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Digital Transformation and Its Impact on Production Improvement: A Case Study at PT Gajah Mada Plastik

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Abstract
PT Gajah Mada Plastik is a plastic manufacturing company that produces plastic bottles using a make-to-stock system, where finished goods are stored before being sold. However, the company has not implemented effective production planning, leading to a mismatch between production volume and market demand. In February 2024, production exceeded demand, resulting in overstock and increased storage costs. This study aims to conduct demand forecasting and aggregate planning to improve production scheduling in a timely, accurate, and cost-efficient manner. Forecasting is performed using one year of historical sales data to project future demand. Aggregate planning is then calculated using two methods: the level method and the chase strategy. The results indicate that the level method yields the lowest total cost, amounting to Rp 98,207,310. Therefore, the level method is selected for aggregate planning, aligning with the company's current condition of excess inventory. This approach allows the company to fulfill customer demand effectively while minimizing costs and avoiding further overstock.
Keywords: Aggregate planning, forecasting, production, inventory, level method

Introduction
Technological advancement plays a crucial role in driving economic growth and enhancing operational efficiency across various sectors (Nasib et al., 2023). In economic management, technology serves as a strategic tool to optimize the effective allocation of resources (Lestari & Nasib, 2021). The operational efficiency achieved through technological integration not only strengthens national competitiveness but also contributes to the improvement of societal well-being (Nasib et al., 2024). Therefore, leveraging technological innovation in economic management practices is essential for achieving sustainable growth and increasing national productivity (Khairani, 2023).

Technological innovation both in hardware and software has significantly transformed operational processes (Nofriza, 2022). Through appropriate technology adoption, economic management can gain substantial advantages in efficiency, productivity, and resource utilization (Tezar Arianto et al., 2021). Technological innovation refers to the application of new ideas, concepts, or inventions in developing products, services, or processes that generate added value (Wasiman, 2021). This may involve the creation of new hardware, software, or even novel business models (Pasaribu et al., 2023). The integration of such innovations enables organizations to optimize performance and adapt to dynamic economic environments, ultimately supporting more effective and competitive economic systems (Nasib, 2024).

Technological innovation is often aimed at enhancing efficiency, productivity, and performance, or providing new solutions to existing challenges (Hamidah, 2024). Operational efficiency refers to an organization's ability to carry out processes using minimal resources while achieving maximum output (Basit, 2021). It involves the optimal management of time, labor, and capital to achieve economic goals effectively (Crişan, 2021). Improving operational efficiency can lead to cost reduction, higher productivity, and better quality outcomes (Chidiogo Uzoamaka Akpuokwe et al., 2024). By integrating innovative technologies, organizations can streamline their operations and create more sustainable economic value in a competitive environment (Mior Shariffuddin et al., 2023).

Manufacturing businesses monitor technological advancements to enhance production outcomes, ensuring maximization of results without compromising initial quality; indeed, modern technology yields superior quality compared to previous standards. PT Gajah Mada Plastik is a manufacturer of household items composed of polypropylene (PP) plastic. Polypropylene, abbreviated as PP, is a thermoplastic synthesized from propylene monomers. Thermoplastic is a category of plastic that becomes malleable at elevated temperatures and subsequently solidifies upon cooling. Thermoplastic is easily moldable and recyclable, exemplified by items such as plastic plates, cups, and spoons. The marketing focus targets individuals with middle to lower incomes, as PT Gajah Mada Plastik's products are competitively priced and relatively inexpensive compared to similar quality alternatives.

Although numerous previous studies have discussed the importance of technology adoption in enhancing efficiency and productivity within the manufacturing sector, most of these studies focus on general aspects such as automation or digitalization, without specifically analyzing the step-by-step changes in technology within a particular company. Moreover, empirical research that links actual technological changes to quantifiable improvements in production output remains limited especially in the context of national-level plastic manufacturing companies like PT Gajah Mada Plastik. This study aims to fill that gap by directly analyzing the impact of technological changes implemented by the company on production output over a defined period. Through an analytical approach using internal company data, this research seeks to provide concrete, contextual insights that are often underrepresented in existing literature.

Theoretical Review

Technology Innovation

In an industrial era characterized by rapid transformation, technical innovation is a crucial factor in establishing a company's competitive edge and operational efficiency (Idris, 2021). For manufacturing firms, the integration of advanced technology is no longer merely supplementary; it has become a fundamental component of the core business plan. The utilization of advanced technological devices, systems, and procedures significantly enhances production capacity, precision, and velocity, consequently influencing more optimal and superior production outcomes (Cappelli & Cini, 2021).

Technological innovation refers to the endeavor to create or apply novel methods, concepts, or systems designed to enhance production processes, minimize error rates, and optimize resource utilization (Sun, 2022). This innovation can be implemented through various methods, including automation robots, artificial intelligence (AI) for predictive maintenance detection, the adoption of Enterprise Resource Planning (ERP) systems, and the utilization of Internet of Things (IoT) devices for precise production data acquisition. These technologies transform the production management system, enabling organizations to quickly address market demands, reduce operational disturbances, and continuously uphold product quality (Gaglio et al., 2022).

Numerous empirical studies have demonstrated a strong correlation between the implementation of technical innovation and enhanced productivity in the industrial sector (Wahab et al., 2021). Organizations that incorporate automation technology and intelligent production systems typically get enhanced production time efficiency and diminished raw material waste (Masnila et al., 2022). This innovation also offers scalability advantages, allowing for increasing production volume without a corresponding rise in manpower and operational costs. This results in a notable increase in productivity, as assessed by the ratio of output to input (M. T. Khan et al., 2022).

Technological innovation fosters the development of an adaptive work culture focused on continual improvement within the business environment (Mahardhani, 2023). Human resources are urged to acquire proficiency in new technologies, enhance competencies, and engage proactively in optimizing work processes. This enhances operational effectiveness and fortifies long-term business resilience against global market changes. In a worldwide supply chain requiring high efficiency, rapid response, and reliable service, technological innovation serves as the primary tool for sustaining competitiveness (Radicic & Petković, 2023).

Productivity

Productivity is a vital factor that indicates a company's operational performance. In a more competitive and evolving corporate landscape, elevated productivity signifies operational efficiency and serves as a crucial factor in long-term firm sustainability (Su et al., 2021). This productivity demonstrates the degree to which a corporation can utilize resources, including labor, raw materials, and time, to achieve maximum production. High productivity enables organizations to manufacture things in substantial quantities, ensure quality uniformity, lower production expenses, and expedite process completion (Xue et al., 2022). The amalgamation of these efficiencies directly influences the augmentation of corporate profitability by lowering expenses per unit and enhancing profit margins. Moreover, enhanced efficiency bolsters the company's competitiveness, particularly in the context of pricing pressures and shifts in consumer demands (Czarnitzki et al., 2023).

The sustainability of a company is contingent upon its capacity to uphold its market position, adapt to external circumstances, and guarantee customer happiness and loyalty (N. Khan et al., 2021). Productivity constitutes the primary foundation. Unproductive enterprises will struggle to satisfy market demand, incur resource wastage, and encounter a deterioration in product quality (Abiri et al., 2023). If these issues are not resolved, the company may incur revenue loss, diminished market share, and maybe confront bankruptcy risks. In contrast, organizations that sustain optimal productivity levels exhibit enhanced resilience in confronting market fluctuations. Business entities are more proficient in enhancing process efficiency, innovating products, and expediting market launch timelines (Shan et al., 2021). This offers a significant adaptive advantage amid economic volatility, supply chain interruptions, and the rise of new competitors.

Productivity influences the sustainability of the organization by enhancing job effectiveness and managerial efficiency (Alola & Adebayo, 2023). An organized manufacturing process will alleviate excessive workload and foster a more favorable work atmosphere. This positively influences employee motivation, satisfaction, and productivity (Xu et al., 2022). Moreover, precise productivity data assists management in formulating more focused strategic decisions. Numerous manufacturing firms have demonstrated their capacity to endure and prosper in the face of worldwide challenges due to their dedication to enhancing productivity (Sahoo et al., 2023). Business entities achieve this by using new technology, providing personnel training, and modernizing production systems. This research indicates that a company's longevity is not only reliant on capital strength or marketing strategy, but is predominantly influenced by internal efficiency and the attainment of high production (Li et al., 2022).

Methodology

This study used a descriptive quantitative methodology to examine the impact of technological innovations on enhancing production outcomes at PT Gajah Mada Plastik. This methodology was selected to get an objective and quantifiable representation of the correlation between technology and productivity. The study's population comprised production and technical staff directly engaged in operational processes and the utilization of machinery or production technologies. The sample method employed was purposive sampling, specifically selecting respondents with knowledge and expertise about technological advancements inside the firm. Data were gathered using two methods: questionnaires and documentation. The questionnaire assessed respondents' perceptions of technical improvements, encompassing indices of automation, efficiency, accuracy, and adaptability, as well as production outcomes, including output volume, process duration, and product defect rate. Documentation was utilized to retrieve historical production data before to and subsequent to the implementation of technical upgrades. The data analysis method commenced with descriptive statistical analysis to delineate the distribution of data, averages, and overarching trends of the examined variables. Prior to doing further analysis, the questionnaire underwent validity and reliability assessments to confirm that the instruments employed were genuinely valid and consistent.

Additionally, multiple linear regression analysis was employed to ascertain the extent of technical innovations' impact on production outcomes. The regression model incorporates four elements of technical progress as independent factors and production outcomes as dependent variables. Hypothesis testing is conducted using the t-test to assess the individual impact of each

variable, and the F-test to evaluate their collective effect. Furthermore, the coefficient of determination (R^2) is employed to assess the extent of the influence of technological change variables on production outcomes. All analyses are conducted using statistical software, such as SPSS, to achieve precise and quantifiable results.

Results and Discussions

Results

PT Gajah Mada Plastik is a company that produces plastic bottles in the period 1986-1990. During this period, the company experienced slow growth because it used simple production machines and less modern technology, so that bottle orders from clients such as paint, oil, and beverage companies were still minimal.

1. Raw material
   The main raw materials used in the production of plastic bottles are HDPE (High-Density Polyethylene) and PP (Polypropylene). HDPE is suitable for thicker and pressure-resistant products, while PP is used for products that require heat resistance.
2. Labor
   The number of workers involved in production increased from 5 people in 1986 to 8 people in 1990, although it was still limited due to limited production equipment and minimal demand.
3. Machines and Production Processes
   The two main methods used in bottle manufacturing are Extrusion Blow Molding and Stretch Blow Molding. This process involves making preforms, heating, and finishing to ensure the quality and appearance of the bottle as per market demand.
4. Production result
   Bottle production output increased from 460 balls in 1986 to 700 balls in 1990, along with increased orders and the introduction of more modern technology.
5. Technology Development and Quality
   After implementing more modern technology, the company was able to improve efficiency and product quality, which had a positive impact on consumer confidence and the number of orders.
6. Production Planning
   The company implements two production planning methods, namely Level Method and Chase Strategy. Level Method focuses on production stability by maintaining inventory, while Chase Strategy adapts to market demand. The Level Method is chosen because it provides a lower total cost.

Discussions

The development of the era is increasingly changing, human power is replaced by modern and sophisticated machine power. This is what is followed by companies that produce products such as plastic bottles. In 1986 - 1990, PT Gajah Mada Plastic still used simple machines and tools to produce plastic bottles so that the results obtained were not that much. This company produces plastic bottles according to order. So if there is an order, it will be made and there is no safety stock because this company does not have a warehouse for storing goods. Another reason is that raw materials are also difficult to obtain, they must be ordered from outside the city such as East Java province and several cities in Central Java. The production results obtained each year have indeed increased but have not been able to cover operational costs. However, over time from 2008 until now, PT Gajahmada has received orders for plastic bottles from several large companies. So that it can produce a lot so that this company can add modern and sophisticated technological production tools and machines so that it can process its production quickly. For this reason, the author will discuss the results of plastic bottle production using the aggregate planning method so that it is known how much production results and production costs must be incurred. This is in accordance with the results of research from (Ding et al., 2022) entitled the plastic production process using technology that modern and sophisticated technology can affect plastic production results. This is similar to the research results

of (Hu et al., 2021) that technology has a significant influence on income, productivity and business efficiency in the appropriate industry.

Furthermore, the calculation of production using the monthly forecasting method is used as a reference in aggregate production planning. The first strategy is to use *the level method* . In this strategy, the company's production capacity is limited and the number of workers is fixed, so the production scheduled in a month is taken as an average for each week because production considers the stability of *stock* or *safety stock* with 700 plastic bottle balls in one month, then production will be varied into minimum production planning using 1 production machine with 1 plastic bottle ball per hour producing a total of 168 plastic balls in one month. This is done because the initial inventory with a total of 1688 plastic bottle balls when reduced by the demand of 970 will result in a remaining inventory of 718, this value still meets the company's safety stock for one month, but the company also does not really not carry out the production process by considering raw materials.

For this reason, the company will continue to carry out a minimum production process of 168 plastic bottle balls. The results can still maintain safety stock with a total of 886 plastic balls while reducing the inventory that has accumulated in the past year with a total cost of Rp98.207.310, this is obtained by multiplying the production cost of Rp370.684.264 by the amount of production. While the second method is the chasing strategy method. In this method, the amount of production is adjusted to the amount of demand so that the remaining stock or inventory is very minimal, even the same as nothing. This method is a calculation of the chase strategy method with variations in its calculation without taking from the initial inventory by maintaining or following the production forecast demand that has been obtained in the forecast calculation of 970 plastic bottle balls in February 2024 with production in the first week of 257, the second week 237, the third week 227 and the fourth week of 249 resulting in a total cost of IDR370.684.264. These results are obtained from the production cost per plastic bottle ball of IDR316.900 multiplied by the amount of production. From the two methods, the level method was chosen with a cost far below the chase strategy method which uses different variations where the chase strategy method does not use initial inventory for demand production. This can be seen from the research [24] , [25] , [26] , Chandra (2022) entitled Analysis of Plastic Packaging Production Planning at CV Jempol using the Aggregate Planning method with planning results aggregate or *aggregate planning* with using the *level method* with variations in inventory usage early to cover the number of requests.

Conclusions

From the research findings, the subsequent conclusions can be inferred: Technology can influence production outcomes, particularly in the manufacturing of plastic bottle products. From 1986 to 1990, PT Gajahmada Plastik utilized hand tools and machinery to manufacture plastic bottles, resulting in an annual production of only 500 to 700 units. Nonetheless, output has escalated over time. The utilization of advanced technological tools and machinery enhances the production process, rendering it swifter, more efficient, and more effective. The production volume is escalating annually, corresponding with the substantial influx of orders and requests from various companies for plastic bottles. To determine the production quantity of plastic bottle products, it is essential to employ forecasting techniques, namely the level approach and chase strategy, which yield varying results leading to a total cost that is very disparate. The level technique employs little production planning, producing 168 plastic bottle balls while aiming to decrease the current inventory by 1688 plastic bottle balls. The company can sustain a safety stock of 700 plastic bottle balls while producing 168 plastic bottle balls monthly, resulting in a total of 886 plastic bottle balls at a cost of Rp. 98,207,310. The alternative approach, the chase strategy, entails adjusting production to align with demand forecasts, resulting in a total output of 970 plastic bottle balls at a cost of Rp. 370,684,264. This method, which does not leverage existing inventory, demonstrates significantly higher costs compared to the first approach.

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