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Application of Collaborative Forecasting in a Corn-Starch Manufacturing Company in Vietnam

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***Abstract*—** *In Vietnam, the business landscape has been changing dramatically over the last few years for manufacturers. Food manufacturers, in particularly, have been shifted into the position whereby they have to deal with recent trends of high and volatile commodity prices, transportation and energy cost. One of the big problem for small-sized companies in Vietnam is demand forecasting, especially for products have short shelf-life. In this work, five different forecasting techniques are employed and the results are evaluated. Those are ARIMA, exponential smoothing, GM(1,1), DGM(1,) and Verhulst. The result indicates that ARIMA and has the best performance with smallest error. The second best methods were the GM(1,1). Since the forecast values show small variations from the actual values, it could have a huge impact on the company's effort to reduce cost.*

***Keywords*—** *ARIMA, grey mode, discrete grey mode.*

I. INTRODUCTION

In recent years, in Vietnam there has been a significant growth in the economy, which is the result of the development in various field. One of which is the manufacturing industry. Due to the fact that requirements in product quality, mass production profit earnings are getting stricter, more challenging and more competitive among firms, the manufacturers themselves have to invest for improvement and enhancement to optimise its processes, minimise uncertainties and maximize capacities as much as possible. Moreover, with the support from foreign investments and technology transfer, domestic manufacturers are more probably acknowledge of advanced techniques and technologies as well as professional management approaches. This really made the picture of the industry positively promising. Companies from small to medium size seems to have started to investigate carefully in mathematically controlling the business, which can be seen in demand and production planning.

On the other hand, the economic growth has been making an obvious escalation in citizens' living standard that can be seen in entertainment or food industries. The demand of tasting new beverages or improved version of existing food, may have been consequently led to the new and higher requirements for food production. Better packages, new method of preparation or new ingredients for the product could also be factors. Further than that, with an economy that has long been backed by agriculture, Vietnamese are thought to be experience in agricultural and agricultural-based products, which can be seen in traditional harvesting and storing techniques. However, with the push of the competitors worldwide and the needs to optimise the business to survive through any uncertainty may happen.

Moreover, it is obvious that agricultural products, in general, has some typical characteristics that differs from others, such as the ease of perishability under time, temperature, humidity, insect conditions, etc. Therefore, proper methods that are usable for such type of product is essential to handle the special specification. Consequently, an appealing forecasting method generating a reliable prediction helps ensuring later performance of manufacturing planning. Specifically, it would be less likely to be either out of stock or high stock that there would not be times the process has no input or product go out of date. The overall risk is mitigated while the efficiency is maintained and the performance is enhanced. Accordingly, providing a suitable forecasting really benefits any company in food industry.

The company in this research has been facing the problems of balancing the discrepancy volume between raw materials and market demand. In other words, although the company apply similar make-tostock inventory system, having not studied the demand properly made that experience-based forecast less accurate. This leads to fluctuation in production in a year, sometimes it has to excessively produce while other times the process works idly and therefore, cost of loss of expiration, continuously manufacturing adjustments may significantly affect the business.

Specifically, storing overwhelmingly huge amount of stock that is easy to be damaged is risky to the company's financial flow while the cost of high inventory has always been a problem to any manufacturer. The cost is not limited to cash but environment, waste or energy consumption.

Thus, it is vital build a suitable forecast system to help handle such uncertainties. A variety of forecasting techniques should be taken to test for best fitness, performance and accuracy. Furthermore, a production planning is generated to complete the whole optimization managing process.

The research studied on a baking ingredient - corn-starch, therefore, it may only work for related agricultural product ranges while others may lead to unexpected results. In addition, based on the data collected, only daily demands within two years were investigated so only limited forecasting values are preferred to be reliable.

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II. Literature Review

For manufacturing firms, demand understanding from historical data to forthcoming one decides the productivity, performance and competitiveness comparing to its rivals. Yet, with plenty of methods from simple to complex, it is the operator's challenge to choose an applicable one. As being said, linear models are widely used as one of the first alternatives to be applied, tested and compared to others. Some forecasting approaches that are commonly used are exponential smoothing, moving average (MA), autoregressive (AR), autoregressive integrated moving average (ARIMA).

Since moving average is considered to be one of the easiest methods to construct and implement in almost any circumstance, it is popularly used as a comparative factor, or a benchmark for other methods. On the other side, ARIMA is favoured to be used in more advanced scenarios that combines the characteristics of AR – changing values from its past one and MA – dependency between observed value and the error of applying MA. It has the capability of being built with seasonal or seasonal trends also. ARIMA has quite plenty of application in food and beverage industry as Dr. Forst forecasted a campus restaurant for weekly demand for beginning years (Frank G. Frost, 2011). Meanwhile, the method integrated in agriculture production with various studies. For instance, Kumar and Bhramaramba, B. used ARIMA for predicting the agricultural production in India [(A.V.S. Pavan Kumar & R. Bhramaramba (2018)]; a research on forecasting wheat production in Pakistan using variants of ARIMA with different sets of parameters by Najeeb and his partners [Najeeb et al. (2014)] and an application in predicting daily sales in wholesale vegetable market [Shukla, M. & Jharkharia, S (2011)]. And many other works that have been successfully implemented in the field in variety of countries and proven to be an easy but promising technique that could be adjust to use in numerous cases.

Otherwise, as not as popular as above approaches, grey forecasting method (GM) shines to be a highly competitor towards the race. This is because of the ability of understanding the data better with limited source of information of the grey model with uncertainties and randomly unexpected conditions may happening to the agriculture. Because of that aspect, until now, grey forecasting method has been getting much attention from researchers from distinct professionals such as economy, health care, hospitality, transportation, etc. Yuhong Wang, Jianrong Tang and Wenbin Cao successfully proposed a model to predict the trend of food quality to perform warning action whenever there could be risks to people's health [Yuhong Wang, Jianrong Tang & Wenbin Cao (2012)]. On the other hand, an enhancement version of grey model called discrete grey model (DGM) was proved to increase the prediction accuracy that really claim the reliability of the original grey model for researchers to further investigate to propose better suitable model for cases [Naiming Xie & Si-feng Liu (2008)]. Conventionally, GM(1,1) is the main model one of the most commonly used in the system.

III. Methodology

A. Exponential Smoothing

$$St + 1 = ayt + (1 - a)St \quad (1)$$

In which: a: smoothing weight component, $0 < a \leq 1$

B. Auto Regressive Integrated Moving Average (ARIMA)

ARIMA model predicts future values by combining characteristics of AR and MA on historical data and the discrepancy between actual and predicted values by time. This means, with different component sets of time (p,d,q), p is lag time of autoregressive component, q is lag time of moving average component, d is number of time series.

C. Grey Mode

Grey Model was built by a Chinese researcher, Deng, in order to firstly handle the situation of limited data. Grey Forecasting Model can be understood as using grey information, through an accumulating generation operator to find a structure for the series. Originally, Grey Model was established with two versions, the basic grey model GM(1,1) – the first order and single variable grey dynamic model and the other first order and multivariable GM(1,N). Later on, several variants were formed, such as Discrete Grey Model, Verhulst Model, etc.

D. Performance Measures

Each forecasting method provides different outcomes from its characteristics and therefore, will not fit any dataset in any scenario totally. There will be no best or most appropriate approach for a forecasting problem, only the better and the fitter, which reflect the performance, quality and reliability of the model towards the problem. The fitness requires verification and validation by comparison between given data and forecasting results beside method's internal tests. Such gap between the two is considered to be error. Some accuracy evaluation approaches are built to form equivalent-analogy factor.

Some of popular ones are: Mean Absolute Deviation (MAD), Mean Absolute Percentage Error (MAPE), Mean Squared Error (MSE) and Root Mean Squared Error (RMSE).

$$MAD = \frac{\sum_{i=1}^{n} |e_i|}{n} \quad (2)$$

$$MAPE = \frac{\sum_{i=1}^{n} \frac{|y_i - y_{i'}|}{y_i}}{n} \quad (3)$$

$$MSE = \frac{\sum_{i=1}^{n} (y_i - y_{i'})^2}{n} \quad (4)$$

$$MSE = \sqrt{\frac{\sum_{i=1}^{n} (y_i - y_{i'})^2}{n}} \quad (5)$$

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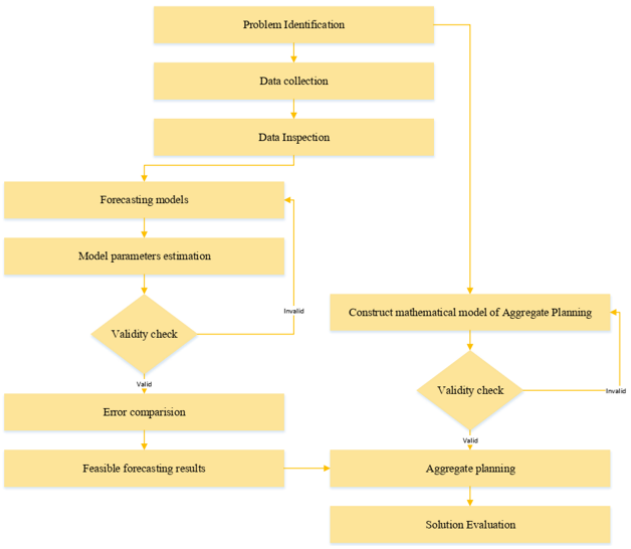

Fig. 1. Flowchart of the study

IV. Forcasting Results

Forecasting results using different approaches are shown in the Figure 2, 3, 4 and Table 1.

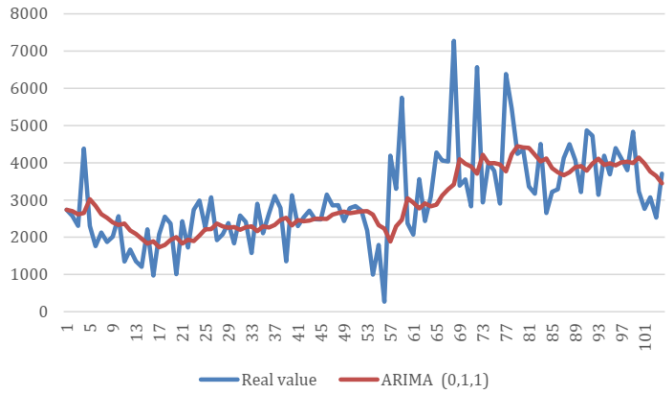

Fig. 2. Comparison chart between Real Value and forecasted value of ARIMA (0,1,1)

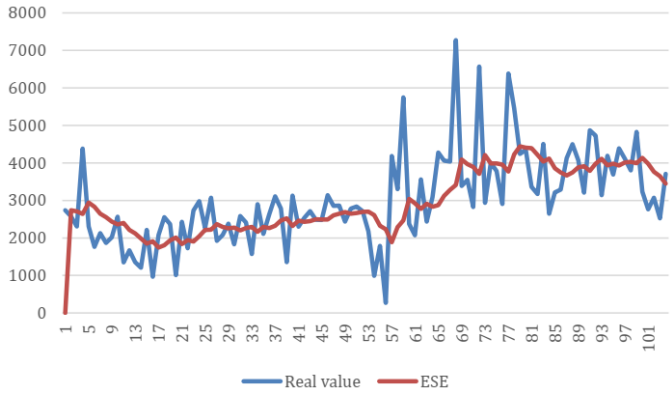

Fig. 3. Comparison chart between Real Value and forecasted value of Exponential smoothing

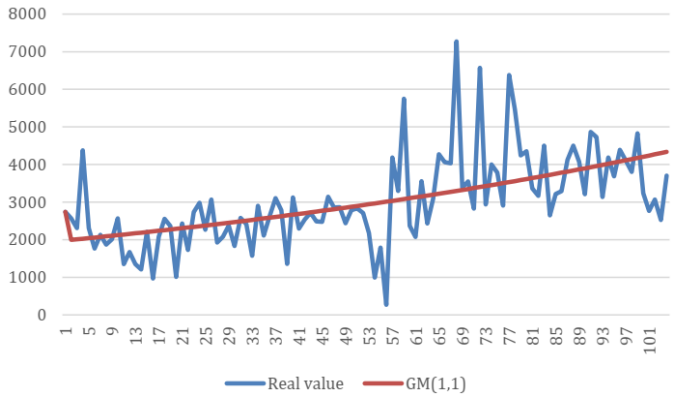

Fig. 4. Comparison chart between Real Value and forecasted value of GM(1,1)

Table I. Forecast errors comparison

	ARIMA	Exponential smoothing	GM(1,1)
MAPE	**32.29**	33.38	34.05
MSE	**951450.18**	1025751.33	959957.53
RMSE	**975.42**	1012.79	979.77
MAD	716.32	744.26	**673.6**

ARIMA(0,1,1) is revealed to be the fittest model towards the case with its overall smallest errors comparing to others. Grey Model meanwhile just be a step behind. However, because ARIMA(0,1,1) and GM(1,1) errors are not really significant while ARIMA(0,1,1) generate constant values for future forecast and GM(1,1) varies results, which well matches the chasing aggregate planning and make the planning like reality behaviour, GM(1,1) will be used for Aggregate Planning later.

V. Conclusion

In order to be prepared for the future scenarios right in the first place, a company must adopt a good forecasting technique. Once a forecast is established, a manufacturer can schedule their production efficiently with resources are well allocated. This can eventually lead to an improvement in financial statement and company's performance in general. Regardless of how much a good forecast can do for supply chain management, its error also cause huge damage to a business. One fail prediction can lead to a sequence of wrong decisions. Therefore, selecting a method for prediction asks for a lot of effort and resource. As there are many approaches available for estimate the future value, one must observe closely to obtain the characteristics of the variable and industry, then consider the strength and drawbacks of each forecasting methods.

This research identified the suitable forecasting techniques for demand of corn starch in the first stage when several factors are still missing. The result after being evaluated GM(1,1) work efficiently on the data set and manage to provide a good prediction for production planning. Since we only include three forecasting methods (include an auto ARIMA) for comparison in this study, there are still rooms for further research. GM(1,1) might or might not be the final options for developing demand forecast. However, it is still possible to take into account if any of the forecasting result are

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seems to be not consistent with the current performance and resources distribution. In short, the result of this research can be considered as an indicator showing whether or not there are any bottleneck within the whole system.

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