



Investigating the Effectiveness of Lean Manufacturing Principles in Improving Productivity for Malaysian Automotive Company

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ABSTRACT

This study examines the effectiveness of lean manufacturing principles in enhancing productivity within a Malaysian automotive company. Through a comprehensive literature review, the research explores the implementation and impact of lean manufacturing on productivity, focusing on key strategies such as reducing lead times, lowering operational costs, and improving product quality. Quantitative analysis techniques, including descriptive statistics, moving averages, and simple regression, were applied to a dataset from Kaggle to assess production trends and future forecasts. Findings suggest a strong correlation between population growth and car production in Asian countries from 2015 to 2019, with predictions indicating continued growth. The analysis highlights the role of lean principles in fostering sustainable car manufacturing by minimizing waste and enhancing efficiency. By adopting lean practices, automotive companies can optimize resource utilization, improve working conditions, and contribute to a greener environment. The study provides valuable insights and recommendations for Malaysian automotive firms seeking to maximize productivity and sustainability through lean manufacturing.

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1. INTRODUCTION

Quantitative techniques, also known as quantitative analysis, involve the use of mathematical and statistical models to analyze and interpret data in order to make informed decisions. Businesses use quantitative techniques to help them make strategic decisions, identify problems, and evaluate the effectiveness of their operations. Quantitative techniques are important in decision making for businesses for several reasons. Firstly, they provide a systematic and objective approach to decision making, reducing the influence of personal biases and subjective opinions. Secondly, they enable businesses to make predictions and forecasts, allowing them to plan for the future and anticipate potential outcomes.

Moreover, quantitative techniques help businesses to analyze complex data sets and identify patterns and trends that might not be apparent through qualitative analysis. This helps businesses to gain insights into their operations, customers, and

markets, which in turn can inform their decision making. Apart from that, quantitative techniques also enable businesses to evaluate the effectiveness of their decisions and operations by providing objective metrics and measurements. This allows businesses to assess their performance and identify areas for improvement. Overall, the use of quantitative techniques is essential for businesses that want to make data-driven decisions and achieve their goals in a competitive and dynamic marketplace. The main objective of this paper is to study the relations of quantitative techniques and decisions making in the context of investigating the effectiveness of lean manufacturing principles in improving productivity for a Malaysian automotive company. Through this study we are able to understand the influence and importance of applying the quantitative techniques into the lean manufacturing system of Malaysian automotive industry which results in highlighting the weakness in the system and improving the overall efficiencies of the lean manufacturing principles in the local automotive industry.

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Multiple sources of research papers and journals related to the lean manufacturing principals of Malaysian automotive company have been referred to carry out this study.

2. LITERATURE REVIEW

The purpose of this section is to discuss the conceptual and empirical studies that have been performed on the study variables, as well as any prior research that has been done on this issue by other writers.

2.1 *Lean Manufacturing Principles in Automotive Industry in Malaysia.*

The concept of lean manufacturing principles is based on the idea of minimizing waste and increasing efficiency in the production process. The philosophy has its roots in the Toyota Production System (TPS), which was developed in Japan in the 1950s. Since then, lean manufacturing principles have been adopted by many manufacturing companies worldwide to improve their productivity and profitability. Lean manufacturing principles have been widely implemented in the automotive industry worldwide, including Malaysia. Malaysia is one of the countries that have developed a robust automotive industry in recent years. The country has several automotive manufacturing companies that are operating successfully in the international market. However, the Malaysian automotive industry has faced various challenges, such as low productivity, high costs, and low-quality products. By adopting lean manufacturing principles, Malaysian automotive manufacturers can reduce costs, improve productivity, and produce high-quality vehicles that meet customers' expectations. The five core principles of lean manufacturing are value, value stream, flow, pull, and perfection. The first principle, value, involves identifying the customer's needs and delivering products that meet those needs. In the Malaysian automotive industry, this could include producing fuel-efficient and eco-friendly cars that are affordable and of high quality. The second principle, value stream, involves mapping out the production process and identifying areas of waste. This can include anything from excess inventory to unnecessary waiting times between production steps. By identifying these inefficiencies, Malaysian automotive manufacturers can reduce costs and improve productivity. The third principle, flow, involves ensuring that work flows smoothly through the production process. In the automotive industry, this could mean implementing a just-in-time (JIT) system, where parts and components are delivered into the assembly line just in time for production. This can help reduce the time it takes to produce a car and minimize waste. The fourth principle, pull, involves producing products based on customer demand rather than on a forecast. This can help reduce excess inventory and minimize waste. In the Malaysian automotive industry, this could mean producing cars based on orders rather than stockpiling them in anticipation of future sales. The fifth and final principle, perfection, involves striving for continuous improvement. This means continually identifying areas of waste and finding ways to eliminate them. Malaysian automotive manufacturers can achieve this by encouraging employees to suggest ideas for improvement and implementing those ideas that will lead to greater efficiency and productivity. One example of a Malaysian automotive manufacturer that has successfully implemented lean manufacturing principles is Perodua. Perodua is the second-largest carmaker in Malaysia, producing popular models such as the Myvi and the Axia. By implementing lean manufacturing

principles, Perodua has been able to reduce costs and improve productivity, resulting in increased profitability and customer satisfaction. Perodua has implemented several lean manufacturing practices, including JIT production, kaizen (continuous improvement), and 5S (sort, set in order, shine, standardize, and sustain). These practices have helped Perodua reduce waste, improve efficiency, and produce high-quality cars that meet customer demand. Several research studies have investigated the effectiveness of lean manufacturing principles in improving productivity for Malaysian automotive companies. The following is a review of some of these studies.

According to the literature 'A Study on the Implementation of Lean Manufacturing Principles in a Malaysian Automotive Company' by Mohamad et al. (2015) investigated the implementation of lean manufacturing principles in a Malaysian automotive company. The study found that the implementation of lean manufacturing principles resulted in a reduction in lead time, inventory levels, and defects. The study also found that the implementation of lean manufacturing principles improved the company's productivity. Next, 'A Review of Lean Manufacturing Implementation in Malaysian Automotive Industry' by Tan and Ahmad (2018) reviewed the implementation of lean manufacturing in the Malaysian automotive industry. The study found that lean manufacturing had been successfully implemented in several Malaysian automotive companies, resulting in improved productivity and reduced costs. The study also found that the successful implementation of lean manufacturing principles depended on the commitment of top management, the involvement of all employees, and the provision of adequate training and resources. Apart from that, 'A Study on the Implementation of Lean Manufacturing Principles in a Malaysian Automotive Parts Manufacturer' by Chong and Lee (2019) investigated the implementation of lean manufacturing principles in a Malaysian automotive parts manufacturer. The study found that the implementation of lean manufacturing principles resulted in a reduction in lead time, inventory levels, and defects. The study also found that the implementation of lean manufacturing principles improved the company's productivity and customer satisfaction. Then, another study, 'Lean Manufacturing Implementation in Malaysian Automotive Industry: A Review of Success Factors and Barriers' by Baharom et al. (2020) reviewed the success factors and barriers to the implementation of lean manufacturing in the Malaysian automotive industry. The study found that the successful implementation of lean manufacturing principles depended on several factors, including top management commitment, employee involvement, training and development, communication and collaboration, and the use of appropriate tools and techniques. The study also identified several barriers to the implementation of lean manufacturing, including a lack of awareness and understanding, resistance to change, and lack of new technology adaptation.

2.2 *Enabling Advanced Technologies Application with Lean Manufacturing in Automotive Industry in Malaysia.*

In the automotive industry in Malaysia, the implementation of lean manufacturing principles is crucial for enhancing competitiveness and enabling the integration of advanced technologies like artificial intelligence (AI), machine learning (ML), and the Internet of Things (IoT). AI is a branch of computer science focused on creating systems that can perform tasks requiring human-like intelligence, while ML is a subset of AI that involves developing algorithms that allow computers to learn from and make predictions or decisions based on data without explicit programming (Krishna S. R., et al., 2024). On

the other hand, IoT refers to the network of interconnected devices embedded with sensors, software, and other technologies that enables them to collect and exchange data over the internet (Peng Lean Chong., et. al, 2024). Lean manufacturing principles enable implementation of such advanced technologies into the streamlined processes, standardization of work, continuous improvement, visual management, and flexible production system to improve yield, enhance efficiency and to improve human factors in manufacturing (Ng, P.K. et al., 2023).

Lean principles emphasize identifying and eliminating waste in manufacturing processes. By streamlining operations and minimizing unnecessary steps, manufacturers create a more conducive environment for implementing AI, ML, and IoT solutions (Chong, P. L., et. al., 2022, Peng Lean Chong, et. al., 2023). Streamlined processes provide clean data and clear process flows, which are essential for the effective deployment of AI and ML algorithms. Besides that, lean methodologies encourage the establishment of standardized work procedures to ensure consistency and efficiency. Standardization simplifies the integration of IoT devices by providing clear guidelines for data collection and analysis (Silvia Ganesan., et al., 2024; Swathi Manoharan., et al., 2024; Dashini, A., et al., 2024). For example, IoT sensors can be strategically placed on equipment to monitor performance and detect anomalies, contributing to predictive maintenance practices (Peng, C., et. al, 2024, C. Peng Lean and K. Feng Yuan, 2024).

Furthermore, the principle of continuous improvement, or Kaizen, is fundamental to lean manufacturing. By fostering a culture of continuous learning and problem-solving, companies in the Malaysian automotive industry can leverage AI and ML algorithms to analyze vast amounts of data collected from the IoT sensors incorporated into the production processes (Sannasy, K., et. al., 2024). These technologies can identify patterns, suggest optimizations, and even automate decision-making to further enhance efficiency and quality. Moreover, visual management tools such as Kanban boards and Andon systems are commonly used in lean manufacturing to provide real-time visibility into production status and identify issues promptly. Integrating IoT sensors with visual management systems allows for even greater transparency and responsiveness. For instance, IoT-enabled dashboards can display key performance indicators (KPIs) and alert operators to potential bottlenecks or equipment failures in real time, enabling swift corrective actions.

Besides that, lean manufacturing encourages the adoption of flexible production systems that can quickly adapt to changing customer demands. AI and ML algorithms and data collected from IoT devices can analyze market trends, customer preferences, and supply chain data to optimize production schedules and inventory management. By dynamically adjusting production processes based on demand forecasts, manufacturers in Malaysia can minimize overproduction and inventory holding costs while maximizing customer satisfaction.

2.3 Quantitative Techniques and Decision Making in Lean Manufacturing System.

Lean manufacturing principles are widely recognized to improve productivity in manufacturing companies. To investigate the effectiveness of these principles in improving productivity for a Malaysian automotive company, several

quantitative techniques can be used. Some of these techniques are:

Time study: This technique involves observing and timing the work activities of employees to identify non-value-added activities. The aim is to reduce waste and improve productivity by optimizing the work process.

Value Stream Mapping: This is a tool used to visualize the entire process flow of a product, from raw materials to finished goods. It helps to identify bottlenecks and waste and enables the team to develop a more efficient process flow.

- **Statistical Process iControl (SPC):** This technique involves monitoring and controlling the production process using statistical methods to ensure that they are operating within specified limits and to analyse data and identify patterns or trends that indicate process is out of control. By analysing process data, it is possible to identify process variations and implement corrective actions to improve the process.
- **Root cause Analysis (RCA):** This technique is used to identify the root causes of a problem or issue. It involves investigating the problem and identifying the underlying causes, which can then be addressed to improve productivity.
- **Six Sigma:** This is a data-driven methodology used to improve quality and reduce defects. It involves defining, measuring, analysing, improving, and controlling a process to achieve near-perfect quality.
- **Cost-Benefit Analysis:** This technique involves comparing the costs of implementing lean manufacturing principles with the expected benefits, such as increased productivity, reduced waste, and improved quality.

The use of quantitative techniques in decision making related to lean manufacturing can further enhance the effectiveness of these principles. Malaysian automotive companies can benefit from the implementation of lean manufacturing principles and the use of quantitative techniques to improve their productivity and efficiency, thereby remaining competitive in the global market. The data obtained from these techniques can be used to identify areas for improvement and to develop strategies to implement lean principles effectively.

3. METHODOLOGY AND RESULTS

This paper is basically discussing on the effectiveness of lean manufacturing principles in improving the productivity for Malaysia automotive company. By referring to a dataset from Kaggle.com which has been collected through qualitative and quantitative methods by the previous researchers, this paper intended to use the dataset of “*Number of Cars Produced in Asia Countries from year 2015-2019*” to perform some quantitative techniques analysis to obtain some useful results which can help to understand further about the related topic and dataset. The number of populations in Asia countries were gradually increasing from year 2015 until 2019 same goes to the number of cars produced in Asia countries which were increasing gradually in the five years’ time. Malaysia’s population were recorded at 30.37 million in 2015 and slowly increase to 31.95 million within the span of five years. However, the number of cars produced in Malaysia was recorded the highest in 2015 which was around 0.67 million units while the lowest record was in 2017 which was around 0.58 million units. There can be various of macro and micro-

environmental factors that can influence the unsteady number of cars produced within the year 2015-2019 in Malaysia even though with increasing population.

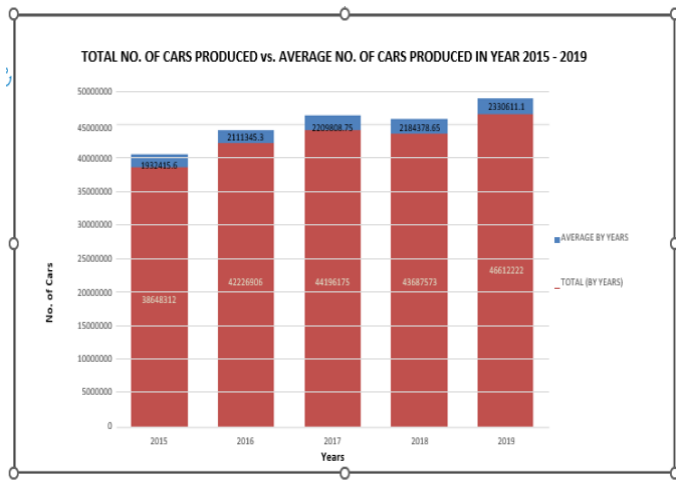


Fig. 1. Number of Population and Cars Produced in Asia Countries from year 2015-2019.

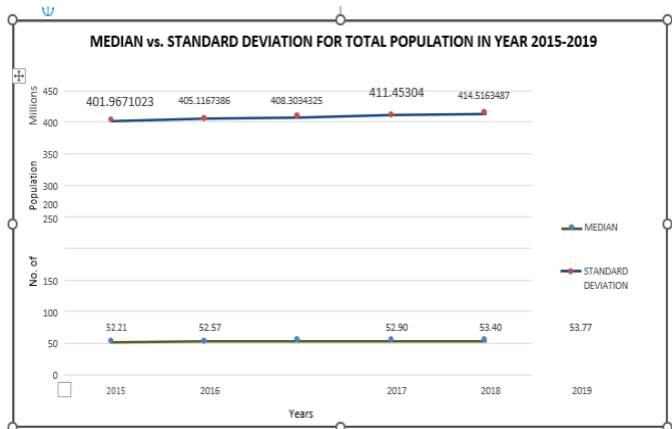


Fig. 2. Total Number of Cars Produced versus Average Number of Cars Produced in Asia Countries from year 2015-2019.

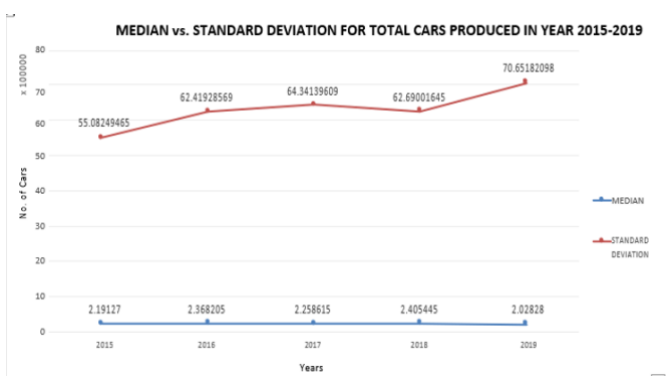


Fig. 3. Median versus Standard Deviation for Total Population in Asia Countries from year 2015-2019.

Based on Figure 1, we can observe the total number of cars produced versus the average of cars produced for each year from 2015 to 2019 in the Asia countries. The highest number of cars produced was in the year 2019 which was about 46.6 million units. The number of cars produced directly influenced by the high population which in the year 2019 was the highest record with i4.1 billion of people in Asia countries. Then based

on Figure 2, the descriptive statistics such as mean, median and standard deviation were calculated by using the Microsoft Excel solver. These descriptive statistics allow a researcher to quantify and describe the basic characteristics of a data set. The average of population and cars produced for the year 2015 to 2019 were recorded with a gradual increment every year. About 197.8 million of people recorded in the year 2015 with gradual increment up to 204.8 million in the year i2019 while for the cars produced, it shows i1.93 million units of cars produced in i2015 and increased up to i2.33 million units in year i2019. The median value for population shows moderate increment from i52.2 million to i53.7 million in the five years' time. However, the median for the number of cars produced in Asia countries shows inconsistency with lowest record in i2019 which is about i0.2 million units while the highest median is recorded in i2018 with value of i0.24 million units. As for the standard deviation, 2015 shows the lowest standard deviation value for both total population and total number of cars produced with 402 million of people and i5.5 million units of cars respectively while 2019 shows the highest record for both variables. A low standard deviation indicates that the data points it end to be close to the mean of the data set, while is high standard deviation indicates that the data points are spread out over a wider range of values. Figure 2 and Figure 3 are the graphs piloted to show the median and standard deviation correlation for both total population and total cars produced in Asia countries for the five years.

Table 1. Moving Average Forecasting for Number of Cars Produced in 2020.

Country	Moving average (3 years) - Forecasting		
	2018	2019	2020
Bangladesh	538.53	1781667	4680
Brunei	1555.39	90000	22500.00
Cambodia	1555.035	22500219	2957605267
China	7758860	402962	6092165
India	727886	402962	667
Indonesia	1439738	7080800	8059385
Japan	1509288	916518	52334160333
Laos	152208.67	9208067	9140
Malaysia	8723	883193	599173.67
Mongolia	7758382	220352	5905385
Myanmar	745.667	8148939	14637.39839
Nepal	1524268	1836.33853	18436.333
Pakistan	1425027	2352102	2270813833
Philippines	723873	409966	420717.3853
Singapore	11005265	109865.7	300748.2333
South Korea	1529288	8582723	2857687
Sri Lanka	152555.7	2108253	3200.60067
Taiwan	151555.8	3108307	296107
Thailand	381607	938065	1081786359
Vietnam	159405	225005.7	245865.2559

Apart from the descriptive statistics analysis, another quantitative technique used in this study is the simple moving average method which are frequently used to estimate the current level of a time series, with this value being projected is a forecast for future observations. As for this data set, moving average of 3 years been performed to forecast the number of cars produced for the year 2020. As there is not any data existed to justify and determine the number of cars produced for year 2020, thus by using Microsoft Excel Solver, we able to obtain the number of cars for each country in the data set. Based on Table 1, China has recorded the highest forecast of number of cars to be produced in year 2020 with 29.6 million units of cars while the lowest was Mongolia with only 3903 units of cars. As for Malaysia, the number of cars to be produced was forecasted to be 0.59 million units which is about 0.02% of the forecasted unit of cars to be produced by China. One of the main factors that influence the increasing volume of cars production was mainly due to the increasing population as well as other macro and micro environmental factors such as technology, political in stability, demographic and of others. Overall, the MA method is a straightforward and effective forecasting method that can be used in a wide range of applications. However, it is essential to understand its limitations and to use it in combination with other forecasting methods for a more accurate forecast.

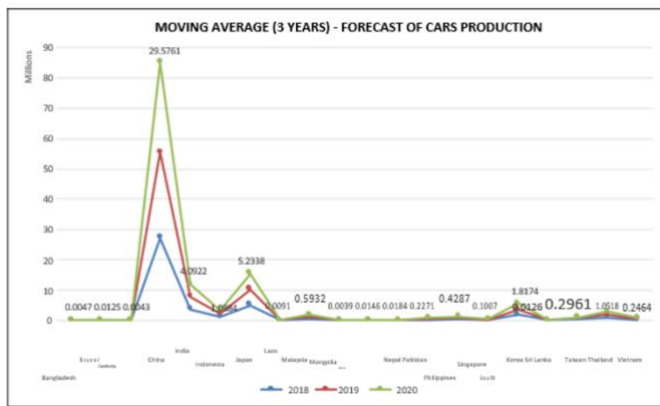


Fig. 4. Moving average (3 years) Forecasting for Total Cars Produced in Asia Countries from year 2018-2020.

Table 2. Simple Linear Regression Data for Total Population and Total Number of Cars Produced in Asia Countries for year 2015-2019.

Year	Simple Linear Regression	
	x-axis	y-axis
	Total Population	Total Cars Produced
2015	3,954,999,865	38,648,312
2016	3,989,758,557	42,226,906
2017	4,025,006,749	44,196,175
2018	4,060,743,417	43,687,573
2019	4,096,322,408	46,612,222

Other than moving average method, regression analysis also has been used in this study. Regression analysis is a statistical technique for quantifying the relationship between variables. in simple regression analysis, there is one

independent variable to be forecast and one independent variable. in this study, the independent variable is the total population which is it ix-axis while the dependent variable is total cars produced it is-axis. Based on table 3, the total population and total cars produced for the year 2015 until 2019 has been shown. By performing the regression analysis using the Excel Solver with assumption of i95% confidence level, we able to calculate the other results such as intercept coefficient, standard error and coefficient of determination i(r2). The value of ir2 obtained is i0.77 which indicate 77% of the variation in cars production is attributable to the simple linear regression relationship between total population and total cars produced in Asia countries for the year 2015 until 2019.

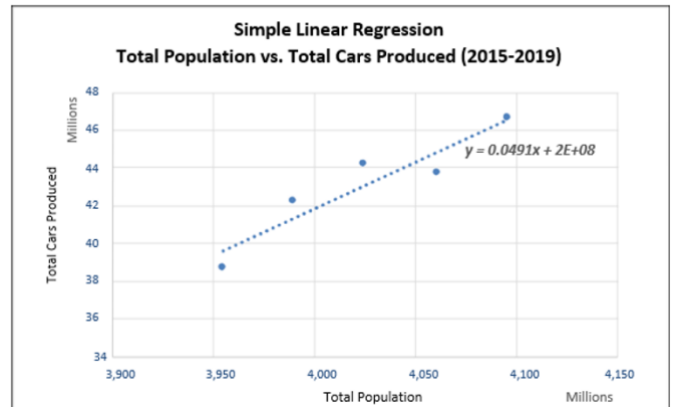


Fig. 5. Scatter Plot of Simple Linear Regression.

The higher the value of ir2, the more successful is the simple near regression model in explaining y variation. On the other hand, by using the data set of total population and total cars produced, in scatter plot or best fitting line is produced to investigate the relationship between the two variables where independent variable plotted ion ix-axis and independent variable it is-axis. The fitted line has a positive is lope, reflecting the positive relationship between the total population and total cars produced. Basically, the simple linear regression model can be expressed in the same value as the simple regression formula $y = \beta_0 + \beta_1 X$. In the simple linear regression model, y refers to the study or dependent variable and X is the explanatory or independent variable. The expressions β_0 and β_1 are the parameters of the linear regression model. The β_0 parameter is regarded as an intercept term, while the β_1 parameter is regarded as the slope parameter.

4. RESULTS AND DISCUSSION

This section presents the findings of the study and discusses the impact of lean manufacturing principles on improving productivity in the Malaysian automotive industry. The analysis is based on quantitative techniques applied to the dataset "Number of Cars Produced in Asia Countries from 2015-2019" sourced from Kaggle.com. The discussion focuses on key trends, descriptive statistics, forecasting using the moving average method, and regression analysis to explore the relationship between total population and total car production.

4.1 Trend Analysis of Car Production in Malaysia

The total number of cars produced in Malaysia fluctuated between 2015 and 2019 despite a steady increase in population. Malaysia's population grew from 30.37 million in 2015 to 31.95 million in 2019. However, car production showed

inconsistency, with the highest output recorded in 2015 at approximately 0.67 million units and the lowest in 2017 at around 0.58 million units. Various macro and micro-environmental factors, including economic conditions, political stability, technological advancements, and supply chain disruptions, could have influenced this variation.

4.2 Descriptive Statistical Analysis

The descriptive statistics provide insights into the distribution and central tendency of the dataset. Based on Figure 1, the total number of cars produced in Asia increased steadily, reaching its highest level in 2019 with approximately 46.6 million units. This upward trend aligns with population growth, which peaked at 4.1 billion people in 2019. By analyzing Figure 2, the mean and standard deviation of car production were calculated using Microsoft Excel Solver. The total population and car production exhibited a gradual annual increase. The average population in Asia grew from 197.8 million in 2015 to 204.8 million in 2019, while car production rose from 1.93 million units to 2.33 million units over the same period. However, the median number of cars produced showed inconsistencies, with the lowest record of 0.2 million units in 2019 and the highest at 0.24 million units in 2018. The standard deviation values indicate the spread of data points. The lowest standard deviation was recorded in 2015 for both population (402 million people) and car production (5.5 million units), while 2019 had the highest standard deviation, reflecting more variability in production numbers.

4.3 Moving Average Forecasting for 2020

To predict car production for 2020, a simple moving average (3-year) forecasting technique was applied. The moving average method smooths fluctuations by averaging data points over a defined period. The results, presented in Table 1, indicate that China was projected to have the highest production in 2020 at approximately 29.6 million units, whereas Mongolia recorded the lowest with only 3,903 units. For Malaysia, the forecasted car production in 2020 was approximately 0.59 million units, representing 0.02% of China's projected output. The results suggest that population growth plays a crucial role in driving car production, but external factors such as government policies, infrastructure development, market demand, and technological improvements also influence production volumes. Although moving average forecasting is a useful tool for trend analysis, it is essential to complement it with other forecasting techniques for increased accuracy.

4.4 Regression Analysis of Population and Car Production

Regression analysis was conducted to examine the relationship between total population and car production in Asia. Using Microsoft Excel Solver, the simple linear regression model was applied with total population as the independent variable (x-axis) and total cars produced as the dependent variable (y-axis). The regression equation obtained was:

$$y = 0.0491x + 2E+08 \quad (1)$$

The coefficient of determination ($R^2 = 0.77$) indicates that 77% of the variation in car production is explained by the total population, suggesting a strong positive relationship. Figure 5 illustrates the scatter plot with a best-fit line, further confirming the correlation between population growth and car production. A higher R^2 value signifies a reliable predictive model,

demonstrating that population trends significantly impact vehicle manufacturing trends.

4.5 Discussion and Implications

The findings suggest that lean manufacturing principles can play a significant role in stabilizing production efficiency despite fluctuations in macroeconomic conditions. While the data indicate that car production generally follows population growth, external factors, such as supply chain efficiency, labor productivity, and technological innovation, influence production trends. Implementing lean strategies—such as waste reduction, process optimization, and continuous improvement—can enhance operational efficiency and stabilize production levels. Furthermore, the regression analysis highlights the potential for predictive modeling in automotive manufacturing. By leveraging data-driven decision-making, manufacturers can forecast demand and adjust production schedules accordingly. The moving average forecast also emphasizes the need for dynamic production strategies to align with market trends and external influences. The analysis confirms that lean manufacturing principles can enhance productivity in the Malaysian automotive industry by improving efficiency and reducing production inconsistencies. While population growth is a strong driver of vehicle production, other macro and microeconomic factors significantly impact output. Moving average forecasting and regression analysis provide valuable insights into production trends, emphasizing the need for strategic planning and continuous improvement to sustain productivity levels. Future research should incorporate additional factors, such as economic indicators and technological advancements, to develop more comprehensive predictive models for the automotive industry.

5. CONCLUSION

This paper is aimed to investigate the effectiveness of lean manufacturing principles in improving productivity for a Malaysian automotive company. By taking a data set from Kaggle website, we able to perform several quantitative analysis techniques such as descriptive statistics, moving average and simple regression methods to understand better and make prediction and forecast for the future values. By referring to previous discussion and data presentation, we can conclude that the total population directly influences the cars production in the Asia countries for the year 2015 until 2019. Higher population influences higher production of cars. It is also predicted that in future, the car production volume will be increasing as the number of populations in the Asia countries are increasing as well according to the 3 years moving average analysis. Simple regression analysis also shows the strong relationship between the two variables. Thus, better quality cars are encouraged to be built by the automotive manufacturers to create a better sustainability environment of cars which can operate for longer term. The lean manufacturing principles ideally helps in producing better quality cars for the citizens. The core principles in implementing lean manufacturing are to eliminate waste to continually improve a process. By reducing waste to deliver process improvements, lean manufacturing sustainably delivers value to the customer. By adapting the lean manufacturing practices, the company should constantly strive to make production more efficient, improve processes, improve working conditions and all activities that lead to the

enhancement and achievement of better lean production which eventually will benefit to the world economy and greener environment with a smarter way of utilizing resources, manpower and energy (Chong, P. L., et. al., 2019; Basir, R., et. al., 2024).

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