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# Management Model for Productivity Improvement in the Craft Beer Production Process through the Application of Demand Planning Techniques, EOQ and MRP

**Jimena Negrón Aching and Giovanna Portocarrero Dávila**
Facultad de Ingeniería, Carrera de Ingeniería Industrial
Universidad de Lima, Lima Perú
20181293@aloe.ulima.edu.pe, 20183086@aloe.ulima.edu.pe

**Carlos-Augusto Lizárraga-Portugal**
Research Professor
Facultad de Ingeniería, Carrera de Ingeniería Industrial
Universidad de Lima, Lima Perú
clizarra@ulima.edu.pe

## Abstract

The craft beer industry has developed in the Peruvian market by 2023, representing sales of 2.33 billion; However, its productivity rate of 12% is still low compared to the industry's average productivity of 55%. Among the causes of the problem, the lack of a production plan and a demand forecasting system was identified; Therefore, the objective of this study is to develop a forecast model for the demand for beer and the economic order quantity of raw materials to develop an adequate production and supply plan to increase productivity in the study company. The Winters demand forecast model was selected by analyzing the mean absolute percentage forecast error (MAPE) indicator of 9.4%, assuming +/- 10% MAPE as a limit and the similarity of the model's behavior with respect to the historical demand of the company. The proposed model was validated through simulations using software in Excel and @Risk. The research has shown a 48% increase in productivity compared to the initial value, achieving an increase of 3,905,656 PEN in the income of the craft beer company investigated.

## Keywords
Craft beer, demand planning, productivity, EOQ, MRP.

## 1. Introduction

In recent years, beer consumption has represented approximately 75% of the most consumed alcoholic beverages in the world according to Deloitte (Almaraz, 2022). In Latin America, total sales amount to 32 million liters, with a projection of 41 million liters by 2025. Thus, 1.34 million liters of beer are sold annually in Peru today. As the beer market has grown, other alternative business options have been created: small craft beer manufacturing companies, which have taken possession of 0.3% of the Peruvian market. Currently, it is possible to identify several problems that craft producers must face in the face of an already developed market such as the commercial beer market. One of the main challenges, as evidenced in the study conducted by (Quispe and Quintanilla, 2018), is the delay in the supply and importation of raw materials such as malt, necessary to produce craft beer. Thus, the importance of a structured production plan that considers sales and market demand is evident, so that the import of raw materials can be managed taking into consideration the lead time and possible delays in t Precisely, in the analyzed company a low productivity has been observed in the production process of craft beer, finding levels of 12% with respect to 55% of average productivity of the sector; in view of which, as a contribution, the research proposes a management model to improve

productivity in the production process of craft beer by applying demand planning techniques, EOQ and MRP. Therefore, the research question arises: How does the availability of inputs and finished product affect the productivity and profitability of a company?

### 1.1 Objectives

The objective of the research is to propose a management model to improve productivity in the craft beer production process by applying demand planning, EOQ and MRP techniques. Likewise, the specific objectives are the following:

- Elaborate a diagnosis of the current situation to determine the problems faced by the company and their root causes and effects.
- Determine the engineering solution techniques for the solution of the problem found by linking the root causes found with solutions proposed in previous research.
- Elaborate and develop a solution model for the problem found in the company.
- Validate the proposed model from the technical and economic point of view.

## 2. Literature Review

To develop this research, several elements have been reviewed such as demand forecasting, which is the basis of a profitable production plan and allows estimating the resources needed for it. This forecast is based on the analysis of past and present data as well as their trends to predict the future (Bashnaini et al., 2018). An adequate estimation of demand prevents the decline in indicators such as productivity, lead time, stock, among others (Silva et al., 2022). Otherwise, if a forecast is not made, it could negatively affect the company, either by a limitation in sales generating dissatisfied customers, excess inventory, longer production cycles or higher activity costs (Hernandes et al., 2022).

There are several techniques for forecasting that are best suited to the type of demand of each company and that generate greater accuracy in the forecast: simple moving average, weighted moving average, simple exponential smoothing, Holt and Holt-Winters model. The simple moving average and weighted moving average are strategies based on the average of the sales results of the last months, either equally for each period or assigning a weight to certain periods in the case of cyclical markets (Galvão et al., 2020). The simple exponential smoothing method calculates the forecast considering the Alpha variable, which is in the range of 0 to 1. It is characterized as an averaging method that weights and reacts to more recent data and changes, and helps in case more recent changes are unpredictable, but significant (Bashnaini et al., 2018). The Holt trend model is evaluated for certain level α and trend β models, so that both parameters can be chosen by maximizing the log likelihood of their values. There are several ways to find the combination of values that best fits the case study, Galvão et al. (2020) proposes the SES method in which it searches for the smoothing value of the level and trend based on a grid search. The Holt-Winters algorithm is applied when the data shows a trend or reasonableness and considers the level of demand and trends over time (Mohan, et al., 2022). This technique involves the analysis of three variables, which are: seasonal factor, trend, and base level. An attenuation constant of the average data, trend and seasonality is applied to these variables to calculate the demand forecast.

All these techniques are compared using the root mean square error (RMSE) and mean absolute scale error (MASE) indicators to determine their effectiveness. Regarding the beer market, there are several studies aimed at finding the most appropriate tool to determine the demand forecast. Gevorgyan (2018) proposes a model that starts from the analysis of a sales observation period taking into consideration the period with the lowest standard deviation to carry out the assessment.

Another aspect to consider is material requirements planning (MRP), which together with the economic order quantity (EOQ) are central tools for the demand planning model to be effective. MRP manages to link the company's systems and in turn, the operational, purchasing and sales areas (Romero et al., 2019) In this way, its main purpose is the proper management of raw materials during the production cycle and to be able to correctly calculate the requirement of materials to be stored based on the demand of the products required by the customers (Tanna et al., 2017; Susanti, 2020) It should be noted, that implementing MRP involves using Master Production Schedule (MPS), Bill of Materials (BOM), inventory register, purchase orders, process lead times and demand projection (Citraresmi & Azizah, 2019). Other authors propose combining the MRP tool in conjunction with the EOQ method to obtain a lot size closer to reality (Citraresmi and Azizah, 2019; Susanti, 2020). Regarding the economic order quantity (EOQ), it can be considered as an alternative proposed by several authors to determine the optimal inventory levels of different materials (Prima et al., 2019). The EOQ calculation allows finding the optimal quantity per order and the optimal lead

time considering different parameters of the inventory process, so as to support the central decisions of supply chain management, determining how much and when to order the raw materials and inputs needed to produce aligning to the existing demand (Lufika, 2019; Thomas and Kumar, 2022; Haming and Awaliyah, 2020).
Finally, the industry selected to apply the methods mentioned above is the craft beer industry located in Peru. As presented in Ulloa- Durand et al. (2022), there is a growing interest in this market within the peruvian population due to the changes in tastes and preference. It is mostly composed by Micro, small and medium-sized enterprises (MSMEs), which consitute 99.5% of formal companies in the local economy (OEE, 2020). As also mention in different studies, the main problem faced by this type of companies, is according to Ulloa et al. (2022) "the management of their operations or activities, since within these, less than 5%, add value to the process, such as, for example, the correct management of resources by the logistic area".

## 3. Methods

This research is carried out during the year 2022 under an empirical methodology, in the form of an applied study in a craft beer production company, proposing an engineering solution based on a management model to improve productivity in the production of craft beer as shown in Figure 1.

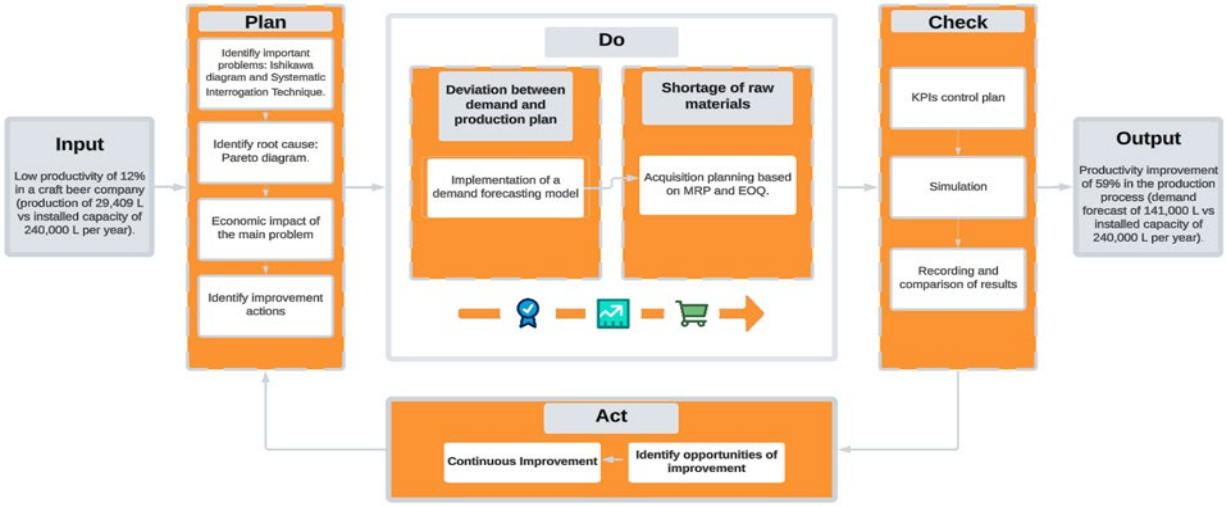


Figure 1. Management Model to Improve Productivity

Since the company productivity indicator of 12% is determined by the production of 29,409 liters of craft beer per year compared to the installed capacity of 240,000 liters per year, the proposed model was carried out in the following phases:

**Phase 1 - Plan**

This phase consists of defining the work plan on the findings in reference to productivity indicators. To do so, the main problems are identified using the Ishikawa Diagram and TIS tools in a period of three-month time for the base of the analysis. Based on this, the root cause is identified to attack the problem in the most optimal way using the Pareto diagram. Among the main problems found in the Pareto diagram, the causes with greater importance were the days the production line was stopped and the delay time of the raw material. Finally, the economic impact of this cause must be determined to value the losses and plan the improvement actions based on the method described below.

**Phase 2 - Do**

It consists of two main actions to be implemented based on the causes previously found. First, we seek to implement a demand forecasting model that best fits the business. Secondly, with the demand correctly defined, the materials acquisition plan is prepared using MRP and EOQ tools. Both steps are detailed below:

**Implementation of a demand forecasting model**

First, we sought to determine the most appropriate demand forecasting model for the type of market in which the company under study is located. Based on historical data collected in previous years, market trends, cycles and main

sales peaks were analyzed, and possible sales alterations due to commercial strategies were considered in consultation with the management of the case study. A year over year analysis was done taking in reference a period of two years prior to the study.
After the analysis, 5 different forecasting tools were applied in Excel, considering a software that allows the model to be replicated in this type of business. The corresponding projection was made for the time periods under study according to the best correlation coefficient and variables of the tool. To find these parameters, a simulation was made using the "What-if" tool with a data table to find the combination of coefficients that best suits the market for each forecasting model. Finally, with the parameters already defined, it is proposed to carry out this procedure week by week, updating the data with the most recent sales and then defining a longer period of time in case a growth trend that is easy to identify is observed.

**Production planning based on MRP and EOQ**
The lot size of the least available input will be calculated together with the MRP to know the quantity and time to place orders for production. The inputs of lead times and previous lot sizes are taken from the current year due to posible changes in arrangements with suppliers. The original EOQ model or a variation of it will be applied according to the type of demand. It should be noted that, if the analyzed demand is very changeable, the average could be calculated, and the annual demand value could be estimated. In addition, data from the master production schedule, component lead time, safety stock and inventories will be used to develop the MRP. See Figure 2.

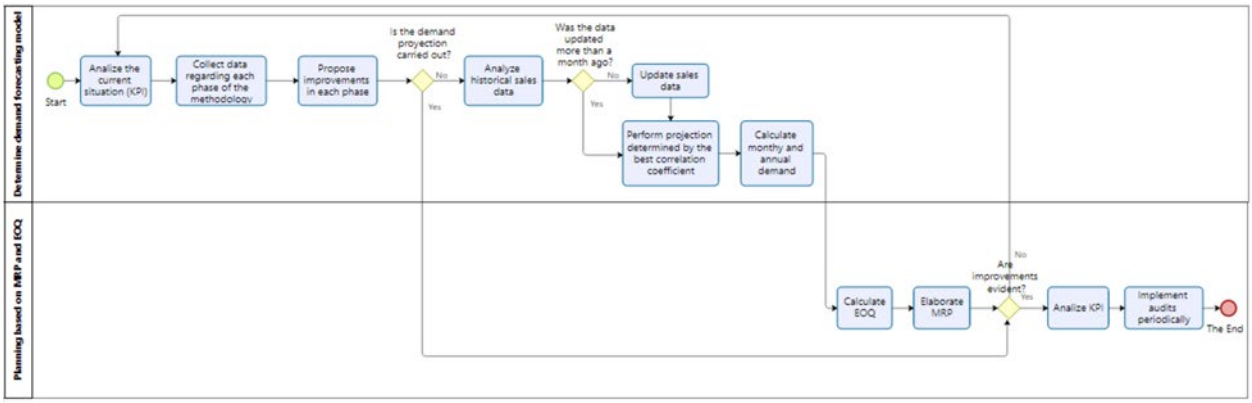


Figure 2. Process flow for realizing the proposed model

**Phase 3 - Check**
The objective of this phase is to corroborate the effectiveness of the applied model. First, a pilot test must be installed and defined to implement the model. Subsequently, the improvement and performance of the Key Performance Indicators (KPIs) is evaluated in comparison to the data previously found to identify improvements in the process.

**Indicators**
Next, the indicators to be evaluated in the model will be determined to measure the impact of the proposal compared to the initial situation.

- **Stock shrinkage - finished goods:** absolute value of the difference between safety stock and actual stock in the warehouse divided by safety stock. The target set for this indicator is a maximum value of 2%.
- **Forecast accuracy indicators:** difference between actual demand and forecasted demand over actual demand.

To obtain a more accurate value, the average of the errors calculated over a period must be obtained. From this value, the accuracy of the demand forecast is calculated, complementing the error obtained as a percentage. The objective is to have an accuracy of 90% in the forecast, equivalent to a maximum MAPE of 10%.

**Phase 4 - Act**
Finally, the measurement and evaluation cycles are defined to determine the effectiveness of the process over time, seeking continuous improvement and opportunities that may arise.

The output of this method resulted in a productivity improvement of 59% in the production process since the demand forecast estimated a production of 141,000 liters of craft beer per year in a company capacity of 240,000 liters per year.

## 4. Data Collection

As mentioned before, the main challenge faced by peruvian MSMEs in craft-beer industry is finding the appropiate method to improve their management in logistic processes. Therfore, the company in study is not strange to this struggle and has a productivity problem. Regarding the first KPI, in the last year it obtained a value of 12% with respect to 55% of average productivity in the sector, which corresponds to a gap of 43 percentage points below the competition. In addition, the company has an average stock out of stock of 90 days per year considering the entire portfolio of available products. The industry standard is 53 days of average stock breakage, so the company is 69 percentage points above the standard. Both factors influence the loss of sales and therefore revenue for the company. When valuing both factors, the economic impact per days of production stoppage amounts to 3 million soles, while losses due to stock breakage are equivalent to 85,883 PEN. In this case, the economic impact due to stock breakage will be used as a reference, since the productivity impact is directly affected by other factors such as commercial strategies, market share and sales. Using a Pareto analysis, which uses as a unit of comparison the number of days in which there were monetary losses due to delays in the process or product shortages, and establishes the problems observed (see Table 1) related to the previously mentioned factors.

First, it was found that the number of days of production line stoppage (NST) represented 41% of the delay days, basically caused by the lack of a production plan in accordance with demand, which is established annually in the company.

Secondly, raw material delay times, which delay production, amounted to 170 days, calculated according to the number of days that elapse from the time the order is placed until it arrives at the warehouse. This represents a delay mainly because the order is placed as soon as the production of a batch is completed, thus creating a waiting period instead of starting immediately upon completion of the previous process. This problem accounts for 39% of the total. The last problem, the breakage of finished product stock, since it only has a 20% impact on the main problem of low productivity, will be analyzed in a later investigation.

Table 1. Problems observed in the company.

| Problem | Indicator | No. days lost | Percentage Cumulative |
|---|---|---|---|
| Inadequate production planning | Time not scheduled (NST) | 180 | 41% |
| Inadequate production planning | Stock outs - Raw materials. | 170 | 80% |
| Variance between demand and production plan | Stock Breakage - Finished Products | 90 | 100% |
| | Total | 440 | |

Thus, two reasons were prioritized as having the greatest impact on the process. The first one, the deviation between demand and production plan, caused by the lack of a demand forecast system, which generates a stock breakage of both inputs and finished products; and as a second reason, the shortage of raw materials, given that there is an inadequate procurement plan. In view of this, it is proposed as a solution to adopt a demand forecast model and a production plan applying materials planning (MRP) and the economic order quantity (EOQ) system as can be seen in the problem tree in Figure 3, which shows the causes of the low productivity found and which has two causes, both quantified in days of lost sales and product availability. Regarding cause 1, the absence of a forecasting system has an impact equivalent to 270 days, originated by the unscheduled times within the production line and the breakage of finished product stock. On the other hand, cause 2 also generates 170 days of line downtime, which is equivalent to 39% of the total, generated by a breakage of stock of material to work with. Both causes generate losses of 3 million soles due to unavailability of product for sale.

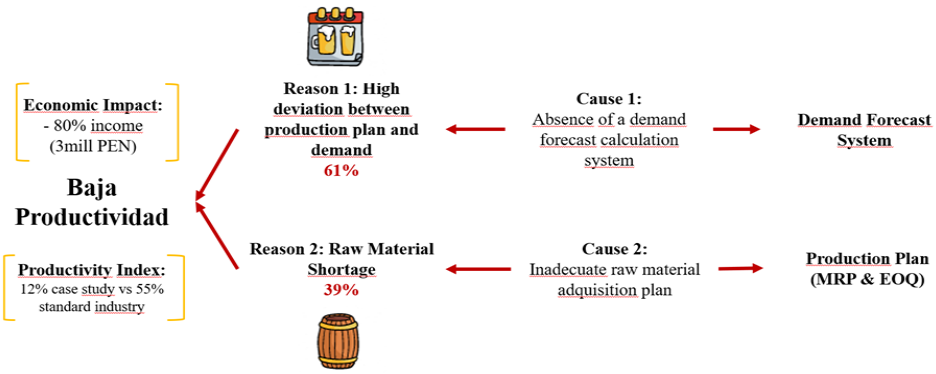


Figure 3. Company's problem tree

## 5. Results and Discussion

### 5.1 Numerical Results

The results of the proposed phases are detailed below:

**Demand forecasting and planning.**

For the application of the model in the case study, two cycles equivalent to one year each were taken into consideration to apply the demand forecasting tools. It should be noted that the years 2020 and 2021 will not be taken into account due to the irregularity of the market due to the restrictions imposed by the COVID-19 pandemic. Having defined this, we proceeded to implement the 5 types of forecasts for the years 2018 and 2019 indicated in Table 2 with the respective parameters found based on the what-if analysis with data Table 2.

Table 2. Parameters defined by method

| Method | Moving average m | Periods t, p | Alpha α | Beta β | Y |
|---|---|---|---|---|---|
| Simple moving average | 5 | - | - | - | - |
| Weighted moving average | - | 3 | - | - | - |
| Simple exponential smoothing | - | - | 0.05 | - | - |
| Holt's method | - | 1 | 0.05 | 0.01 | - |
| Winter's method | - | 4 | 0.15 | 0.10 | 0.50 |

The parameters being.
α = attenuation constant of the average of the data ($0 < \alpha < 1$)
β = attenuation constant of trend estimation ($0 < \beta < 1$)
y = attenuation constant of seasonality estimation ($0 < y < 1$)

For the validation corresponding to this phase of the model, the results obtained were evaluated based on the comparison of 3 indicators (MAD, MSE and MAPE) so that the most appropriate tool is the one that fits the objectives set. The MAD or mean absolute deviation measures the dispersion of the forecast error, while the MSE, the mean squared error, maximizes the error squared. Table 3 shows the values obtained for each indicator (Table 3).

Table 3. Results of prognostic indicators by method

| Indicator vs. Method | Simple moving average | Weighted moving average | Simple exponential smoothing | Holt Method | Winters Method |
|---|---|---|---|---|---|
| Absolute Mean Deviation (MAD) | 945.42 | 1,410.07 | 959.07 | 960.66 | 958.32 |
| Mean Square Error (MSE) | 1,314,891 | 2,852,335 | 1,235,799 | 1,241,138 | 1,370,474 |
| Mean Absolute Percentage Error (MAPE) | 9.0% | 12.9% | 9.3% | 9.3% | 9.4% |

It is considered that the lower the mean absolute percentage error (MAPE), the more effective the forecast. Although it is observed that the lowest MAPE corresponds to the simple moving average technique with 9%, it is considered that Winters' method is the most appropriate for the type of market of the case study as shown in Figure 4.

**Production and procurement scheduling (MRP and EOQ)**

We proceeded to calculate the appropriate economic lot according to the probabilistic model of variable demand and fixed delivery time. For this purpose, data was collected for a period of six months in the company, where it was possible to determine the lead time of suppliers and possible deviations in raw material deliveries. Likewise, it was decided to apply this phase only to the input of bottles, since it is the one with the lowest availability of suppliers, the longest delivery time, and the longest useful life since purchase. The demand projection was considered using the Winter method previously applied. The data used are shown in Table 4.

Table 4. Data used in EOQ calculation.

| Concept | Symbol | Value | Measurement |
|---|---|---|---|
| Demand | M | 9731 | Unit |
| Standard Deviation | d | 619 | Unit |
| Lead Time | Lt | 15 | Days |
| Service Model | Z | 1.65 | |

Based on the above data, the EOQ formula was applied for a variable demand with fixed lead time:

$$EOQ = (d * Lt) + Z\ (d * \sqrt{Lt}\ )$$

Likewise, the minimum safety stock required for this input was determined, using the supplier's lead time as the main parameter with the following formula:

$$SS = Z\ (d * \sqrt{Lt}\ )$$

Note that a reference confidence level of 95% was used, given that it is the industry standard, for which a Z of 1.65 corresponds.

## 5.2 Graphical Results

The behavior of the different forecasts versus the actual demand defined for the period is shown below. While the simple average technique shows a low adherence to trends and market change, the Winters technique shows greater sensitivity to these changes. Therefore, despite having a slightly higher MAPE as shown in Table 3, it is defined that this would be the tool to implement in the proposed model (Figure 4).

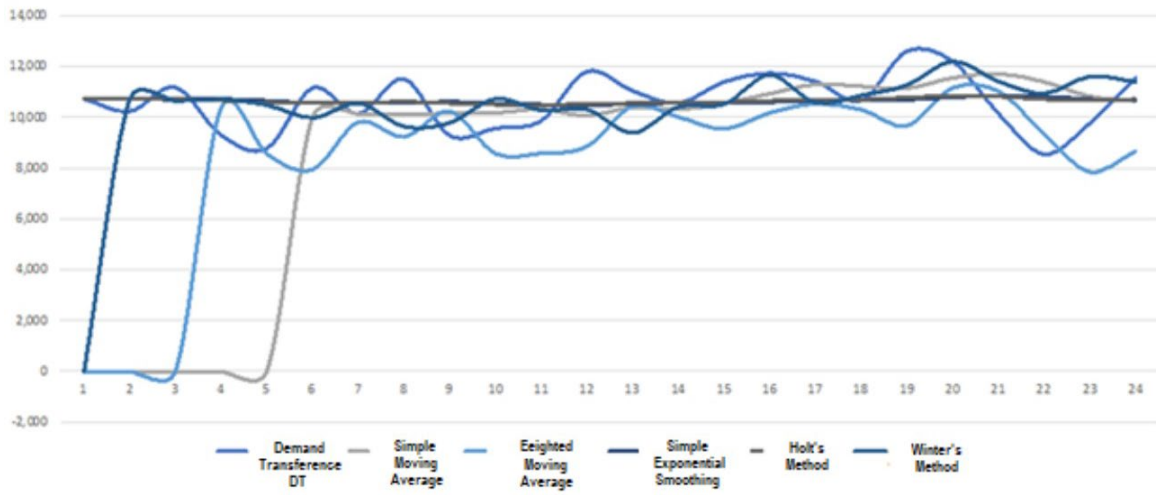


Figure 4. Comparative graph of demand vs quantitative methods

## 5.3 Proposed Improvements

The objective of the research was to propose a management model to increase productivity based on the projection of demand and calculation of the EOQ, so that these can be used for the application of the MRP tool to continue reducing the current gap between the real market demand and the production plan. Therefore, the methodology explained above and the respective validation of the tools was developed through simulations in Excel and @Risk. It should be noted that, although the results have been validated, in the event of wishing to apply the phases of the model to increase productivity in another company that ventures into the craft brewery, it is likely that the context will vary, so special attention should be paid to the variables of sales, production capacity, sales price, delivery time, warehouse space, among others, depending on the company.

It has been shown that, by integrating both tools, in addition to generating a positive impact on productivity, revenues increase and idle production capacity decreases, since this can be planned, as well as the acquisition of inputs to meet the forecasted demand. Table 5 compares the productivity and income of the current scenario of the company under study with the improved scenario with the application of the methods analyzed. The productivity of the case studied is 12%, because production is well below the plant's capacity due to the inability to adequately forecast demand and an inaccurate procurement plan. To determine the value of productivity in the proposed scenario, a demand projection was made for the year 2021. Based on this, the production requirements were determined and, consequently, the necessary inputs for the fulfillment of this plan were determined with the MRP. The application of the EOQ tool for the calculation of packaging, the main input that limited production times, allowed the planning of both inputs and finished product in stock for the estimation of the gaps, taking into consideration the lead time of suppliers that limited the finished product replenishment cycle. Finally, the productivity indicator was calculated based on the annual production capacity and the projected production volume based on the forecast.

Table 5. Current vs. proposed scenario according to research objectives.

| Scenario | Productivity | income |
|---|---|---|
| Current | 12% | 29,410 PEN |
| Proposal | 59% | 4,759,796 PEN |
| Variation | 47% | 3,905,656 PEN |

Although this research has focused on forecasting demand and establishing the amount of acquisition of one of the inputs that the company could lack the most in order to increase productivity and profitability, it is considered that another of the causes that could also contribute to the problem of low productivity, although with less impact, is the disorganization of warehouses. Therefore, it is suggested that, for future research, the 5S method should be used. This is a Lean Manufacturing tool, which has as its main objective the elimination of any activity that does not add value to the final consumer (Balinado and Prasetyo, 2020; Vargas-Hernández et al., 2016; Escaida et al., 2016). In this way, it is proposed as a solution for an improvement in inventory management, so that indicators such as expiration rate, turnover, among others, can be reduced (Rojas-Benites et al., 2021). Its implementation has a direct impact on business profitability, since it achieves time optimization, better use of space, as well as improved conditions for all employees and process productivity (Ashraf et al., 2017; Balinado and Prasetyo, 2020).

## 5.4 Validation

In order to validate the EOQ tool and the respective calculations, @Risk, a risk and decision analysis tool complementary to Excel, was used. Three scenarios were proposed, the first with a minimum demand and a lower standard deviation, the second with an average demand and the standard deviation of the entire projection, and the last with the maximum demand value and a higher standard deviation, as shown in Table 6.

Table 6. Input variable scenarios.

| Input Variable vs Scenarios | Poor | Probable | Optimal |
|---|---|---|---|
| Demand (M) | 8537 | 9731 | 11099 |
| Standard deviation (d) | 600 | 619 | 637 |

Defining the distributions of both variables as triangular, we proceeded to determine the output variables, which were the optimal order lot (EOQ) and safety stock (SS) by applying the first and second equations presented in section 5.1. The results of the simulation applying 10,000 can be seen in Table 7.

Table 7. Output variables.

| Output variables | Units |
|---|---|
| EOQ | 5588 |
| SS | 722 |

It should be noted that an economic lot suitable for 95% certainty should be 6,063 bottles, while the SS would be 737 units as can be seen in the distribution graphs. The most influential variable in both results is demand. See Figure 5. Finally, the forecast was made for the next valid year for the study, which was 2021 because 2020 is considered atypical due to the conditions of the pandemic. Sales and a 7% growth in the market were taken into consideration, as was identified in previous periods. Table 7 shows the calculated forecast in comparison to the available finished product stock and the actual sale.

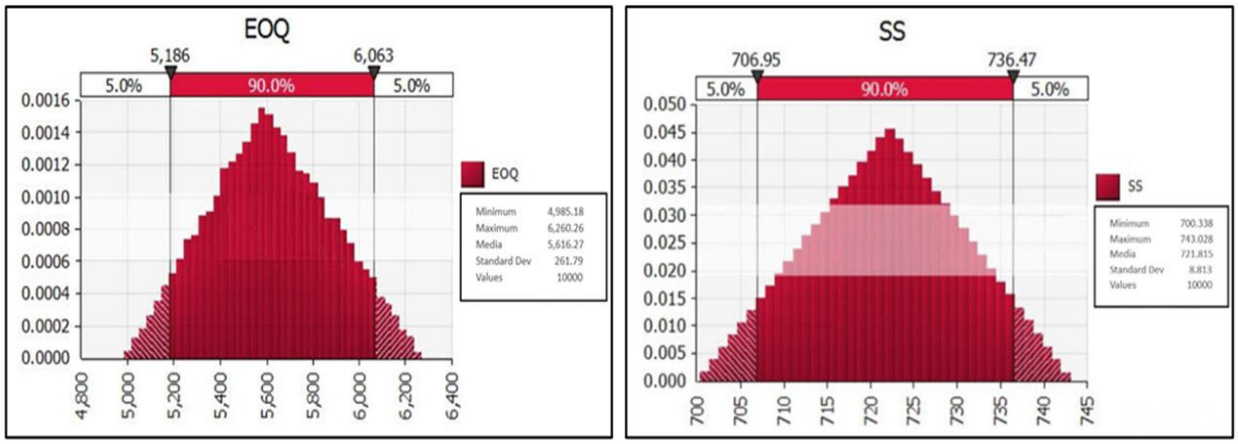


Figure 5. Validation Results in the simulator

The estimated total forecast for the year 2021 is approximately 140 thousand liters, while the actual sale is 29 thousand liters. This is equivalent to 21% of the expected demand for the year. Although stocks are equivalent to 29%, the product availability dates determined by the production plan expanded the GAP month by month. Consequently, the production requirements necessary to meet the estimated demand were calculated.

Table 8. Forecast vs Stock in liters.

| Month (2021) | Forecast | Stocks | Sale | GAP |
|---|---|---|---|---|
| January | 10,107 | 2,000 | 1,753 | -8,107 |
| February | 9,558 | 247 | 231 | -9,311 |
| March | 11,120 | 3,016 | 1,905 | -8,104 |
| April | 12,353 | 2,611 | 1,270 | -9,742 |
| May | 11,732 | 2,841 | 2,313 | -8,891 |
| June | 10,989 | 3,528 | 2,278 | -7,461 |
| July | 12,151 | 5,749 | 4,228 | -6,401 |
| August | 13,127 | 3,021 | 2,409 | -10,106 |
| September | 12,581 | 3,612 | 2,923 | -8,969 |
| October | 11,456 | 5,188 | 4,019 | -6,268 |
| November | 12,531 | 4,169 | 3,121 | -8,362 |
| December | 12,290 | 4,048 | 2,958 | -8,242 |

The result was a total of 141 thousand liters of finished product, which generates an economic impact of 3,905,656 PEN in unsatisfied demand. Likewise, with the new beer production projections there is a recovery of the productivity indicator to 59% annually, 48 percentage points above the current value (Table 8)

## 6. Conclusion

The main objective of the research developed is to propose a management model for increasing productivity using demand forecasting tools and the calculation of the economic order lot. Thus, it is concluded that it is feasible to use both tools to increase productivity by 48% compared to the initial value, which translates into an increase of 3,905,656 PEN in the income of the craft beer company investigated. This impact on the analyzed indicators is achieved by applying a system that integrates both demand prediction to avoid stockouts of finished products and the development of a production plan based on the calculation of the batch of input that could present the greatest problems. have a high lead time when imported: the bottles.

Regarding the demand projection, the MAPE indicator was taken as a reference to measure the variation between the forecast and actual demand, and thus be able to choose the type of forecast that best suited the market: Winters method. In addition, the parameters that should be used for the tool to continue working in the future were defined. While the technique provides an estimated number of liters of beer to produce, the production capacity needed to make this happen must be considered. In the present case, the company has a capacity of 24 thousand liters per month, and the Winters model indicates that 11 thousand liters should be produced per month on average, so it would be feasible to apply this tool in the company. Likewise, the EOQ made it possible to correctly define the replacement of the chosen raw material to ensure the production of the plan. Carrying out the simulation, a quantity of 5,588 bottles was obtained as the ideal economic order lot and a safety stock of 722 units to ensure the company's supply. It must be evaluated whether it is feasible to store the indicated number of bottles, otherwise create new spaces for it if desired.

Finally, the results obtained based on the model demonstrate significant improvements both economically and in the standardization of the purchasing process. It is important to mention that the study was developed during a pandemic period, therefore certain information and periods of data were excluded due to atypical results that could have a significant change in results. It was assumed as a regular market and context as year prior to 2020. Future investigations may develop a plan of solutions for the other main problems such as Master Production Schedule once the forecast and MRP processes are solid. Other areas of development for companies in this market may go on lean manufacturing once the correct planning in production lines is made to keep improving the productivity. Finally, we also encourage research into the 5S methodology, that focuses on reducing waste and optimizing the productivity in the work area.

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## Biographies

**Jimena Negrón Aching** Bachelor of Industrial Engineering from Universidad de Lima.

**Giovanna Portocarrero Dávila** Bachelor of Industrial Engineering from Universidad de Lima.

**Carlos-Augusto Lizárraga-Portugal** Industrial Engineer from the University of Lima, Approved Title "Cum Laude". Master in Administration – ESAN; Doctor of Education, San Martín de Porres University. Post Degree in Auditing and Implementation of Integrated Management Systems (ISO 9001 Quality, ISO 14001 Environment, OHSAS18001 Occupational Health and Safety, Social Responsibility). Business consultant specializing in Strategic Planning, Occupational Health and Safety Management Systems, Logistics Management, Purchasing Management, Strategic Inventory Control – Supply Chain Management, Warehouse Management, State Purchasing Process, Costs and Asset

Management. the production. Experience in sectors such as clothing, plastics, industrial footwear, fishing, services, marketing, training, etc. Professor at the University of Lima in the Industrial Engineering career, teaching courses on Comprehensive Security, Maintenance Management, Business Diagnosis and Research Projects. Trainer and facilitator in Seminars on Strategic Planning, Business Organization, Production Management, Operations Management, Strategic Inventory Control, Supply Chain Management, Industrial Safety and Comprehensive Safety Management. Thesis Advisor and Jury to opt for the Title of Industrial Engineer. Orcid-iD 0000-0002-7057-4099