



Productivity Evaluation and Forecast of Pasteurized Milk Production Line at Vinamilk Dairy Company

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ABSTRACT

In recent years, the dairy industry has been developing extremely strongly in most countries around the world. In this study, the Grey Predictive Model (G (1,1)) and Data Envelopment Analysis DEA (Mamlquist and super-SBM) were used to predict and analyze the demand and potential for pasteurized dairy company development. Moreover, these methods are also applied to forecasting and data analysis of decision making units (DMUs), from which DMUs are known to thrive well in the future [1]. The market results have also shown the solid foundation of this business and brought positive expectations. On the other hand, from the analysis results, it is possible to know the ability of production activities, especially the milk carton packaging process, which needs to be improved, effective solutions for business operations, as well as the development potential of the dairy industry in the coming years. The development of the dairy industry contributes to improving the quality of health as well as the human base in Vietnam, in addition, the dairy industry also creates jobs for people, contributing a large amount to the great growth of the country as well as the global economy.

Keywords: DEA, Grey, Mamlquist and super-SBM, production evaluation and forecast, milk production line

1. INTRODUCTION

The dairy industry is one of the important industries in most countries around the world. Milk plays an important role in the global food system and also in the sustainable development of rural areas. In fact, the dairy industry is contributing positively to the economies of many communities, regions and countries. In recent years, the dairy industry has contributed a lot to our country's economy to our country's economy. Specifically, Vinamilk Pasteurized Milk Company contributed about VND 61012 billion in 2021 and is the highest year from 2018 to 2022. This number is increasing significantly year by year. However, in 2022, after the Covid pandemic, it is tending to decrease to VND 60075 billion. But this figure is still quite high compared to other food industries [11].

Nowadays, drinking milk for everyone in daily life has become very familiar and encouraged. Especially milk can be used at any age, so it becomes more useful and popular. [13] However, at present, the quality of products and production costs of dairy products are still much changed in domestic and foreign markets. Therefore, to solve the problem of reducing costs, increasing productivity and product quality. The team researched and evaluated the efficiency and forecasted the productivity of the pasteurized milk production line at Vinamilk Pasteurized Milk Company. The packaging line is a system specializing in packaging milk cartons automatically. The lines possess a compact design that is optimal in terms of production and operation, making it easy to pack and transport. To ensure that the packaging process is carried out efficiently, the automatic control line will control the packaging operations and ensure that the product is properly packaged and meets quality standards. Control cabinets are used to set the parameters of the packaging process and monitor the operation of the packaging system.

When researching this topic, we aim to research, evaluate and predict the efficiency of the milk production packaging line of Vinamilk pasteurized milk company. Thereby helping to solve energy saving and environmental protection problems. Through the topic of scientific research students will help promote the student scientific research movement of the University of Industry in general and the Faculty of Industrial Systems in particular. From there, it will form the habit of studying with students, regularly learning, the requirements of progress and developing new ones to meet the life as well as the requirements that society sets. From the outset, my team identified three main objectives of this study. The first is to use Grey gray forecasting models to predict Vinamilk's pasteurized milk companies' data, then find the best prediction model [2] [3] [8]. The second is to use the DEA model: using the super efficient model every year, changing techniques, changing the productivity of Vinamilk Pasteurized Milk

Company in the period of 2018-2023 [4]. Finally, use the Plant simulation model to simulate the milk carton packaging production system. The combined results of these three goals help my team come up with more practical and valuable ideas and suggestions.

2. METHODOLOGY

2.1 Research Model

The model demonstrates the pasteurized milk packaging process through stitches from left to right as shown in Figure 1.



Figure 1: Machinery model of the milk production factory

The operating time of the transmission line is 1 shift / 1 day. From the above model, we can see that the milk production line consists of 7 working stations arranged in order: pasteurized milk station, milk filling station, inspection station, box capping station, straw placement station, glossy paper placing station and barrel capping station.

2.2 Research methodology

2.2.1 Data Envelopment Analysis (DEA)

The team used Data Envelopment Analysis (DEA) to measure the efficiency of Vinamilk's production and management. Data Envelopment Analysis is used in operational and economic research to estimate production limits. Specifically, it is often used to evaluate the effectiveness of decision making units (DMUs) in using input resources to create output products or services. Here is the main formula of the SBM model:

$$\min \rho = \frac{1 - \frac{1}{m} \sum_{i=1}^m s_i^- / x_{i0}}{1 + \frac{1}{s} \sum_{i=1}^s s_i^- / y_{i0}} \tag{1}$$

Where there are n DMUs with input and output and input matrices, respectively $X = [(x_{ij})_{ij}] \in R^{(m \times n)}$ $Y = [(y_{ij})_{ij}] \in R^{(s \times n)}$ λ is a non-negative vector in R^n vectors and indicate that inputs are redundant and output shortages.

The best performers have a state of full efficiency indicated by unity across all DMUs. The super SBM model was founded on the old model of SBM. Tone (2002) distinguished these efficient DMUs and ranked efficient DMUs according to the super SBM model. If the DMU (x_0, y_0) is effective SBM $p^* = 1$ the super SBM model is as follows:

$$\min \delta = \frac{\frac{1}{m} \sum_{i=1}^m \bar{x}_i / x_{i0}}{\frac{1}{s} \sum_{r=1}^s \bar{y}_r / y_{r0}} \tag{2}$$

With

$$\text{s.t. } \bar{x} \geq \sum_{j=1, \neq 0}^n \lambda_j x_j, \bar{y} \leq \sum_{j=1, \neq 0}^n \lambda_j x_j, \bar{y} \geq x_0 \text{ and } \bar{y} \leq y_0, \bar{y} \bar{y} \geq y_0, \lambda \geq 0. \tag{3}$$

Although the DEA is closely related to production theory in economics, this method is also used to compare standards in operations management. Accordingly, a set of measures is selected to evaluate the performance of production and service activities.

2.2.2 Grey Forecasting Model

In Vietnam, some fields have applied Grey system theory to predict data in order to overcome, process and improve efficiency in management in that field. However, this is a new method and has not been widely disseminated in all fields, so lecturers and students face many difficulties in accessing research materials about this method. In order to contribute to solving the above difficulties, we will introduce an overview of forecasting models in Grey system theory and assess the reliability of processing data related to Vinamilk’s revenue from 2018 to 2022, then forecast revenue in 2023 and 2024 [5, 7]

This article uses the MAPE (Means Absolute Percentage Error) indicator to evaluate the accuracy of the Grey forecast model [8]. The MAPE index is calculated by the following formula [6]:

$$MAPE = \frac{1}{n} \sum_{k=2}^n \frac{x^{(0)}(k) - \hat{x}^{(0)}(k)}{x^{(0)}(k)} \times 100\% \tag{4}$$

The sum formula of the Grey GM model (1,1) is: [9,10]

$$\hat{x}^{(1)}(k + 1) = \left[x(0) - \frac{b}{a} \right] * (1 - e^{-a}) * e^{ak} + \frac{b}{a} \tag{5}$$

Where:

The next forecast value in the data serie is $\hat{x}^{(1)}(k + 1)$

The initial value of the data series is $x(0)$

(a) and (b) are the parameters of the model, calculated based on the minimum normal method.

k is the index of the next forecasted value in the data series.

3. RESULTS AND DISCUSSION

3.1 Research results of the DEA method

Through the process of evaluating effectiveness by using the DEA method, the obtained results the following two efficacy as shown in Table 1.

Table 1: Vinamilk's ambient efficiency

	Cost and Expenses	Total assets	Total stockholders' equity	Total revenues	Operating income	Net income
Cost and Expenses	1	0.97034	0.97341	0.99614	0.90184	0.8902307

Total assets	0.97034	1	0.99677	0.96342	0.85946	0.843032
Total stockholders' equity	0.97341	0.99677	1	0.96706	0.86513	0.8478888
Total revenues	0.99614	0.96342	0.96706	1	0.9363	0.9265656
Operating income	0.90184	0.85946	0.86513	0.9363	1	0.998526
Net income	0.89023	0.84303	0.84789	0.92657	0.99853	1

Through the table showing the ambient effect of the DEA, we can see that the result of the corresponding correlation coefficient score is very high. The linear relationship between inputs and outputs is strong. Therefore, the researcher's choice of input and output variables from the beginning is appropriate.

The effectiveness evaluation table incorporates the assessment in order of that effectiveness as shown in Table 2.

Table 2: Combined efficiency of Vinamilk

No.	DMU	Score	Rank
1	2011	1.00581	3
2	2012	1.01916	2
3	2013	0.98231	4
4	2014	0.87432	9
5	2015	0.95044	5
6	2016	1.04411	1
7	2017	0.94829	6
8	2018	0.91312	7
9	2019	0.87635	8
10	2020	0.86726	10
11	2021	0.80494	11
12	2022	0.7131	12

The Super – efficiency model (Super – SBM – Oriented) to rank 12 DMUs based on revenue as shown in Figure 2.

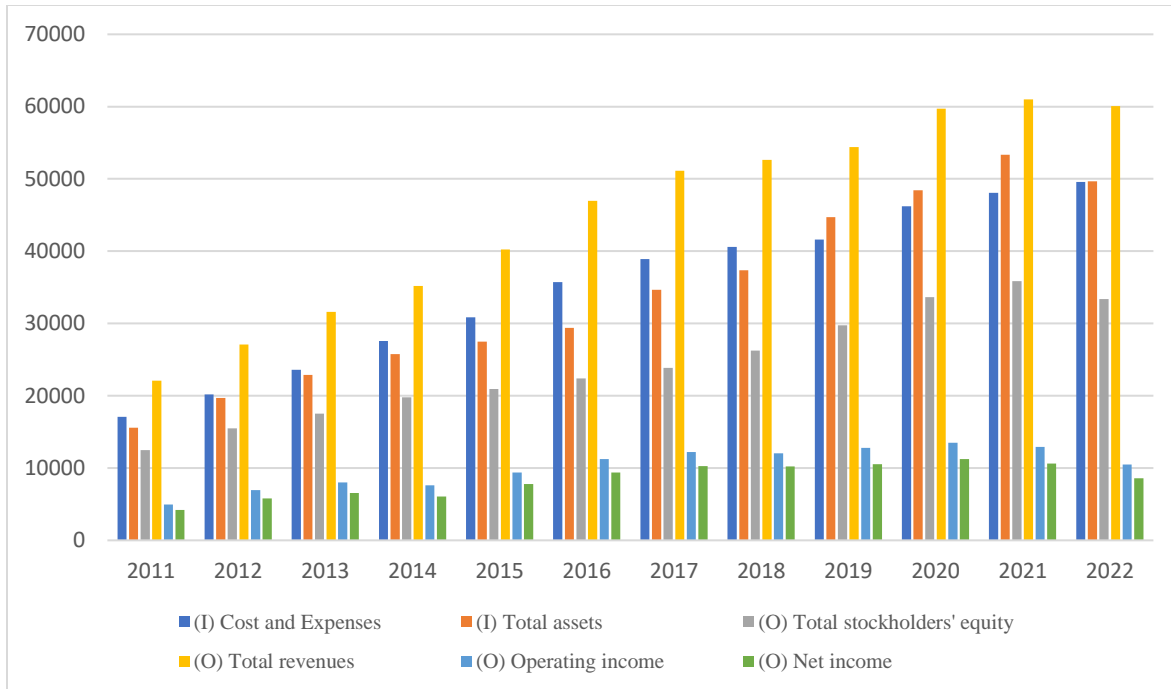


Figure 2: Vinamilk's revenue and expense chart

Thereby, we can see that DMU's business performance in 2021 is the best, it is always in the top 1 or top 2. Besides, the DMUs of 2020 and 2022 are very good (in the top 3 or top 4). The business performance of DMUs in the period from 2017-2019 is quite good (in the top 5). During this phase, 3 DMUs work well and stably. In the future, it is necessary to continue to develop and have better business strategies. The lowest DMU scores were in 2011 and 2012. These two DMUs rank in the last two positions, which means they are not performing well. To achieve higher efficiency, new business strategies and coherent management systems are needed. And a group that includes DMU of the years 2013,2014,2015,2016 performed at average performance and had year-on-year growth.

After researching and analyzing data, the team obtained the results of Vinamilk pasteurized milk company. This result is clearly shown under the following chart in Figure 3.

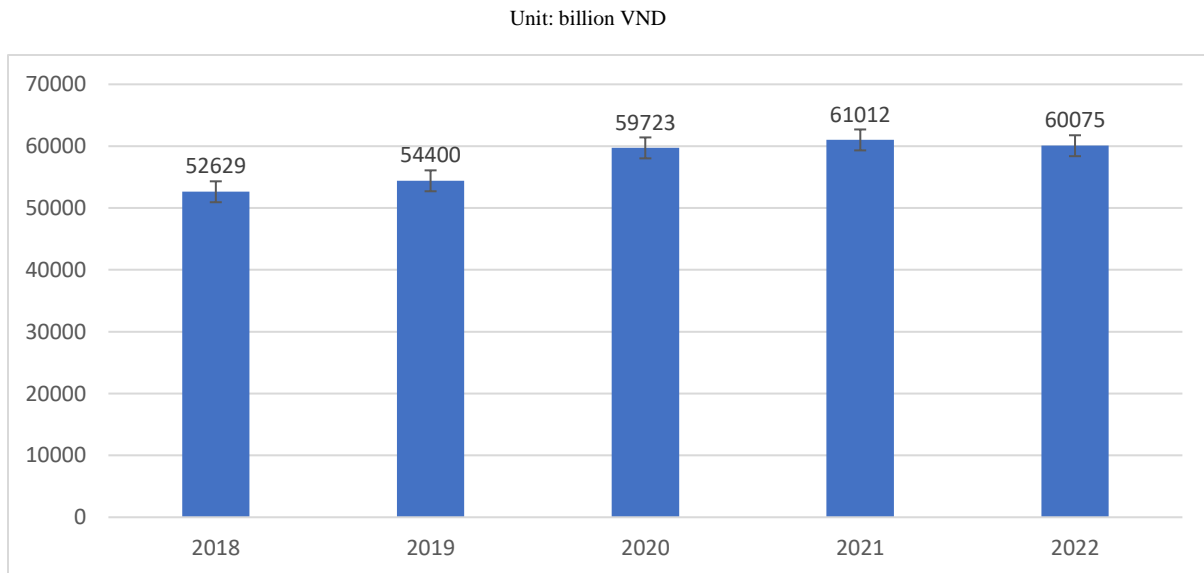


Figure 3: Vinamilk's revenue from 2018 to 2022

In 2021, Vinamilk's total revenue was the highest in year 5. Specifically, VND 61,012 billion, up 2.2% over the same period in 2020. This revenue record was contributed by growth from all 3 segments: domestic, export and foreign branches. Before 2021, revenue was stable and had steady growth. After 2021, revenue has decreased due to the impact of the Covid-19 pandemic. In 2022, Vinamilk continues to seek opportunities to expand and explore export markets. Taking advantage of the "warming" of international trade activities after 2 years of pandemic, Vinamilk continuously appeared at trade promotion events in Shanghai (China), Dubai, Japan... The problem of rising world raw material prices due to the pandemic is a common problem of manufacturing companies, Vinamilk is no exception. The price of imported dairy materials exceeded historical highs, but the increase continued in 2021 due to supply shortages, freight rates increased many times and the demand for hoarding increased sharply in major countries [12].

From the table above, we have a graph showing the score as shown in Figure 4.

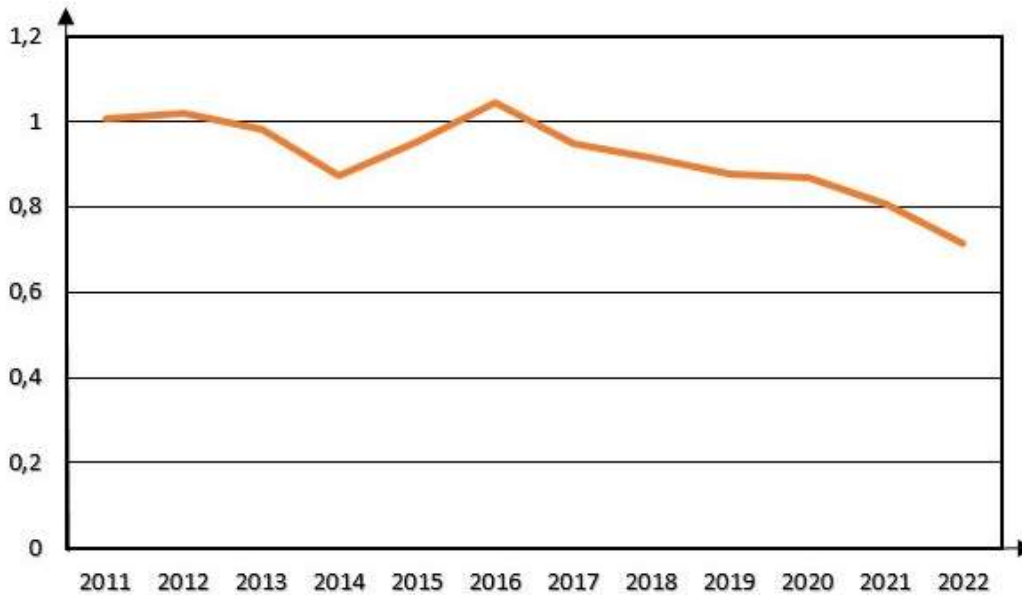


Figure 4: Performance evaluation chart

From the performance rating, we can see the ratings of DMUs from 2011 to 2022. Through this we can see that the change in efficiency of 12 DMUs is negligible. There are almost no major changes in DMUs. Except for the DMU of 2016, the best improved, namely 1.04411. At an early stage between 2011 and 2013, the DMUs were significantly improved. However, from 2020 to 2021, DMUs had a slight decline, the score of 2011 was 1.00581 but after 2 years, 2013 has decreased to 0.98231. The peak was 2020 as the lowest year with a score of only 0.7131. The main cause of this decline is the problem of market prices and changing raw material prices. There is also a challenge to standards and regulations. Vinamilk Pasteurized Milk Company must comply with strict standards and regulations in production and business, including standards of food safety, environmental hygiene and labor. This compliance requires not only financial investment but also an emphasis on management and control. Therefore, there is a need for measures, business and management strategies to increase efficiency for DMUs.

3.2 Grey Forecasting Model

The chart of the announcement and reality of Vinamilk Dairy Company from 2018 to 2026 is as follows Figure 5:

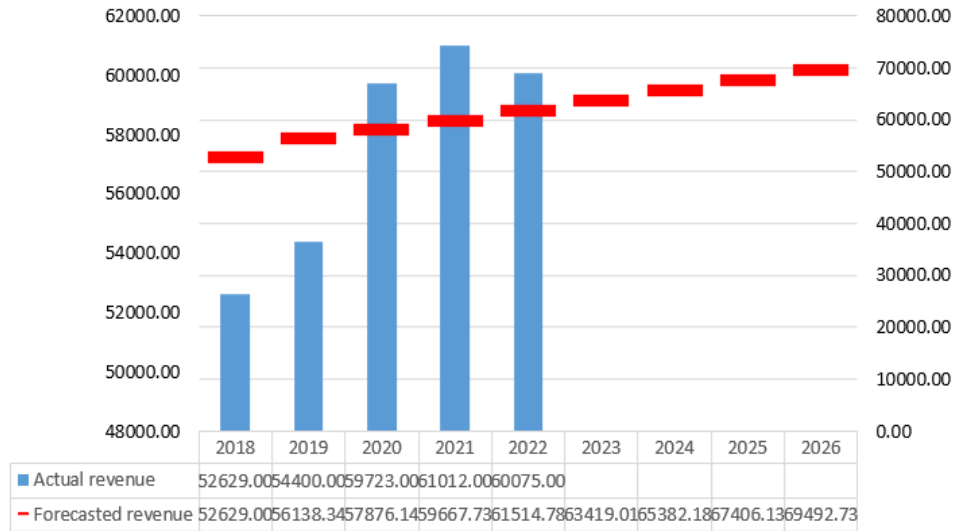


Figure 5: Vinamilk's forecasted and actual sales chart

Through the forecasted and actual sales chart, the group commented as follows:

The Identify trends include: Revenue is forecasted to increase steadily over the years from 2018-2026 with an average of 3% per year.

The period from 2018-2019 increased sharply by 4.8% (VND 3509 billion), the period of 2020-2021 increased slightly by 1.5% (VND 1791 billion).

And actual revenue tends to increase but not continuously over the years from 2018-2022 with an average of 3% per year. The period from 2019-2020 increased sharply by 4.6% (VND 5323 billion), the period of 2020-2021 increased slightly by 1% (VND 1289 billion), the period of 2021-2022 decreased slightly by 0.77% (VND 937 billion).

The error rating: The difference in error between forecast and reality is not much, the largest error is 3.19 (in 2020), the lowest is 2.34 (in 2022). The average margin of error of 2.18% (1% < 2.18% < 5%) is good.

Conclusion: The forecast value is based on actual revenue, so there is an even margin of error in the good range of 2.34-3.10 and the average error of 2.18 is also in a good range. This shows that the level of accurate forecasting of the Grey method is very good, so we can use this method to forecast revenue for the next 4 years, which is 2023-2026.

3.3 Results of running the Simulation model

After using the data collected from Vinamilk's milk carton packaging factory, the team tried to run at 100% machine capacity and found that the amount of goods produced was not as expected despite the large amount of embryos put in and still congested in some areas. After simulation, the team obtained the following results as shown in Figure 6.

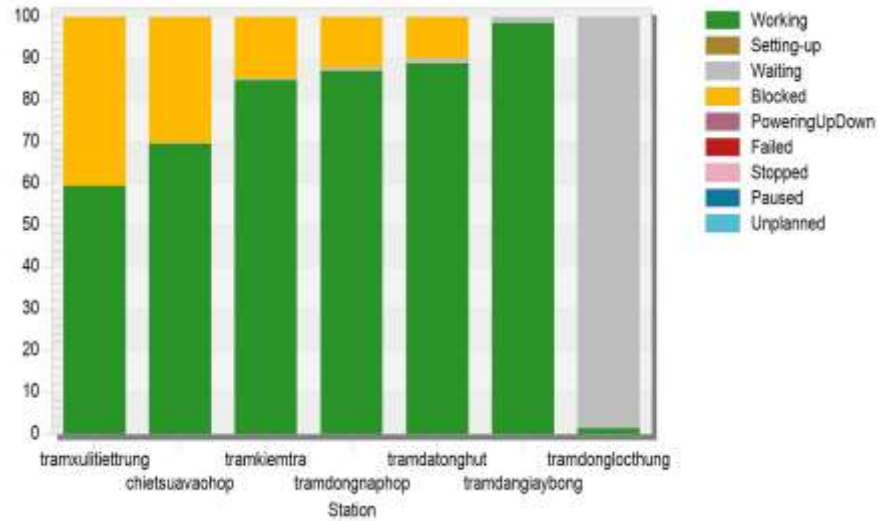


Figure 6: Simulated chat board after running data for the first time

After running tests, the team found that the sterilization treatment and extraction plant was picking up the problem even though the working level of the machines was 100%. Specifically, the most severe degree of blockage was at the sterilization treatment station (more than 40%) and the milk filling station into the can (30%). The remaining stations range from 13% to 16%. Only the glossy paper station is not clogged and runs very stably. Therefore, the team needs to make corrections to increase the time spent at congested stations. After adjustment, the team obtained the following simulation result as shown in Figure 7.

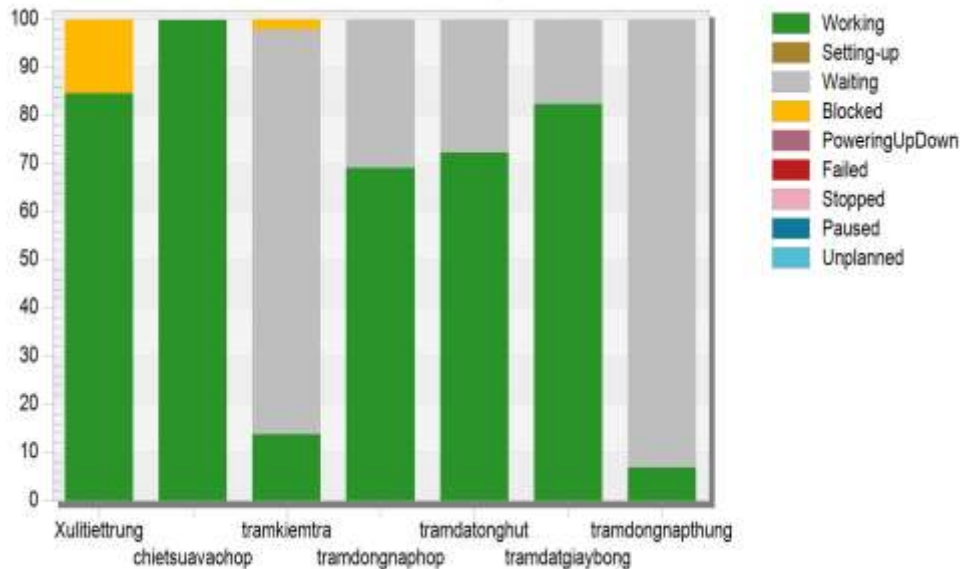


Figure 7: Simulated chat table after running data for the second time

Through the process of completing the content of the project, it shows the layout of the factory site, simulates the results of the line, calculates economic problems and especially finds out the congestion errors of the line and offers ways to increase productivity as well as the cost of wasting economic time of the line. Since then, my team has proposed some future options.

Using safe and environmentally friendly packaging materials: milk is a nutritious food and especially for Vinamilk milk brand, in addition to standard milk quality, the use of packaging materials is also very concerned. With a large amount of milk consumption in the Vietnamese market, the amount of waste from milk cartons and straws is also a concern. We should use packaging that is capable of decomposing for less than 6 months and instead of using plastic straws, we should use paper straws from wood, bamboo, ...

Optimize the packaging system: Use robots in the milk philosophy system and milk cartons to ensure the best cleaning process. In addition, this option also helps the system increase productivity, minimize wasted time.

Therefore, to improve the flexibility of milk carton packaging lines in the future, it is necessary to use new technology and optimize processes to minimize wasted time and increase productivity. In addition, attention must also be paid to environmental, sanitary and food safety issues.

4. CONCLUSION

After researching and completing the topic: "Research, evaluation and forecast of productivity of pasteurized milk production packaging line at Vinamilk Dairy Company." Our team has learned and accumulated a lot of experience in designing a real system model, understanding the problems required in the system design process.

The team learned more about the methods during the process of building the system. From there, know the advantages and disadvantages to apply to the system, helping the system to be more complete. These are methods of operation, analysis and system improvement such as DEA, Grey, Plant simulation. The team evaluated the efficiency of the pasteurized milk production line and forecasted the revenue of Vinamilk Dairy Company.

We have researched and implemented the problems posed and listed the production system scientifically, along with giving target specifications for the design and realization of the system.

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