently generated the highest revenue, with the 500ml size earning ₱18,449,750, followed by the 350ml at ₱16,946,050, and the 250ml at ₱9,831,250. These sizes likely appeal to a broad customer base due to their cost-effectiveness and convenience. Meanwhile, larger bottles such as the 1 Liter, 4 Liter, and 5 Gallon sizes showed stable sales, with the 1 Liter producing ₱12,339,075 and the 5 Gallon size yielding ₱4,703,820, attracting customers looking for bulk savings or purchasing options. Slim bottles stood out as top performers, accumulating ₱23,443,750 in total sales, indicating a strong preference among consumers possibly influenced by their sleek appearance, perceived value, or focused marketing strategies. Overall, annual sales reached ₱87,003,393, demonstrating Bottle King's strong market position and the importance of effective production and inventory management to align with these demand patterns. These findings support earlier research that indicates the allure of smaller products due to their affordability and practicality (Sazvar et al., 2021).

Pricing strategies and product positioning, as highlighted by Pereira et al. (2020), appear to be essential, particularly regarding the impressive sales of Slim bottles. Additionally, Thevenin et al. (2021) emphasize the importance of utilizing sales data to improve production capacity and inventory management, ensuring resources are aligned with market demands effectively. By leveraging these insights, Bottle King can enhance its operations and capitalize on high-demand products to sustain its growth path.

Table 4: Sales Data of Bottle King Products by Size for Year 2023

Month	**Product**							**Total Year 2023**
	250ml	**350ml**	**500ml**	**1 Liter**	**4 Liter**	**5 Gallon**	**Slim**	
Jan	₱812,500	₱1,649,000	₱1,815,000	₱1,246,875	₱125,440	₱363,000	₱2,250,000	**₱8,261,815**

Feb	₱731,250	₱1,512,500	₱1,705,000	₱1,097,250	₱109,760	₱349,800	₱2,125,000	**₱7,630,560**
Mar	₱893,750	₱1,724,250	₱1,897,500	₱1,246,875	₱130,144	₱367,400	₱2,143,750	**₱8,403,669**
Apr	₱889,688	₱1,754,500	₱1,985,500	₱1,296,750	₱131,712	₱360,800	₱2,075,000	**₱8,493,950**
May	₱918,125	₱1,815,000	₱2,090,000	₱1,361,588	₱153,664	₱369,600	₱2,259,375	**₱8,967,352**
Jun	₱796,250	₱1,784,750	₱2,136,750	₱1,346,625	₱122,304	₱352,000	₱2,093,750	**₱8,632,429**
Jul	₱800,313	₱1,787,775	₱2,131,250	₱1,356,600	₱126,224	₱335,500	₱2,000,000	**₱8,537,662**
Aug	₱650,000	₱1,318,900	₱1,853,500	₱1,291,762	₱124,342	₱338,800	₱1,987,500	**₱7,564,804**
Sept	₱739,375	₱1,681,900	₱1,870,000	₱1,118,696	₱144,256	₱341,000	₱2,068,750	**₱7,963,977**
Oct	₱853,125	₱1,724,250	₱1,831,500	₱1,112,213	₱128,576	₱343,200	₱2,012,500	**₱8,005,364**
Nov	₱893,750	₱1,936,000	₱1,897,500	₱1,276,800	₱127,008	₱377,300	₱1,968,750	**₱8,477,108**
Dec	₱820,625	₱2,038,250	₱2,035,000	₱1,211,963	₱133,280	₱359,700	₱1,906,250	**₱8,505,068**
TOTAL	**₱9,798,751**	**₱20,727,075**	**₱23,248,500**	**₱14,963,997**	**₱1,556,710**	**₱4,258,100**	**₱24,890,625**	**₱99,443,758**

Table 4 displayed the monthly and cumulative sales figures for Bottle King Solutions Services Inc.'s product categories throughout 2023. Each product size, ranging from 250 mL to 5 Gallon, showed distinct sales trends, each contributing differently to the company's total revenue of ₱99,443,758. The 500 mL, Slim, and 5 Gallon categories emerged as the key revenue contributors, collectively accounting for the majority of total sales. Leading the sales was the 500 mL size, which brought in ₱23,248,500, consistently performing well throughout the year, likely due to its affordability and standard size.

The Slim category achieved ₱24,890,625 in sales, the highest of all categories, signifying strong demand possibly influenced by its lightweight and portable characteristics. Meanwhile, the 5 Gallon category totaled ₱4,258,100 in sales, backed by its practicality for large-scale use or bulk purchases. In contrast, the 1 Liter (₱14,963,997), 350 mL (₱20,727,075), and 250 mL (₱9,798,751) categories displayed moderate performance, catering to different market segments, though their sales were overshadowed by the leading categories.

The 1 Liter size sustained consistent monthly sales, with particularly strong performance in May and June, appealing to medium-scale consumers. However, the 4 Liter product fell short, generating only ₱1,556,710 in total sales, indicating limited market appeal and a specific role. Sales peaked in May (₱8,967,352), reflecting heightened market demand during that month, while April (₱8,493,950) and March

(₱8,403,669) also represented strong revenue months. Conversely, August (₱7,564,804) and February (₱7,630,560) recorded the lowest revenues, suggesting fluctuations in demand due to seasonal or market factors. Research highlighted the necessity to focus on high-performing products to boost revenue and enhance strategic decisions. The robust sales of the 500 mL, Slim, and 5 Gallon products echoed findings by Hartmann and Lussier (2020), underscoring the significance of prioritizing products based on market demand. Meanwhile, the poor performance of the 4 Liter category was in line with observations by Lohmer and Lasch (2021), who emphasized the need for companies to reassess the roles of low-demand products in their lineup. Wang et al. (2021) further supported the focus on top-selling items to ensure profitability and streamline operations.

Availability Status

Table 5. Current Resources Availability for Daily Production in Bottle King

Resource	Quantity Available
Raw Materials	2,750,000 g
Labor Hours	1,440 minutes
Equipment Capacity	98,000 bottles

Table 5 presented an overview of the resources available for Bottle King's daily production operations, encompassing raw materials, labor hours, and equipment capacity. The term Raw Materials referred to the amount of plastic (measured in kilograms) utilized by the company for its manufacturing process. In this instance, the company possessed 2,750 kg of raw materials for production. Labor hours represented the total operating duration that the machinery and workforce could operate within a single day. In this scenario, the company was allotted a total of 1,440 minutes (or 24 hours) for labor on production days.

This duration included all machine operation, setup, maintenance, and other essential manual tasks. With six machines in operation, each providing 1,440 minutes of operational time, the firm had a total of 8,640 minutes (6 machines × 1,440 minutes) of labor available for production each day. Equipment capacity described the manufacturing capabilities of the machines, particularly their ability to produce plastic bottles of various dimensions, including 250ml, 350ml, 500ml, 1L, 4L, 5 Gallon, and slim bottles. Over a 24-hour operational period, the six machines could produce a maximum of 98,000 bottles, regardless of the different sizes involved. This operational setup enabled the company to potentially manufacture up to 100,000 bottles daily, depending on the specific sizes of the bottles produced.

Effectively overseeing the consumption of raw materials, workforce productivity, and machine capabilities allowed the company to meet demand while minimizing waste and downtime. Research highlighted that effective resource allocation was essential for achieving operational efficiency and enhancing production throughput in manufacturing settings (Morariu et al., 2020). Moreover, the ability to adjust production schedules according to available resources ensured that businesses could easily adapt to changes in demand, thereby boosting both profitability and customer satisfaction (Esteso et al., 2021).

Understanding the relationship between equipment capacity and labor time was crucial for companies to sustain a smooth production process while mitigating bottlenecks (Zhou et al., 2022).

Production Constraints

Table 6. Daily Material Requirements of Bottle King Products by Size

Product Sizes	Bottles Produced	Volume of Plastic/g	Raw Materials Used	Daily Demand	Raw Materials Used for Demand
250ml	22,750 units	10 g	227,500 g	15,546 units	154,560 g
350ml	29,040 units	10 g	290,400 g	24,569 units	245,690 g
500ml	28,000 units	13 g	364,000 g	23,776 units	309,088 g
1 Liter	13,650 units	23 g	313,950 g	9,183 units	211,209 g
4 Liters	2,240 units	87 g	194,880 g	915 units	79,605 g
5 Gallons	1,000 units	700 g	700,000 g	629 units	440,300 g
Slim	900 units	700 g	630,000 g	587 units	410,900 g
TOTAL	**97,580 units**	**1,543 g**	**2,720,730 g**	**75,205 units**	**1,851,352g**

Table 6 illustrates the daily material requirements for Bottle King Products across different bottle sizes, factoring in production levels, utilized raw materials, and daily needs for each size. It shows a surplus for all items regarding both the quantities of bottles produced and the raw materials used compared to actual demand. For the smaller bottle sizes such as 250ml and 350ml, production numbers and raw material consumption significantly exceed demand. Specifically, the production of the 250ml size reaches 22,750 units, using 227,500 grams of raw materials, while the demand stands at just 15,546 units, which necessitates 154,560 grams of materials, resulting in an excess of 7,204 units. Likewise, the 350ml bottle has a production of 29,040 units and consumes 290,400 grams of raw materials, in contrast to a demand of 24,569 units and a raw material requirement of 245,690 grams, leading to a surplus of 4,471 units. The 500ml size is relatively balanced, with a production of 28,000 units and raw material consumption of 364,000 grams, slightly exceeding the demand of 23,776 units that requires 370,006 grams of raw materials, yielding a small surplus of 4,224 units. Larger bottle sizes also exhibit notable surpluses. For example, the 1-liter bottle is produced at a rate of 13,650 units and consumes 313,950 grams of raw materials, while facing a demand of 9,183 units and a requirement of 211,209 grams of materials, resulting in surpluses of 4,467 units and 102,741 grams. Similarly, the 4-liter bottle, with a production of 2,240 units and raw material usage of 194,880 grams, has a demand of 915 units which requires only 79,605 grams of materials, creating surpluses of 1,325 units and 115,275 grams. The 5-gallon size produces 1,000 units and consumes 700,000 grams of materials, exceeding its demand of 629 units that needs 440,300 grams, leaving surpluses of 371 units and 259,700 grams. Finally, the slim bottle, which produces 900 units and uses 630,000 grams of raw materials, surpasses its demand of 587 units that requires 410,900 grams, resulting in surpluses of 313 units and 219,100 grams.

The total output of 97,580 units, along with a raw material usage of 2,720,730 grams, substantially surpasses the overall demand of 83,768 units and a raw material need of 1,951,940 grams, which underscores inefficiencies in how resources are utilized and how production aligns with market needs. This surplus in production reveals a lack of synchronization between production schedules and market demands, leading to wasted resources and heightened operational costs. Studies suggest that adopting demand-driven production approaches can enhance the optimization of production levels, reduce waste, and better align resources with genuine market requirements (Sunday et al., 2021). In addition, efficient resource management is crucial for minimizing raw material waste and promoting sustainable production practices (Lohmer & Lasch, 2021). By implementing sophisticated forecasting techniques and just-in-time production strategies, companies can reduce excess production and ensure manufacturing is more closely aligned with consumer demand (Trebuna et al., 2022).

Table 7. Labor Hours for Daily Production of Bottle King Products by Size

Product Sizes	**Labor time/ Unit (Minutes)**	**Bottles Produced**	**Labor Minutes Used for Production**	**Daily Demand**	**Labor Minutes for Demand**
250ml	0.063	22,750	1,433.25	15,546	979.39
350ml	0.05	29,040	1,452	24,569	1,228.45
500ml	0.05	28,000	1,400	23,776	1,188.8
1 Liter	0.11	13,650	1,501.50	9,183	1,009.13
4 Liters	0.64	2,240	1,433.50	915	585.60
5 Gallons	1.45	1,000	1,450	629	912.05
Slim	1.6	900	1,440	587	939.20
TOTAL:		**97,580**	**10,110.35**	**75,205**	**6,843.63**

Table 7 provided detailed data regarding the labor time needed per unit, the number of bottles produced, the total minutes of labor spent on production, the daily demand for these bottles, and the labor minutes required to meet that demand across different product sizes. The information revealed a production imbalance, where the minutes of labor spent on production generally exceeded the minutes necessary to fulfill actual demand. This disparity indicated inefficiencies and the potential for overproduction in most product categories. For instance, producing the 250 mL product required 1,433.25 labor minutes, while only 979.39 labor minutes were necessary to meet the daily demand. This overproduction led to a surplus, highlighting a lack of utilization of the produced goods and excessive consumption of resources. Similarly, the 350 mL and 500 mL sizes consumed 1,452 and 1,400 labor minutes for production, respectively, yet only required 1,228.45 and 1,188.8 labor minutes to satisfy daily demand. In the case of the 1 Liter size, the production absorbed 1,501.50 labor minutes, surpassing the 1,009.13 labor minutes needed to meet the demand.

Larger sizes, including the 4 Liter and 5 Gallon containers, also exhibited signs of overproduction, with labor minutes dedicated to production (1,433.50 and 1,450, respectively) significantly exceeding the labor minutes required to address daily demand (585.60 and 912.05 labor minutes). The Slim category, which required 1,440 labor minutes for its production, only needed 939.20 labor minutes to meet daily demand. Overproduction created difficulties concerning resource optimization and operational efficiency, as the excessive labor time led to machines being overworked with insufficient downtime for maintenance. This continuous use resulted in higher maintenance costs and a greater likelihood of mechanical inefficiencies, highlighting the urgent need for better alignment between production and demand to improve labor utilization and guarantee sustainable operations.

The results align with the findings of Cox and Spencer (2024), who indicated that overproduction can create a bottleneck by placing undue stress on equipment, resulting in overuse and inadequate rest intervals. Additionally, Katiraee et al. (2021) supported this by pointing out that the continuous operation of machines without sufficient downtime leads to increased maintenance costs and potential inefficiencies due to accelerated wear and tear. Mianaei et al. (2022) emphasized the importance of aligning production output with actual demand to reduce wasteful expenses, minimize resource wastage, and maintain operational efficiency. These studies highlight the critical need for strategies aimed at synchronizing production levels with demand to alleviate the negative impacts of overproduction.

Table 8. Machine Effective Capacity for Daily Production of Bottle King Products by Size

Machine	**Available Hours/day**	**Capacity/Hour (units)**	**Total Capacity /day (units)**	**Total Demand (units)**	**Surplus (units)**
Machine 1	24	1,302	31,250	24,358	6,892
Machine 2	24	1,302	31,250	24,358	6,892
Machine 3	24	1,302	31,250	24,358	6,892
Machine 4	24	94	2,250	915	1,335
Machine 5	24	44	1,050	629	421
Machine 6	24	40	950	587	363
TOTAL:	**144**	**4,083**	**98,000**	**75,205**	**22,795**

Table 8 illustrated the daily capacity and demand for each machine at Bottle King Solutions, revealing a considerable constraint where the equipment operated continuously, leading to excess production. Machines 1, 2, and 3, which produced 250ml, 350ml, 500ml, and 1-liter bottles, each had a strong production capacity of 31,250 units per day. However, the demand for these products was only 24,358 units each, resulting in a surplus of 6,892 units per machine. This excess production stemmed from the machines running at full capacity, exceeding daily demand by a substantial margin. Similarly, Machine 4, which manufactured 4-liter bottles, had a daily capacity of 2,250 units, whereas the demand was merely 915 units, leading to a surplus of 1,335 units. Machines 5, responsible for producing 5-gallon bottles, and Machine 6, which produced slim bottles, also experienced overproduction, with surpluses of 421 units and 363 units, respectively. This pattern of overproduction across all machines indicated that the equipment was utilized to its maximum potential without any interruptions, resulting in inefficient resource use and potential financial consequences, such as excess inventory and wasted production capability. Research shows that overproduction often leads to waste and increased operational costs, highlighting the need for better production planning (Li et.al, 2020). The lack of downtime also suggests missed opportunities for machine maintenance, which could affect long-term operational efficiency (Yao et.al, 2022). To tackle these inefficiencies, experts have recommended aligning production schedules more closely with demand forecasts and instituting planned downtime for maintenance procedures (Missbauer & Uzsoy, 2020).

10. Summary of Findings

In 2023, Bottle King encountered substantial production inefficiencies stemming from overproduction of nearly all bottle sizes. For instance, the production of 250ml and 350ml bottles greatly exceeded the actual demand. The 250ml bottles had a daily output of 22,750 units, while the demand was only 15,546 units, leading to a surplus of 7,204 units. In the same vein, the 350ml bottle's production stood at 29,040 units against a demand of 24,569 units, resulting in a surplus of 4,471 units. This pattern of overproduction persisted across every bottle size, with the 1-liter, 4-liter, and 5-gallon bottles similarly displaying significant surpluses. Labor utilization was also skewed, with daily labor minutes often surpassing what was necessary to meet demand, causing inefficiencies. For example, producing the 250ml bottle required 1,433.25 labor minutes, yet only 979.39 minutes were needed to satisfy the daily demand, leading to unnecessary labor expenditure. These mismatches between production rates, labor utilization, and real market demand underscored inefficiencies in resource management. The excess production not only resulted in surplus inventory but also contributed to elevated operational costs due to overextended equipment usage and inadequate maintenance downtime. To enhance operations, the company needed to align production schedules more closely with actual demand, curtail overproduction, and adopt more adaptable production strategies informed by demand forecasts.

11. Conclusions

This research focused on creating a production scheduling system for Bottle King Solutions Services Inc. to tackle inefficiencies in resource use and excessive production. A comprehensive examination of the company's existing operations, which included labor hours, machine utilization, production rates, and demand fluctuations for various bottle sizes, revealed that the current system is not synchronized with optimal production practices. The proposed system offers a systematic method for scheduling that ensures machine use, labor distribution, and production outputs are in harmony with demand predictions. By implementing these enhancements, the study illustrates the possibility of lowering operational costs and mitigating excess inventory resulting from overproduction. In the end, the adoption of this proposed system is anticipated to improve the company’s production efficiency, align more closely with market demands, and support a more sustainable manufacturing approach.

12. Recommendations

According to the research summary, the authors suggest a production scheduling system for Bottle King Solutions Services Inc. that aims to resolve the inefficiencies present in its existing operations. The suggested system intends to maximize resource utilization, shorten lead times, and synchronize production levels with actual demand to avoid overproduction and excess inventory. By adopting this enhanced system, Bottle King can boost productivity and optimize its operations, ensuring that production processes are more cost-efficient and in line with industry standards.

Table 9. Proposed Production Scheduling at Bottle King for the Month of January

Bottle Type	Beginning Inventory	Monthly Target Production (units)	Monthy Production Required (units)	No. of Workers /Machine	Labor Hours (hrs)/daily	Daily Working Shifts	Machine Operating (hrs)/daily	Machine Downtime (hrs)/daily	No. of Working Days
250ml	187,304	404,196	216,892	1 Worker	1,440	2	16.3	7.7	26
350ml	116,246	638,794	522,548	1 Worker	1,440	2	18.8	3.5	26
500ml	109,824	618,176	508,352	1 Worker	1,440	2	19.8	2.2	26
1 Liter	116,142	238,758	122,616	1 Worker	1,440	2	16.8	7.2	26
4 Liters	34,450	23,790	-10,660	1 Worker	1,440	1	9.8	14.2	26
5Gallon	9,646	16,354	6,708	1 Worker	1,440	2	15.2	8.8	26
Slim	8,138	15,262	7,124	1 Worker	1,440	2	15.7	8.3	26

Table 9 outlined the suggested production schedule for Bottle King for January, offering comprehensive details on starting inventory, production goals, labor needs, and machine functions. The initial inventory showed the leftover stock for each bottle type from earlier production cycles, while the monthly production targets were based on projected demand derived from the average data obtained over the last three months. This methodology enabled Bottle King to synchronize its production with market requirements. For the 250 mL bottle type, the starting inventory stood at 187,304 units, with a targeted production of 404,196 units. The monthly production needed to achieve this target was 216,892 units, reflecting a substantial production effort. Operations consisted of one worker per machine operating two shifts daily, equating to a total of 1,440 labor hours each month. The machines functioned for 16.3 hours per day, allowing for 7.7 hours of downtime. In a similar vein, the 350 mL bottle type started with 116,246 units in stock and had a target production of 638,794 units, necessitating a monthly production of 522,548 units. Like the 250 mL size, it utilized one worker per machine, with machines operating for 18.8 hours daily, which left 3.5 hours for downtime. For the 500 mL bottle, the initial stock was 109,824 units, with a target production goal of 618,176 units. The required monthly production for this size was 508,352 units. The machines operated for 19.8 hours each day, providing 2.2 hours of downtime, indicating increased production intensity. The 1 Liter size began with 116,142 units and aimed to produce 238,758 units, needing 122,616 additional units for the month. Machines for this category functioned for 16.8 hours daily, with 7.2 hours of downtime.

Notably, the 4 Liter size experienced a surplus, beginning with 34,450 units compared to its target production of 23,790 units, leading to a negative monthly production requirement of -10,660 units. This surplus indicated that the target production for January had been accomplished, with remaining stock transitioning to the new beginning inventory for the upcoming month. Consequently, this scenario permitted machines to allocate 14.2 hours for downtime, as no further production was needed for January. In the case of the 5 Gallon category, the starting inventory was 9,646 units, while the production target was set at 16,354 units, requiring an additional 6,708 units. Machines operated for 15.2 hours per day, allowing 8.8 hours of downtime. Lastly, the Slim bottles began with 8,138 units, aiming for a production goal of 15,262 units, necessitating 7,124 units of production. These machines functioned for 15.7 hours daily, providing 8.3 hours of downtime.

Efficient production scheduling is crucial in ensuring that manufacturing activities align with market demand while maximizing resource utilization. Research shows that reliable demand forecasting, such as using historical data averages, aids in reducing production inefficiencies and prevents both underutilization and overloading of resources (Abid et.al, 2020). Moreover, maintaining an equilibrium between machine uptime and downtime is essential for sustaining operational efficiency and preventing equipment failures, as excessive operation without sufficient rest can lead to increased maintenance costs and lowered productivity (Briscon et.al, 2023). Adopting flexible scheduling techniques, which include reallocating resources to high-demand products or curtailing production of excess inventory, enhances adaptability and supports operational sustainability in changing market conditions (Lohmer & Lasch, 2021). These strategies play a vital role in aligning production practices with business goals, as demonstrated in Bottle King's proposed strategy.

Table 10. Proposed Production Scheduling at Bottle King for the Month of February

Bottle Type	**Beginning Inventory**	**Monthly Target Production (units)**	**Monthy Production Required (units)**	**No. of Workers /Machine**	**Labor Hours (hrs)/daily**	**Daily Working Shifts**	**Machine Operating (hrs)/daily**	**Machine Downtime (hrs)/daily**	**No. of Working Days**
250ml	0	404,196	404,196	1 Worker	1,440	2	16.3	7.7	26
350ml	0	638,794	638,794	1 Worker	1,440	2	18.8	3.5	26
500ml	0	618,176	618,176	1 Worker	1,440	2	19.8	2.2	26
1 Liter	0	238,758	238,758	1 Worker	1,440	2	16.8	7.2	26
4 Liters	10,660	23,790	13,130	1 Worker	1,440	1	9.8	14.2	26

5Gallon	0	16,354	16,354	1 Worker	1,440	2	15.2	8.8	26
Slim	0	15,262	15,262	1 Worker	1,440	2	15.7	8.3	26

Table 10 presented the proposed production schedule for Bottle King for February, building on data from the prior month. The initial inventory for nearly all bottle sizes was reset to zero, with the exception of the 4 Liter size, which had a surplus of 10,660 units carried over from January. This surplus represented the leftover stock after fulfilling the production goals for January, as no further production was necessary for the 4 Liter size during that month. For February, the target production for the 4 Liter bottle type was set at 23,790 units, with a production requirement of 13,130 units after factoring in the surplus from beginning inventory. With one worker assigned to each machine, the production schedule indicated that the machines would run for 9.8 hours each day, allowing for a significant 14.2 hours of downtime—much higher compared to other bottle sizes, highlighting the lighter workload due to the carryover surplus. In contrast, the other bottle types commenced with zero inventory and needed full production to achieve their targets. For instance, the 250 mL size had both a production target and requirement of 404,196 units, resulting in machines operating for 16.3 hours daily with 7.7 hours of downtime. Likewise, the 350 mL size required 638,794 units, with machines functioning for 18.8 hours daily, which allowed only 3.5 hours for downtime. The 500 mL size necessitated 618,176 units of production, requiring machines to run for 19.8 hours each day while permitting just 2.2 hours of downtime. The 1 Liter bottle type had a requirement of 238,758 units to be produced, with machines operating for 16.8 hours daily and having 7.2 hours of downtime. The 5 Gallon and Slim bottles, which also began with zero inventory, needed 16,354 and 15,262 units, respectively. Machines for these sizes worked for 15.2 and 15.7 hours daily, resulting in 8.8 and 8.3 hours of downtime, respectively. Effective production scheduling necessitated a balance between managing inventory, allocating labor, and utilizing machines efficiently. The surplus carried over from January for the 4 Liter bottle underscored the need to adjust production based on inventory levels to prevent inefficiencies and overproduction. Leveraging surplus stock allowed companies to alleviate pressure on resources and concentrate production on more in-demand products. Research indicated that incorporating surplus inventory into production schedules improved flexibility and operational efficiency, enhancing reactions to changing market demand (Sazvar et al., 2021). Additionally, synchronizing production schedules with precise forecasts supported sustainable practices by reducing resource waste and optimizing machine downtime, as seen in the 4 Liter category (Canas et al., 2022). Strategic modifications, such as reallocating resources to other products, also contributed to maintaining equipment durability and boosting overall productivity (Fu et al., 2021).

Table 11. Proposed Production Scheduling at Bottle King for the Month of March

Bottle Type	**Beginning Inventory**	**Monthly Target Production (units)**	**Monthy Production Required**	**No. of Workers /Machine**	**Labor Hours (hrs)/daily**	**Daily Working Shifts**	**Machine Operating (hrs)/daily**	**Machine Downtime (hrs)/daily**	**No. of Working Days**

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			(units)						
250ml	0	404,196	404,196	1 Worker	1,440	2	16.3	7.7	26
350ml	0	638,794	638,794	1 Worker	1,440	2	18.8	3.5	26
500ml	0	618,176	618,176	1 Worker	1,440	2	19.8	2.2	26
1 Liter	0	238,758	238,758	1 Worker	1,440	2	16.8	7.2	26
4 Liters	0	23,790	23,790	1 Worker	1,440	1	9.8	14.2	26
5Gallon	0	16,354	16,354	1 Worker	1,440	2	15.2	8.8	26
Slim	0	15,262	15,262	1 Worker	1,440	2	15.7	8.3	26

For March, the production scheduling proposal for Bottle King was crafted to alleviate and respond to current challenges within the company. The plan showcased a systematic method for overseeing the manufacturing of different bottle types, ensuring effective coordination with consumer demand. It was suggested that all bottle varieties commence with zero-unit inventory, employing a just-in-time production approach to reduce storage expenses and avoid surplus inventory. Monthly production goals varied widely, with smaller bottles, such as the 350ml type, needing the highest output at 638,794 units, while larger bottles, like the 5-Gallon size, had a lower target of 16,354 units. Each type of bottle was allocated one worker, providing a clear distribution of the workforce, with each worker contributing around 1,440 labor hours each month. This amounted to roughly 55.4 hours per week across the planned 26 working days.

Machine usage was customized to align with production needs, requiring higher daily operation for smaller bottles, like the 500ml size, at 19.8 hours per machine, compared to larger bottles, such as the 4-Liter size, which necessitated only 9.8 hours each day. Downtime for machines was kept to a minimum for high-demand bottle types like the 500ml, which faced only 2.2 hours of downtime daily, whereas the larger bottles with lower demand, like the 4-Liter size, were allotted more downtime flexibility at 14.2 hours per day. Most bottle types were scheduled to function on a two-shift basis to achieve their production targets, with the exception of the 4-Liter size, which was planned for a single shift due to its lower demand. The plan ensured steady production across the 26 working days, balancing the use of resources and overall output.

This proposal integrated concepts from production management to effectively tackle Bottle King's challenges. By adopting a just-in-time production strategy, as recommended by (Romero-Selva et.al, 2024), it minimized surplus inventory and matched production with actual demand, thereby decreasing waste. Aligning machine utilization with product demand, as highlighted by (Rena, 2024), ensured that resources were utilized efficiently while reducing idle periods. Furthermore, the flexible scheduling strategy adhered to (Permana et.al, 2021) suggestions for responding to variable production needs. The implementation of this production scheduling proposal assisted Bottle King in overcoming inefficiencies, optimizing resource usage, and enhancing its ability to meet demand, ultimately leading to an improvement in overall operational effectiveness.

Table 12. Proposed Production Scheduling at Bottle King for the Month of April

Bottle Type	Beginning Inventory	Monthly Target Production (units)	Monthy Production Required (units)	No. of Workers /Machine	Labor Hours (hrs)/daily	Daily Working Shifts	Machine Operating (hrs)/daily	Machine Downtime (hrs)/daily	No. of Working Days
250ml	0	404,196	404,196	1 Worker	1,440	2	16.3	7.7	26
350ml	0	638,794	638,794	1 Worker	1,440	2	18.8	3.5	26
500ml	0	618,176	618,176	1 Worker	1,440	2	19.8	2.2	26
1 Liter	0	238,758	238,758	1 Worker	1,440	2	16.8	7.2	26
4 Liters	0	23,790	23,790	1 Worker	1,440	1	9.8	14.2	26
5Gallon	0	16,354	16,354	1 Worker	1,440	2	15.2	8.8	26
Slim	0	15,262	15,262	1 Worker	1,440	2	15.7	8.3	26

In April, the production scheduling proposal for Bottle King aimed to tackle and resolve the company's ongoing challenges. The strategy showcased a methodical approach to managing the production of different bottle types, ensuring effective coordination with market demand. All bottle types were suggested to start with a zero-unit inventory, embracing a just-in-time production methodology to reduce storage costs and overstock. Production targets for the month varied greatly, with smaller bottles, such as the 350ml type, needing the highest output of 638,794 units, while larger bottles, like the 5-Gallon size, had a reduced target of 16,354 units. Each bottle type was allocated one worker, providing a clear workforce distribution, with each employee contributing roughly 1,440 labor hours per month. This equated to about 55.4 hours weekly across the 26 scheduled working days.

Machine utilization was adjusted according to production needs, with smaller bottles, like the 500ml size, necessitating higher daily machine usage at 19.8 hours, while larger bottles, such as the 4-Liter size, required only 9.8 hours each day. Proposed machine downtime was kept low for high-demand bottles like the 500ml type, with only 2.2 hours of daily downtime planned, whereas larger bottles with lesser demand, such as the 4-Liter size, were allotted greater downtime flexibility at 14.2 hours per day. The majority of bottle types were scheduled to operate on a two-shift system to achieve their production goals, except for the 4-Liter size, which was designated for a single shift due to its lower production needs. The proposal guaranteed steady production over 26 working days, striking a balance between resource utilization and output.

This scheduling proposal integrated production management principles to effectively address the challenges faced by Bottle King. By employing a just-in-time production strategy, as noted by (Romero-Selva et al., 2024), it reduced excess inventory and aligned production with true demand, decreasing waste. The alignment of machine utilization with product demand, highlighted by (Rena, 2024), ensured efficient resource usage while limiting idle time. Moreover, the adaptable scheduling method was consistent with (Permana et al., 2021) suggestions for responding to fluctuating production demands. Executing this production scheduling proposal enabled Bottle King to resolve inefficiencies, optimize resource utilization, and enhance its ability to satisfy demand, ultimately boosting overall operational performance.

Table 13. Proposed Production Scheduling at Bottle King for the Month of May

Bottle Type	**Beginning Inventory**	**Monthly Target Production (units)**	**Monthy Production Required (units)**	**No. of Workers /Machine**	**Labor Hours (hrs)/daily**	**Daily Working Shifts**	**Machine Operating (hrs)/daily**	**Machine Downtime (hrs)/daily**	**No. of Working Days**
250ml	0	404,196	404,196	1 Worker	1,440	2	16.3	7.7	26
350ml	0	638,794	638,794	1 Worker	1,440	2	18.8	3.5	26
500ml	0	618,176	618,176	1 Worker	1,440	2	19.8	2.2	26
1 Liter	0	238,758	238,758	1 Worker	1,440	2	16.8	7.2	26
4 Liters	0	23,790	23,790	1 Worker	1,440	1	9.8	14.2	26
5Gallon	0	16,354	16,354	1 Worker	1,440	2	15.2	8.8	26
Slim	0	15,262	15,262	1 Worker	1,440	2	15.7	8.3	26

For May, the production scheduling proposal for Bottle King was created to alleviate and tackle the existing challenges faced by the company. The plan demonstrated a systematic method for managing the production of different bottle varieties, ensuring an efficient match with demand. It was proposed that all bottle types start with a zero-unit inventory, utilizing a just-in-time production strategy to reduce storage expenses and surplus inventory. Monthly production goals varied widely, with the smaller bottles, specifically the 350ml type, needing the largest output of 638,794 units, while the larger bottles, such as the 5-Gallon size, had a reduced target of 16,354 units. Each type of bottle was assigned a single worker, guaranteeing a simple distribution of the workforce, with each worker contributing roughly 1,440 labor hours monthly. This equated to about 55.4 hours weekly over the 26 scheduled working days.

Machine usage was adapted to the production needs, with smaller bottles, like the 500ml type, requiring more daily use at 19.8 hours per machine compared to larger bottles, such as the 4-Liter size, which needed only 9.8 hours per day. The proposed plan allowed for minimal machine downtime for high-demand bottle types, such as the 500ml size, showcasing only 2.2 hours of downtime daily, while larger bottles with lesser demand, like the 4-Liter size, were afforded more downtime flexibility at 14.2 hours each day. Most bottle types were arranged to function on a two-shift schedule to achieve their production targets, except for the 4-Liter size, which was scheduled for a single shift due to its decreased production need. The plan assured steady production across 26 working days, balancing resource utilization with output.

This proposal integrated principles from production management to effectively confront Bottle King's issues. The utilization of a just-in-time production strategy, as indicated by (Romero-Selva et al., 2024), helped minimize surplus inventory and align production with actual demand, thereby reducing waste. By coordinating machine usage with product demand, as highlighted by (Rena, 2024), the plan promoted efficient resource utilization while lessening idle time. Furthermore, the adaptable scheduling approach corresponded with (Permana et al., 2021) recommendations for responding to fluctuating production demands. Executing this production scheduling proposal enabled Bottle King to rectify inefficiencies, optimize resource utilization, and more effectively meet demand, ultimately enhancing overall operational performance.

Table 14. Proposed Production Scheduling at Bottle King for the Month of June

Bottle Type	**Beginning Inventory**	**Monthly Target Production (units)**	**Monthy Production Required (units)**	**No. of Workers /Machine**	**Labor Hours (hrs)/daily**	**Daily Working Shifts**	**Machine Operating (hrs)/daily**	**Machine Downtime (hrs)/daily**	**No. of Working Days**
250ml	0	404,196	404,196	1 Worker	1,440	2	16.3	7.7	26
350ml	0	638,794	638,794	1 Worker	1,440	2	18.8	3.5	26
500ml	0	618,176	618,176	1 Worker	1,440	2	19.8	2.2	26
1 Liter	0	238,758	238,758	1 Worker	1,440	2	16.8	7.2	26

4 Liters	0	23,790	23,790	1 Worker	1,440	1	9.8	14.2	26
5Gallon	0	16,354	16,354	1 Worker	1,440	2	15.2	8.8	26
Slim	0	15,262	15,262	1 Worker	1,440	2	15.7	8.3	26

For June, the production scheduling strategy for Bottle King was crafted to tackle current challenges within the company. This plan showcased a systematic method for managing the production of different bottle types, ensuring an effective match with consumer demand. All bottle varieties were suggested to commence with zero inventory, embracing a just-in-time production model to reduce storage expenses and minimize surplus stock. Monthly production goals varied considerably, with smaller bottles, like the 350ml variety, necessitating the highest output of 638,794 units, whereas larger bottles, such as the 5-Gallon size, had a lower target of 16,354 units. Each bottle type was allocated a single worker, providing a straightforward distribution of the workforce, with each worker contributing roughly 1,440 labor hours each month. This amounted to about 55.4 hours weekly over the planned 26 working days.

Machine utilization was customized to meet production needs, with smaller bottles, like the 500ml type, requiring greater daily machine time at 19.8 hours, while larger bottles, like the 4-Liter type, needed only 9.8 hours per day. Proposed machine downtime was kept minimal for high-demand bottles, such as the 500ml type, with just 2.2 hours of downtime daily, while larger bottles with lesser demand, like the 4-Liter size, were allocated more downtime flexibility at 14.2 hours per day. Most bottle types were intended to operate on a two-shift schedule to achieve production goals, with the exception of the 4-Liter size, which would run on a single shift due to lower production requirements. The plan facilitated steady production across 26 working days, effectively balancing resource use and output.

This proposal integrated production management principles to effectively tackle Bottle King's challenges. By adopting a just-in-time production approach, as proposed by (Romero-Selva et al., 2024), it reduced excess inventory and aligned production with real demand, cutting down on waste. By adjusting machine utilization to match product demand, as highlighted by (Rena, 2024), the plan ensured efficient resource usage while minimizing downtime. Furthermore, the adaptable scheduling method aligned with (Permana et al., 2021) recommendations for responding to fluctuating production demands. The implementation of this production scheduling proposal assisted Bottle King in addressing inefficiencies, optimizing resource utilization, and aligning better with demand, thereby enhancing overall operational effectiveness.

Table 15. Proposed Production Scheduling at Bottle King for the Month of July

Bottle Type	Beginning Inventory	Monthly Target Production (units)	Monthy Production Required	No. of Workers /Machine	Labor Hours (hrs)/daily	Daily Working Shifts	Machine Operating (hrs)/daily	Machine Downtime (hrs)/daily	No. of Working Days

			(units)						
250ml	0	404,196	404,196	1 Worker	1,440	2	16.3	7.7	26
350ml	0	638,794	638,794	1 Worker	1,440	2	18.8	3.5	26
500ml	0	618,176	618,176	1 Worker	1,440	2	19.8	2.2	26
1 Liter	0	238,758	238,758	1 Worker	1,440	2	16.8	7.2	26
4 Liters	0	23,790	23,790	1 Worker	1,440	1	9.8	14.2	26
5Gall on	0	16,354	16,354	1 Worker	1,440	2	15.2	8.8	26
Slim	0	15,262	15,262	1 Worker	1,440	2	15.7	8.3	26

For July, the production scheduling proposal for Bottle King was crafted to alleviate current challenges within the company. The strategy showcased a well-organized method of overseeing the production of different bottle types, ensuring alignment with market demand. Each bottle type was proposed to start with an inventory of zero units, adopting a just-in-time production model to reduce storage expenses and surplus inventory. Monthly production goals varied greatly, with the smaller 350ml bottles needing the highest output at 638,794 units, while the larger 5-Gallon bottles had a significantly lower target of 16,354 units. Each bottle type was assigned one worker, facilitating a simple distribution of the workforce, with each contributing around 1,440 labor hours monthly. This equated to approximately 55.4 hours weekly across the 26 scheduled working days.

Machine usage was customized according to production needs, with smaller bottles, like the 500ml size, necessitating greater daily utilization at 19.8 hours per machine, in contrast to larger bottles such as the 4-Liter size, which only required 9.8 hours per day. Daily machine downtime was kept to a minimum for the high-demand bottle types, like the 500ml bottle, with just 2.2 hours of downtime each day, whereas larger bottles with less demand, such as the 4-Liter size, were allotted more downtime flexibility at 14.2 hours per day. Most bottle types were scheduled to function on a two-shift basis to achieve their production objectives, except for the 4-Liter size, which was designated for a single shift due to its lower production requirements. The plan maintained steady production over the course of 26 working days, effectively balancing resource utilization and output.

This proposal integrated concepts from production management to tackle Bottle King's challenges successfully. By implementing a just-in-time production strategy, as indicated by Romero-Selva et al. (2024), the proposal reduced excess inventory and aligned production closely with actual demand, cutting down on waste. Ensuring machine utilization matched product demand, as highlighted by Rena (2024), helped the plan make efficient use of resources while minimizing idle time. Furthermore, the adaptable scheduling method matched the recommendations of Permana et al. (2021) for responding to fluctuating production needs. The execution of this production scheduling proposal enabled Bottle King to resolve inefficiencies, maximize resource utilization, and better satisfy demand, ultimately enhancing overall operational effectiveness.

Table 16. Proposed Production Scheduling at Bottle King for the Month of August

Bottle Type	Beginning Inventory	Monthly Target Production (units)	Monthy Production Required (units)	No. of Workers /Machine	Labor Hours (hrs)/daily	Daily Working Shifts	Machine Operating (hrs)/daily	Machine Downtime (hrs)/daily	No. of Working Days
250ml	0	404,196	404,196	1 Worker	1,440	2	16.3	7.7	26
350ml	0	638,794	638,794	1 Worker	1,440	2	18.8	3.5	26
500ml	0	618,176	618,176	1 Worker	1,440	2	19.8	2.2	26
1 Liter	0	238,758	238,758	1 Worker	1,440	2	16.8	7.2	26
4 Liters	0	23,790	23,790	1 Worker	1,440	1	9.8	14.2	26
5Gallon	0	16,354	16,354	1 Worker	1,440	2	15.2	8.8	26
Slim	0	15,262	15,262	1 Worker	1,440	2	15.7	8.3	26

In August, the production scheduling proposal for Bottle King was crafted to tackle and resolve ongoing company challenges. The plan demonstrated a systematic method for overseeing the production of different bottle varieties, ensuring effective coordination with market demand. It was proposed that all bottle categories start with a zero-unit inventory, employing a just-in-time production model to reduce storage costs and prevent surplus inventory. Monthly production goals varied considerably, with smaller bottles, like the 350ml type, necessitating the highest volume at 638,794 units, while larger bottles, such as the 5-Gallon variety, had a much lower target of 16,354 units. Each bottle type was designated a single worker, leading to a clear distribution of the workforce, with each worker providing roughly 1,440 labor hours each month. This equated to approximately 55.4 hours per week throughout the planned 26 working days.

Machine usage was customized according to production needs, with smaller bottles, like the 500ml size, requiring a greater daily operation of 19.8 hours per machine, in contrast to larger bottles, such as the 4-Liter size, which demanded only 9.8 hours of daily usage. Daily machine downtime was intended to be minimal for high-demand bottles, like the 500ml size, allowing for only 2.2 hours of downtime each day, while larger bottles, like the 4-Liter size, were allocated more downtime flexibility at 14.2 hours per day. The majority of bottle types were scheduled to operate using a two-shift system to meet their production goals, except for the 4-Liter size, which would function with just a single shift due to lower production demand. The plan aimed to maintain steady production over the course of 26 working days, striking a balance between resource utilization and output.

This proposal embraced production management principles to effectively confront Bottle King's challenges. Implementing a just-in-time production strategy, as advocated by (Romero-Selva et.al, 2024), reduced excess inventory and aligned production efforts with actual demand, thereby minimizing waste. By correlating machine utilization with product demand, as highlighted by (Rena, 2024), the plan ensured effective resource utilization while reducing idle time. Furthermore, the adaptive scheduling approach resonated with (Permana et.al, 2021) recommendations for accommodating fluctuating production demands. Executing this production scheduling proposal enabled Bottle King to rectify inefficiencies, optimize resource utilization, and more accurately fulfill demand, leading to enhanced overall operational performance.

Table 17. Proposed Production Scheduling at Bottle King for the Month of September

Bottle Type	**Beginning Inventory**	**Monthly Target Production (units)**	**Monthy Production Required (units)**	**No. of Workers /Machine**	**Labor Hours (hrs)/daily**	**Daily Working Shifts**	**Machine Operating (hrs)/daily**	**Machine Downtime (hrs)/daily**	**No. of Working Days**
250ml	0	404,196	404,196	1 Worker	1,440	2	16.3	7.7	26
350ml	0	638,794	638,794	1 Worker	1,440	2	18.8	3.5	26
500ml	0	618,176	618,176	1 Worker	1,440	2	19.8	2.2	26
1 Liter	0	238,758	238,758	1 Worker	1,440	2	16.8	7.2	26
4 Liters	0	23,790	23,790	1 Worker	1,440	1	9.8	14.2	26
5Gallon	0	16,354	16,354	1 Worker	1,440	2	15.2	8.8	26
Slim	0	15,262	15,262	1 Worker	1,440	2	15.7	8.3	26

For September, the proposed production schedule for Bottle King aimed to resolve current challenges within the company. The plan showcased a methodical approach to managing the output of different bottle types, ensuring effective coordination with market demand. All bottle types were slated to start with zero inventory, utilizing a just-in-time production method to reduce storage costs and surplus inventory. Monthly production goals varied widely, with smaller bottles like the 350ml type necessitating the highest output of 638,794 units, whereas larger bottles, such as the 5-Gallon size, had a significantly lower target of 16,354 units. Each bottle category was assigned one worker, allowing for a clear distribution of labor, with each worker contributing roughly 1,440 hours per month, equating to about 55.4 hours weekly over the planned 26 working days.

Machine usage was adjusted according to production needs, with smaller bottles, such as the 500ml size, requiring more daily usage at 19.8 hours per machine, in contrast to larger bottles like the 4-Liter size, which only needed 9.8 hours daily. Proposed machine downtime was kept minimal for high-demand bottles, like the 500ml size, allowing for just 2.2 hours of downtime each day, while larger bottles with lower demand, such as the 4-Liter size, had a more flexible downtime of 14.2 hours per day. Most bottle types were scheduled to operate on a dual-shift basis to achieve their production goals, except for the 4-Liter size, which was planned for a single shift due to its reduced demand. The proposal ensured steady production across the 26 working days, striking a balance between resource use and output.

The proposal integrated various production management principles to effectively tackle Bottle King's issues. The adoption of a just-in-time production strategy, as recommended by (Romero-Selva et al., 2024), helped to minimize excess inventory and synchronize production with genuine demand, thereby reducing waste. By aligning machine utilization with product demand, as highlighted by (Rena, 2024), the plan guaranteed efficient resource usage while cutting down on idle periods. Furthermore, the adaptable scheduling approach was in agreement with (Permana et al., 2021) guidelines for responding to fluctuating production demands. The implementation of this production scheduling proposal enabled Bottle King to address inefficiencies, optimize resource allocation, and improve its ability to meet demand, ultimately enhancing overall operational performance.

Table 18. Proposed Production Scheduling at Bottle King for the Month of October

Bottle Type	**Beginning Inventory**	**Monthly Target Production (units)**	**Monthy Production Required (units)**	**No. of Workers /Machine**	**Labor Hours (hrs)/daily**	**Daily Working Shifts**	**Machine Operating (hrs)/daily**	**Machine Downtime (hrs)/daily**	**No. of Working Days**
250ml	0	404,196	404,196	1 Worker	1,440	2	16.3	7.7	26
350ml	0	638,794	638,794	1 Worker	1,440	2	18.8	3.5	26
500ml	0	618,176	618,176	1 Worker	1,440	2	19.8	2.2	26

1 Liter	0	238,758	238,758	1 Worker	1,440	2	16.8	7.2	26
4 Liters	0	23,790	23,790	1 Worker	1,440	1	9.8	14.2	26
5Gall on	0	16,354	16,354	1 Worker	1,440	2	15.2	8.8	26
Slim	0	15,262	15,262	1 Worker	1,440	2	15.7	8.3	26

For October, the production scheduling plan for Bottle King was crafted to tackle and resolve existing challenges within the company. The proposal presented a methodical strategy for managing the manufacturing of different bottle types, ensuring that production was efficiently matched with customer demand. Each type of bottle was set to start with a zero-unit inventory, utilizing a just-in-time production approach to reduce storage expenses and avoid surplus inventory. Monthly production goals varied widely, with the smaller 350ml bottles needing the highest output at 638,794 units, while the larger 5-Gallon bottles had a lower target of 16,354 units. One worker was assigned to each type of bottle, providing a clear distribution of the workforce, with each worker contributing around 1,440 labor hours per month. This equated to roughly 55.4 hours a week during the 26 designated working days.

Machine utilization was adjusted based on production needs, with the smaller 500ml bottles requiring more daily machine hours at 19.8, while larger bottles, like the 4-Liter size, needed only 9.8 hours daily. To minimize downtime for the high-demand 500ml bottles, only 2.2 hours of daily downtime was recommended, whereas larger bottles like the 4-Liter size were allowed a more flexible downtime schedule of 14.2 hours per day. Most varieties were scheduled to run on a two-shift system to accomplish their production goals, except for the 4-Liter size, which was planned for a single shift due to its reduced production needs. The proposal enabled consistent production across the 26 working days, maintaining a balance between resource utilization and output.

This proposal integrated production management principles to effectively address Bottle King's challenges. Implementing a just-in-time production strategy, as proposed by (Romero-Selva et.al, 2024), helped to minimize excess inventory and aligned output with genuine demand, thereby decreasing waste. By aligning machine usage with product requirements, as highlighted by (Rena, 2024), the strategy promoted efficient resource allocation while minimizing downtime. Furthermore, the flexible scheduling method conformed to (Permana et.al, 2021) recommendations for adjusting to fluctuating production demands. The introduction of this production scheduling proposal enabled Bottle King to combat inefficiencies, enhance resource utilization, and more effectively satisfy demand, ultimately leading to improved overall operational performance.

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Table 19. Proposed Production Scheduling at Bottle King for the Month of November

Bottle Type	Beginning Inventory	Monthly Target Production (units)	Monthy Production Required (units)	No. of Workers /Machine	Labor Hours (hrs)/daily	Daily Working Shifts	Machine Operating (hrs)/daily	Machine Downtime (hrs)/daily	No. of Working Days
250ml	0	404,196	404,196	1 Worker	1,440	2	16.3	7.7	26
350ml	0	638,794	638,794	1 Worker	1,440	2	18.8	3.5	26
500ml	0	618,176	618,176	1 Worker	1,440	2	19.8	2.2	26
1 Liter	0	238,758	238,758	1 Worker	1,440	2	16.8	7.2	26
4 Liters	0	23,790	23,790	1 Worker	1,440	1	9.8	14.2	26
5Gallon	0	16,354	16,354	1 Worker	1,440	2	15.2	8.8	26
Slim	0	15,262	15,262	1 Worker	1,440	2	15.7	8.3	26

In November, the production scheduling proposal for Bottle King was crafted to tackle and resolve ongoing company issues. The strategy showcased an organized method for overseeing the production of different bottle types, ensuring effective coordination with demand. All bottle types were set to start with zero inventory, adopting a just-in-time production approach to reduce storage costs and surplus inventory. The monthly production goals varied widely, with the smaller 350ml bottles needing the highest output at 638,794 units, while larger bottles, like the 5-Gallon size, had a lower target of 16,354 units. Each type of bottle was assigned one worker, resulting in a simple distribution of the workforce, with each worker contributing about 1,440 labor hours monthly. This equated to roughly 55.4 hours weekly over the planned 26 working days. Machine utilization was adjusted according to production needs, with smaller bottles, such as the 500ml size, needing higher daily machine use at 19.8 hours per machine, in contrast to larger bottles like the 4-Liter size, which only required 9.8 hours per day. To maintain high demand, machine downtime was kept low for popular bottle types, like the 500ml size, with only 2.2 hours of downtime each day, while larger bottles, such as the 4-Liter size, had more flexibility for downtime at 14.2 hours daily. Most bottle types were scheduled for two shifts to meet their production goals, except for the 4-Liter size, which was planned for a single shift due to its lesser production needs. The proposal ensured steady production across 26 working days, achieving a balance of resource use and output. This plan integrated production management principles to effectively confront Bottle King's challenges. By implementing a just-in-time production strategy, as highlighted by (Romero-Selva et al., 2024), it curtailed excess inventory and synchronized production with genuine demand, minimizing waste. The alignment of machine utilization with product demand, as stressed by (Rena, 2024), ensured efficient resource use while reducing idle time. Furthermore, the flexible scheduling method adhered to (Permana et al., 2021) recommendations for accommodating shifting production needs. The execution of this production scheduling proposal enabled Bottle King to resolve inefficiencies, optimize resource utilization, and better fulfill demand, ultimately enhancing overall operational performance.

Table 20. Proposed Production Scheduling at Bottle King for the Month of December

Bottle Type	**Beginning Inventory**	**Monthly Target Production (units)**	**Monthy Production Required (units)**	**No. of Workers /Machine**	**Labor Hours (hrs)/daily**	**Daily Working Shifts**	**Machine Operating (hrs)/daily**	**Machine Downtime (hrs)/daily**	**No. of Working Days**
250ml	0	404,196	404,196	1 Worker	1,440	2	16.3	7.7	26
350ml	0	638,794	638,794	1 Worker	1,440	2	18.8	3.5	26
500ml	0	618,176	618,176	1 Worker	1,440	2	19.8	2.2	26
1 Liter	0	238,758	238,758	1 Worker	1,440	2	16.8	7.2	26
4 Liters	0	23,790	23,790	1 Worker	1,440	1	9.8	14.2	26
5Gallon	0	16,354	16,354	1 Worker	1,440	2	15.2	8.8	26
Slim	0	15,262	15,262	1 Worker	1,440	2	15.7	8.3	26

For the month of December, Bottle King's production scheduling proposal was crafted to tackle ongoing challenges within the company. The plan featured an organized method for managing the production of various types of bottles, ensuring effective alignment with market demand. All bottle varieties were set to start with zero inventory, employing a just-in-time production strategy to reduce storage expenses and surplus inventory. The monthly production objectives differed greatly, with the smaller 350ml bottles needing the highest output at 638,794 units, while the larger 5-Gallon bottles had a lower target of 16,354 units. Each type of bottle was allocated one worker, providing a clear distribution of the workforce, with each worker contributing around 1,440 labor hours monthly. This amounted to about 55.4 hours per week across the 26 scheduled working days.

Machine utilization was customized to fit the production needs, with the smaller 500ml bottles needing higher daily machine use at 19.8 hours, compared to the larger 4-Liter bottles, which required only 9.8 hours daily. Downtime for machines was kept minimal for high-demand products like the 500ml bottles, allowing for just 2.2 hours of daily downtime, while larger bottles like the 4-Liter size had more downtime flexibility, set at 14.2 hours per day. Most bottle types were intended to function on a two-shift system to reach their production goals, except for the 4-Liter bottles, which were designated for a single shift due to their lower production needs. The plan guaranteed steady production throughout the 26 working days, balancing the utilization of resources with output.

This proposal integrated production management principles to effectively overcome Bottle King's challenges. By implementing a just-in-time production strategy, as recommended by (Romero-Selva et al., 2024), excess inventory was minimized, and production was aligned with actual demand, thus reducing waste. The plan ensured efficient resource use by aligning machine utilization with product demand, as highlighted by (Rena, 2024), while minimizing idle time. Furthermore, the adaptable scheduling approach was in line with (Permana et al., 2021) suggestions for responding to fluctuating production needs. The execution of this production scheduling proposal allowed Bottle King to resolve inefficiencies, optimize resource use, and more effectively meet demand, ultimately enhancing overall operational performance.

13. Appendixes

APPENDIX A
Production Data Collection Form

CAPACITY PLANNING AND PRODUCTION SCHEDULING AT BOTTLE KING SOLUTIONS SERVICES INC.: SOME PROPOSALS

Production Data Collection Form

Product: __________ml/liter/gallon/slim

Production Capacity: __________units/day

Raw Material Usage: __________kg of plastic/unit

Labor Requirement: __________hrs/unit

Machine Time Required: __________hrs/unit

Variable Cost: __________pesos/unit

Selling Price: __________pesos/unit

Monthly Demand: __________units/month

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References

1. Alamgir Hossain M., "Capacity Constrained Materials Planning and Scheduling in a Plastic Manufacturing Company," 2020.
2. Anusorn A., Tharmmaphornphilas W., "Production Allocation and Distribution for Bottled Water Manufacturing," 2020 6th International Conference on Control, Automation and Robotics (ICCAR), April 2020, 509–512.
3. Arbabi H., Bozorgi-Amiri A., Tavakkoli-Moghaddam R., "Integrated Configuration Design and Capacity Planning in a Dynamic Cloud Manufacturing System," International Journal of Production Research, 2023, 61 (9), 2873–2894.
4. Avadiappan V., Gupta D., Maravelias C. T., "Production Scheduling Under Demand Uncertainty in the Presence of Feedback: Model Comparisons, Insights, and Paradoxes," Computers & Chemical Engineering, 2022, 168, 108028.
5. Bakke N. A., Hellberg R., "The Challenges of Capacity Planning," International Journal of Production Economics, 2021, 30, 243–264.
6. Bałdowska-Witos P., Piasecka I., Flizikowski J., Tomporowski A., Idzikowski A., Zawada M., "Life Cycle Assessment of Two Alternative Plastics for Bottle Production," Materials, 2021, 14 (16), 4552.
7. Benyathiar P., Kumar P., Carpenter G., Brace J., Mishra D. K., "Polyethylene Terephthalate (PET) Bottle-to-Bottle Recycling for the Beverage Industry: A Review," Polymers, 2022, 14 (12), 2366.
8. Berry W. L., Vollmann T. E., "Capacity Planning Techniques for Manufacturing Control Systems: Information Requirements and Operational Features," Journal of Operations Management, 2020, 3 (1), 13–25.
9. Bhosale K. C., Pawar P. J., "Production Planning and Scheduling Problem of Continuous Parallel Lines with Demand Uncertainty and Different Production Capacities," Journal of Computational Design and Engineering, 2020, 7 (6), 761–774.
10. Bueno A., Godinho Filho M., Frank A. G., "Smart Production Planning and Control in the Industry 4.0 Context: A Systematic Literature Review," Computers & Industrial Engineering, 2020, 149, 106774.
11. Cañas H., Mula J., Campuzano-Bolarín F., Poler R., "A Conceptual Framework for Smart Production Planning and Control in Industry 4.0," Computers & Industrial Engineering, 2022, 173, 108659.
12. Cantamessa M., Valentini C., "Planning and Managing Manufacturing Capacity When Demand is Subject to Diffusion Effects," International Journal of Production Economics, 2021, 66 (3), 227–240.
13. Chand S., Moskowitz H., Novak A., Rekhi I., Sorger G., "Capacity Allocation for Dynamic Process Improvement with Quality and Demand Considerations," Operations Research, 2022, 44 (6), 964–975.
14. Chandra S., Gozali L., Tjhia A., Daywin F. J., "Production Planning and Control Industry 4.0 on Plastic Bottles with the Blow Moulding Process (Case Study: PT. Peace Industrial Packaging)," International Journal of Industrial Engineering and Operation Management, 2021.
15. Chen A., Hsu C. H., Blue J., "Demand Planning Approaches to Aggregating and Forecasting Interrelated Demands for Safety Stock and Backup Capacity Planning," International Journal of Production Research, 2020, 45 (10), 2269–2294.

16. Chen C., Lee Kong T., Kan W., "Identifying the Promising Production Planning and Scheduling Method for Manufacturing in Industry 4.0: A Literature Review," Production & Manufacturing Research, 2023, 11 (1), 2279329.
17. Chien C. F., Dou R., Fu W., "Strategic Capacity Planning for Smart Production: Decision Modeling Under Demand Uncertainty," Applied Soft Computing, 2020, 68, 900–909.
18. Cox I., Spencer M. S., "The Constraints Management Handbook," CRC Press, 2024.
19. Briskorn D., Rotfuß, L., Helmdach M. "Modelling and optimising the capacity and production network planning in plastics processing factories." International Journal of Production Research, April 2023, 61 (7), 2105-2128.
20. Danket T., Tanachutiwat S., Rungreunganun V. "A Mixture-of-experts Approach to Production Capacity Planning for Diverse Demand Patterns via Deep Reinforcement Learning." Engineering Access, 2024, 10 (2), 154-165.
21. Desole M.P., Aversa C., Barletta, M., Gisario A., Vosooghnia A. "Life cycle assessment (LCA) of PET and PLA bottles for the packaging of fresh pasteurised milk: The role of the manufacturing process and the disposal scenario." Packaging Technology and Science, 2022, 35 (2), 135-152.
22. Dittfeld H., Scholten K., Van Donk D.P. "Proactively and reactively managing risks through sales & operations planning." International Journal of Physical Distribution and Logistics Management, 2020, 51 (6), 566-584.
23. Du C., Dai X., Wang Z., Fan C., Chang H. "Plant-wide optimal scheduling of multi-grade PET production with time window constraints: A hybrid discrete/continuous-time optimization formulation." Computers & Chemical Engineering, 2024, 186, 108682.
24. Guzman E., Andres B., Poler R. "Models and algorithms for production planning, scheduling and sequencing problems: A holistic framework and a systematic review." Journal of Industrial Information Integration, 2022, 27, 100287.
25. Ertogral K., Öztürk F.S. "An integrated production scheduling and workforce capacity planning model for the maintenance and repair operations in the airline industry." Computers & Industrial Engineering, 2020, 127, 832-840.
26. Esteso A., Peidro D., Mula J., Díaz-Madroñero M. "Reinforcement learning applied to production planning and control." International Journal of Production Research, 2023, 61 (16), 5772-5789.
27. Fu Y., Hou Y., Wang Z., Wu X., Gao K., Wang L. "Distributed scheduling problems in intelligent manufacturing systems." Tsinghua Science and Technology, 2021, 26 (5), 625-645.
28. Gao J., Guo Z., Liu L., Dong Y., Du J. "Integrated batch production planning and scheduling optimization considering processing time uncertainty." Optimization and Engineering, 2024, 1-32.
29. Gao J., Zhu X., Bai K., Zhang R. "New controllable processing time scheduling with subcontracting strategy for no-wait job shop problem." International Journal of Production Research, 2022, 60 (7), 2254-2274.
30. Ghaleb M., Zolfagharinia H., Taghipour S. "Real-time production scheduling in the Industry-4.0 context: Addressing uncertainties in job arrivals and machine breakdowns." Computers & Operations Research, 2020, 123, 105031.
31. Ghiyasinasab M., Lehoux N., Ménard S., Cloutier C. "Production planning and project scheduling for engineer-to-order systems-case study for engineered wood production." International Journal of Production Research, 2021, 59 (4), 1068-1087.

32. Hartmann N.N., Lussier B. "Managing the sales force through the unexpected exogenous COVID-19 crisis." Industrial Marketing Management, 2020, 88, 101-111.
33. Ho J.W., Fang C.C. "Production capacity planning for multiple products under uncertain demand conditions." International Journal of Production Economics, 2020, 141 (2), 593-604.
34. Indah A., Muliyadi M., Satria D.N. "Production capacity planning of water bottled using rough cut capacity planning method." AIP Conference Proceedings, May 2023, 2596 (1).
35. Lohmer J., Lasch R. "Production planning and scheduling in multi-factory production networks: A systematic literature review." International Journal of Production Research, 2021, 59 (7), 2028-2054.
36. Johnston M.W., Marshall G.W. "Sales force management: Leadership, innovation, technology." Routledge, 2020.
37. Kamoga Mulungi S.M. "Water bottle manufacture and production." Unknown Publisher, 2023.
38. Katiraee N., Calzavara M., Finco S., Battini D., Battaïa O. "Consideration of workers' differences in production systems modelling and design: State of the art and directions for future research." International Journal of Production Research, 2021, 59 (11), 3237-3268.
39. Kaya O., Bagci F., Turkay M., "Planning of capacity, production and inventory decisions in a generic reverse supply chain under uncertain demand and returns." International Journal of Production Research, 2021, 52(1), 270-282.
40. Lapide L., "Sales and operations planning (S&OP) mindsets", The Journal of Business Forecasting, Spring 2007, 2021 pp. 21-31.
41. Lee M., Moon K., Lee K., Hong J., Pinedo M., "A critical review of planning and scheduling in steel-making and continuous casting in the steel industry", Journal of the Operational Research Society, 2024, 75 (8), 1421–1455.
42. Li Y., Carabelli S., Fadda E., Manerba D., Tadei R., Terzo O., "Machine learning and optimization for production rescheduling in Industry 4.0", The International Journal of Advanced Manufacturing Technology, 2020, 110 (9), 2445–2463.
43. Li Z., Ierapetritou M.G., "Production planning and scheduling integration through augmented Lagrangian optimization", Computers & Chemical Engineering, 2021, 34 (6), 996–1006.
44. Lindahl S.B., Babi D.K., Gernaey K.V., Sin G., "Integrated capacity and production planning in the pharmaceutical supply chain: Framework and models", Computers & Chemical Engineering, 2023, 171, 108163.
45. Liu R., Piplani R., Toro C., "Deep reinforcement learning for dynamic scheduling of a flexible job shop", International Journal of Production Research, 2022, 60 (13), 4049–4069.
46. Lohmer J., Lasch R., "Production planning and scheduling in multi-factory production networks: a systematic literature review", International Journal of Production Research, 2021, 59 (7), 2028–2054.
47. Luft A., Bremen S., Luft N., "A cost/benefit and flexibility evaluation framework for additive technologies in strategic factory planning", Processes, 2023, 11 (7), 1968.
48. Alimian M., Ghezavati V., Tavakkoli-Moghaddam R., "New integration of preventive maintenance and production planning with cell formation and group scheduling for dynamic cellular manufacturing systems", Journal of Manufacturing Systems, 2020, 56, 341–358.
49. Mac Cawley A., Maturana S., Pascual R., Tortorella G.L., "Scheduling wine bottling operations with multiple lines and sequence-dependent set-up times: Robust formulation and a decomposition solution approach", European Journal of Operational Research, 2022, 303 (2), 819–839.

50. Makul N., "Cost-benefit analysis of the production of ready-mixed high-performance concrete made with recycled concrete aggregate: A case study in Thailand", Heliyon, 2020, 6 (6).
51. Mateljak Ž., Mihanović D., "Operational planning level of development in production enterprises in the machine building industry and its impact on the effectiveness of production", Economic Research-Ekonomska Istraživanja, 2016, 29 (1), 325–342.
52. McNair C.J., Vangermeersch R., "Total capacity management: Optimizing at the operational, tactical, and strategic levels", CRC Press, 2020.
53. Samouilidou M.E., Georgiadis G.P., Georgiadis M.C., "A multi-bucket time representation framework for optimal scheduling in beverage production facilities", Computers & Chemical Engineering, 2024, 183, 108611.
54. Mianaei P.K., Aliahmadi M., Faghri S., Ensaf M., Ghasemi A., Abdoos A.A., "Chance-constrained programming for optimal scheduling of combined cooling, heating, and power-based microgrid coupled with flexible technologies", Sustainable Cities and Society, 2022, 77, 103502.
55. Missbauer H., Uzsoy R., "Production planning with capacitated resources and congestion", Springer, 2020.
56. Mohammadi M., "Designing an Integrated Reliable Model for Stochastic Lot-Sizing and Scheduling Problem in Hazardous Materials Supply Chain Under Disruption and Demand Uncertainty", Journal of Cleaner Production, 2020, 274, 122621.
57. Morariu C., Morariu O., Răileanu S., Borangiu T., "Machine Learning for Predictive Scheduling and Resource Allocation in Large Scale Manufacturing Systems", Computers in Industry, 2020, 120, 103244.
58. Naji Nasrabadi Yazd S.A., Salamirad A., Kheybari S., Ishizaka A., "An Efficiency-Based Aggregate Production Planning Model for Multi-Line Manufacturing Systems", Operations Management Research, 2023, 16 (4), 2008–2024.
59. Nunag J.O.M., Paderes N.C.S., Paner K.N.G., Retirado M.E.D., Rosete S.B., Navarro M.M., "Process Improvement: Strategic Approach to Enhance Productivity in the Plastic Bottle Cap Secondary Process Using ProModel Simulation", 2024.
60. Owens A., "Scheduling Problem with Drying Requirements, Machine Eligibility Restrictions, Setup Times, and Assembly Requirements for an Injection Molding Facility", 2023.
61. Gunawan P.A., Gozali L., Widodo L., Jusuf Daywin F., Doaly C.O., "Production Planning and Capacity Control with Demand Forecasting Using Artificial Neural Network (Case Study PT. Dynaplast) for Industry 4.0", Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management, 2021, 2722–2732.
62. Parag Y., Elimelech E., Opher T., "Bottled Water: An Evidence-Based Overview of Economic Viability, Environmental Impact, and Social Equity", Sustainability, 2023, 15 (12), 9760.
63. Parente M., Figueira G., Amorim P., Marques A., "Production Scheduling in the Context of Industry 4.0: Review and Trends", International Journal of Production Research, 2020, 58 (17), 5401–5431.
64. Pereira D.F., Oliveira J.F., Carravilla M.A., "Tactical Sales and Operations Planning: A Holistic Framework and a Literature Review of Decision-Making Models", International Journal of Production Economics, 2020, 228, 107695.
65. Permana S., Andriani M., Dewiyana D., "Production Capacity Requirements Planning Using the Capacity Method Requirement Planning", International Journal of Engineering, Science and Information Technology, 2021, 1 (4), 36–40.

66. Phung T.K., Pham T.L.M., Vu K.B., Busca G., “(Bio) Propylene Production Processes: A Critical Review”, Journal of Environmental Chemical Engineering, 2021, 9 (4), 105673.
67. Renna P., “A Review of Game Theory Models to Support Production Planning, Scheduling, Cloud Manufacturing and Sustainable Production Systems”, Designs, 2024, 8 (2), 26.
68. Teerasoponpong S., Sopadang A., “A Simulation-Optimization Approach for Adaptive Manufacturing Capacity Planning in Small and Medium-Sized Enterprises”, Expert Systems with Applications, 2021, 168, 114451.
69. Santosa S.H., Hidayat A.P., Rizkiriani A., Husyairi K.A., Suwanda B.S., “Enhancing Production Planning and Inventory Management: A Quantitative Approach to Forecasting for Bottled Mineral Water Products at PT Arima”, Journal of Applied Science, Technology & Humanities, 2024, 1 (3), 242–248.
70. Santosa S.H., Hidayat A.P., Siskandar R., Rizkiriani A., “Production Scheduling Based on Smart Forecasting Model of Bottled Mineral Water Products”, E3S Web of Conferences, 2023, 454, 03003.
71. Sazvar Z., Tafakkori K., Oladzad N., Nayeri S., “A Capacity Planning Approach for Sustainable-Resilient Supply Chain Network Design Under Uncertainty: A Case Study of Vaccine Supply Chain”, Computers & Industrial Engineering, 2021, 159, 107406.
72. Sifaleras A., Karakalidis A., Nikolaidis Y., “Shift Scheduling in Multi-Item Production Lines: A Case Study of a Mineral Water Bottling Company”, International Journal of Systems Science: Operations & Logistics, 2022, 9 (1), 75–86.
73. Sunday A.A., Omolayo M.I., Remilekun E.E., Abdulkareem A., Moses E.E., Samuel O.O., Olamma U.I., “Impact of Problems Associated with Scheduling and Capacity Planning of a Production Process–An Overview”, E3S Web of Conferences, 2021, 309, 01003.
74. Abid T.B., Ayadi O., Masmoudi F., “An Integrated Production-Distribution Planning Problem Under Demand and Production Capacity Uncertainties: New Formulation and Case Study”, Mathematical Problems in Engineering, 2020, 2020 (1), 1520764.
75. Teerasoponpong S., Sopadang A., “A Simulation-Optimization Approach for Adaptive Manufacturing Capacity Planning in Small and Medium-Sized Enterprises”, Expert Systems with Applications, 2021, 168, 114451.
76. Thevenin S., Adulyasak Y., Cordeau J.F., “Material Requirements Planning Under Demand Uncertainty Using Stochastic Optimization”, Production and Operations Management, 2021, 30 (2), 475–493.
77. Tineo E.Y.T., Vásquez J.M.C., Mendez M.R.H., Pacheco O.A.S., Ninaquispe-Soto M.M., Riega-Virú D.Y., “Improvement of the Production Process, Through Simulation Models, in a Pet Bottle Manufacturing Company”, Intelligent Sustainable Systems: Selected Papers of WorldS4 2022, Volume 1, 2023, 105–118.
78. Trebuna P., Pekarcikova M., Dic M., “Comparing Modern Manufacturing Tools and Their Effect on Zero-Defect Manufacturing Strategies”, Applied Sciences, 2022, 12 (22), 11487.
79. Van Fan Y., Si C., Woon K.S., Čuček L., Dokl M., Varbanov P.S., “Environmental Footprint Allocation in Driving Plastic Avoidance and Sustainable Recycling: Game-Theoretic Model”, Resources, Conservation and Recycling, 2024, 203, 107443.
80. Wang L.C., Chen C.C., Liu J.L., Chu P.C., “Framework and Deployment of a Cloud-Based Advanced Planning and Scheduling System”, Robotics and Computer-Integrated Manufacturing, 2021, 70, 102088.

81. Wang L., Zhao Y., Yin X., "Precast Production Scheduling in Off-Site Construction: Mainstream Contents and Optimization Perspective", Journal of Cleaner Production, 2023, 405, 137054.
82. Yang H., Li W., Wang B., "Joint Optimization of Preventive Maintenance and Production Scheduling for Multi-State Production Systems Based on Reinforcement Learning", Reliability Engineering & System Safety, 2021, 214, 107713.
83. Yao X., Almatooq N., Askin R.G., Gruber G., "Capacity Planning and Production Scheduling Integration: Improving Operational Efficiency via Detailed Modelling", International Journal of Production Research, 2022, 60 (24), 7239–7261.
84. Yao X., Almatooq N., Askin R.G., Gruber G., "Capacity planning and production scheduling integration: improving operational efficiency via detailed modelling", International Journal of Production Research, 2022, 60 (24), 7239–7261.
85. Yorke E., Chowdary B., Bansee J., "A study on the improvement of a local bottle manufacturing operation: Deployment of lean principles and discrete event simulation", [Publisher/Journal Name], 2020, [Volume] (Issue), [Page Numbers].
86. Wang Y., Wu Z., "Model construction of planning and scheduling system based on digital twin", The International Journal of Advanced Manufacturing Technology, 2020, 109 (7), 2189–2203.
87. Zhou L., Jiang Z., Geng N., Niu Y., Cui F., Liu K., Qi N., "Production and operations management for intelligent manufacturing: A systematic literature review", International Journal of Production Research, 2022, 60 (2), 808–846.