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Inventory simulation model of frozen-meat for food-safety program

Moch. Yandra Darajat*, Komarudin, Akhmad Hidayatno

Department of Industrial Engineering, Universitas Indonesia, Depok, Indonesia

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Abstract

This research discusses the application of inventory simulation and optimization model for food safety program in Indonesia. Frozen meat is a complementary commodity for fresh meat that has an inadequate supply in the country. The disadvantage of frozen meat is that it needs to be stored in a refrigerator to maintain its quality and thus increases the cost. Therefore, an appropriate inventory policy is crucial to minimize the cost. In order to deal with this situation, a Monte Carlo simulation followed by an optimization model is proposed. Specifically, the Moving Average and the Winter Methods are used to predict the demand in the future. The results show the best inventory policy thus the cost is minimized and the national needs are satisfied.

Keywords: Inventory model; demand forecast; food-safety; simulation; optimization.

1. Introduction

Development of the quality of human resources is one of the goals of Indonesia's development. It is closely related to the improvement of the community nutrition, health, and education level. One source of nutrition is a food of animal origin in the form of protein derived from beef. The domestic need for meat will continue to increase along with the increase in population, the increasing of economic level, the awareness of the society of nutrition, and the existence of a foreign community. Beef imports to meet market demand are still continuing, as Indonesia's local meat production is still unable to meet domestic demand (Fig. 1). Besides imported meat has several advantages, namely more tender, a high degree of marbling so that it is preferred by consumers [1].

The Center for Agricultural Data and Information Systems in the 2016's Beef Outlook presents data on national beef production and consumption as shown in Table 1. It shows the national meat consumption is still in deficit in 2014 and 2015 at 196 thousand tons and 207 thousand tons and according to projections will continue to experience supply shortages until 2020 [2].

Based on data from the National Socioeconomic Survey (SUSENAS) in 2015, Indonesian beef consumption is 2.40 kg/capita/year, that is relatively small compared to the consumption of developed countries. Indonesian people generally only eat beef when there is a celebration or religious holidays. Nevertheless, Indonesia cannot yet become a self-sufficient state of beef, to meet the demand for beef, especially in big cities like Jakarta, is still widely obtained from imports. On the other hand, this deficiency becomes an obstacle that must be fulfilled by the state to its people [2].

* Corresponding author.
Email: myandrad@gmail.com

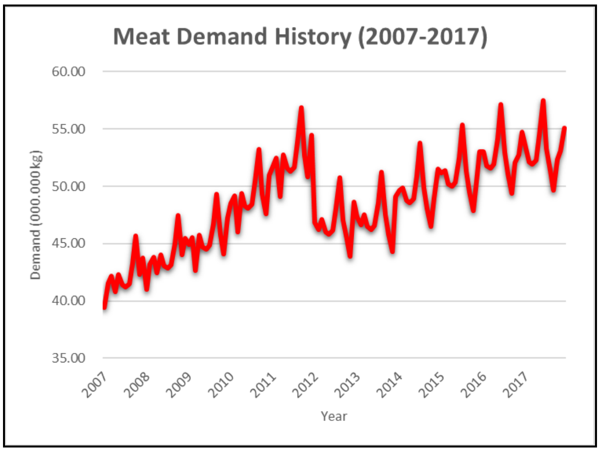

Fig 1. National meat demand in Indonesia for period of 2007 – 2017

In order to achieve food security, availability is not enough, the food must also fulfill the principle of affordability and stability. That is, the food should be within an affordable price range to be purchased by all levels of society and the supply can fulfill the demands.

In order to provide adequate supply, the government continues to open faucet imports of livestock products including beef. In 2016 the government officially opens imports of buffalo meat from India as an additional supply source to meet people's need for meat at an affordable price. This was performed as well as imported meat from Australia and New Zealand.

The imported meat from India is in a hope to provide an alternative for meat consumers in Indonesia because it is cheaper than the local meat or the imported one from Australia and New Zealand. As per Ministry of Trade Decree no. 27/2017 on the pricing of purchases at farmers and reference prices in consumers, it has set the reference price of frozen meat at the consumer level of Rp. 80,000,- per kilogram, and its mandatory for all meat seller both for traditional and modern markets.

Storage of frozen meat in cold storage costs more than an ordinary warehouse. Good inventory management can reduce inventory costs and it can help the sellers to meet the reference price.

Table 1. Projection of surplus/deficit meat for period of 2014 – 2020

Period	**Production (000 Tons)**		**National Consumption**	**Surplus/Defisit**
	Carcas Production (000 Tons)	**Meat Production (000 Tons)**	**(000 Tons)**	**(000 Tons)**
2014	497.67	398.14	595.11	-196.97
2015	506.66	405.33	613.11	-207.78
2016*)	524.11	419.29	623.48	-204.19
2017)**	531.21	424.97	636.39	-211.42
2018)**	540.13	432.1	641.33	-209.23
2019)**	549.05	439.24	642.76	-203.52
2020)**	557.96	446.37	644.73	-198.36
Growth (%)	**1.93**	**1.93**	**1.35**	**0.17**

Source: Outlook Beef. Center for Agricultural Data and Information Systems, 2016.
Information :
*) 2016 Production of Temporary Figures, DG PKH (Directorate General of Husbandry and Veterinary)
**) Consumption of Pusdatin estimation

Frozen meat storage is a separate issue in the meat supply chain in Indonesia. This is because long time the people of Indonesia still prefer to buy meat that is served in fresh condition, so the storage infrastructure of frozen product is still limited. Nevertheless, the government continues to encourage people to consume beef in frozen form. The policies issued increasingly lead to the handling of slaughterhouses with cold supply chain, such as Regulation of the Minister of Agriculture no. 13 of 2010 on the requirements of slaughterhouses and meat cutting plants where modern slaughterhouses (RPH) should be equipped with chiller, blast freezer and cold storage facilities [13].

Inventory management is a method of streamlining inventory control and helping companies to determine when and how many purchases are made. Good inventory management enables companies to reduce their inventory levels while maintaining a good level of service [3]. Inventory control at the desired level in the company's operational activities is an important activity to meet market needs and control inventory costs [4].

The cost of storage determined by the amount of inventory that controlled within a certain time determined by the time order (reorder point) and the ordering size [5]. Effective or not a company's inventory management can affect the performance of the company [6]. The optimum inventory level affected by the low purchase cost in the procurement period and with the number of purchases that adjust to the demand (demand) in the same period. Fig. 2 shows the inventory level and cost relation.

One of the objectives of inventory control is to minimize costs arising from the availability of such inventories [7]. The costs are:

a. Holding cost, is the cost incurred by the storage of inventory in the warehouse at certain period of time, including the cost of insurance, depreciation, interest and others.
b. Ordering cost, is the cost incurred by the activity of ordering supplies in one message, eg: forms, supplies, ordering and administration process; as long as material / goods are not available for further processing.
c. Stock out cost, is the loss due to unmet demand at certain period such as: loss of sale, loss of customer, special ordering cost, the difference of price, disruption of operation, and additional expenditure of managerial activity.

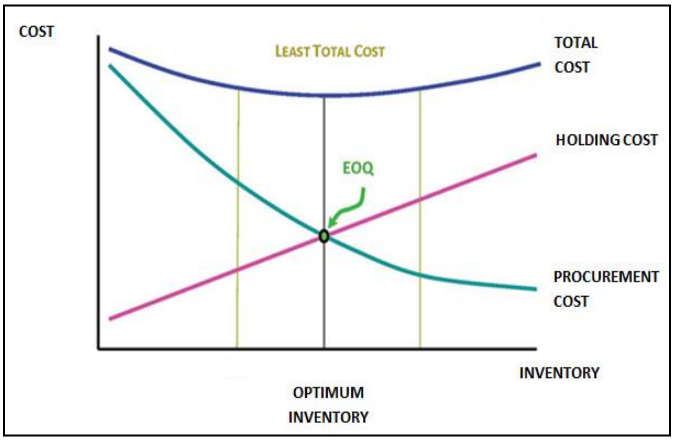

Fig 2. Inventory level and cost relation

There are two important decisions in an inventory model: 1. How much amounts should be ordered for a particular supply of goods? 2. When the optimal time to order the item back so that the inventory can reach the optimum point? Every decision taken has an effect on the cost of inventory. To make easier decisions, models for inventory management developed. The demand model is divided into two types i.e. deterministic demand and probabilistic demand [7].

Several previous studies have found a formula that can help in determining inventory models that can form the basis of determining inventory policies. Li et.al (2013) [8] conducted a reorder point optimization research on manufacturing spare parts systems under permit conditions and random leadtime. With demand assumed to be normally distributed. His research aims to find the best order strategy to minimize inventory costs.

Wang et.al (2006) [9] examined the optimal ways to minimize the annual inventory cost by determining the production lot size, reorder point, and isvestation to reduce setup cost. The study considers historical data of normally distributed and exponential demand. El-Wakeel et.al (2013) [10] conducted a probabilistic system backorder inventory with order cost is a function of order quantity. The study is to minimize the total annual cost with demand following the normal distribution.

From the description of the problem in the background, there is no research that discusses the problem of meat supply model in Indonesia, therefore this research is trying to fill the gap. Limitations of the problem in this study:

1. Import quota constraints. The import quota granted by the government must be realized 100%.
2. The object of research is imported frozen meat as a complementary commodity of beef / buffalo in Indonesia.
3. The scope of research covers the territory of the Unitary State of the Republic of Indonesia.
4. The inventory control period undertaken for 2018.
5. The selling price of the commodity has the upper limit (the applicable ceiling price) according to the Minister of Trade Regulation no. 27 year 2017. Therefore, it is done optimization efforts at the level of importers to obtain the minimum management cost in order to achieve the expected retail price at the consumer level.

With the commodity price fluctuation and the uncertain demand for commodities in each period, the purchasing model should be adjusted to the price level occurring in a period by following the demand rate for a given period. In other words, the question arises: whether to buy with more amounts when the price is low, but at the same time demand at low position? Or do more purchases still be made on the eve of high demand despite high commodity purchase price?

Under existing condition there will be a trade-off between the purchase amount at a low purchase price and the amount of purchase at the time of high demand. Thus, the purchase pattern and inventory level will follow the pattern as in Fig. 2.

The purpose of this study is to determine the appropriate inventory policy scenario to support the fulfillment of meat requirements in Indonesia by streamlining the cost of purchasing and supplies; thus this generally can be realized in the provision of meat at affordable prices for the community.

2. Research Method

Some methods below are used to analyze the data:

2.1. Monte Carlo

Monte Carlo simulations defined as all statistical sampling techniques used to estimate solutions to quantitative problems (Risk Glosary, 2008). This method used to evaluate business situations where there are uncertainties and random situations (Leong, 2007). In a Monte Carlo a model is built on the actual system. Each variable in the model has a value that has a different probability, indicated by the probability distribution or commonly called the probability distribution function (pdf) of each variable. The Monte Carlo method simulates the system over and over, hundreds or even thousands of times depending on the system reviewed, by choosing a random value for each variable of the probability distribution. The result of the simulation is a project distribution.

The research will be done by comparing the model obtained from previous research and simulating the model with the condition of frozen meat stock in Indonesia. The model that generates the minimum total inventory cost will be selected. Model simulation will be done by taking the procurement and inventory data from the company engaged in the field of food logistics. In order to validate the inventory model obtained will be a sensitivity analysis.

2.2. Forecasting Method

Data demand considered the trend of seasonal data where the demand for meat is usually high in the days leading up to the big religious days. Demand forecast with Weighted Moving Average method and Holt-Winter Technique conducted to determine the demand in the future.

2.3. Moving Average (WMA)

Moving average is a general forecasting method and it is easy to use the tools available for technical analysis. Moving averages provide a simple method for smoothing past data. This method is useful for forecasting when a trend occurs. If there are trends, use different estimates to consider.

2.4. Holt-Winter (HM)

The Holt-Winters method is an extension of two Holt parameters. The Holt-Winters method is a time series prediction method that can handle seasonal behavior on a data based on past data [12].

2.5. Simulation Scenario

Five scenarios were created to simulate the control of frozen meat stocks:

Scenario 1. Purchase of 10,000 tons per month, arrival in stages per month without price contract;
Scenario 2. Total purchase of optimization result with safety stock 10% without price contract;
Scenario 3. Total purchase of optimization result without safety stock without price contract;
Scenario 4. Total purchase of optimization result with 2-month price contract;
Scenario 5. Total purchase of optimization result with 3-month price contract.

From the simulation result with some scenarios above, we get the total cost which different each scenario.

3. Result and Discussion

Fluctuating purchasing and demand prices led to the need for simulations to determine the policy of frozen meat stock control. Data fluctuations in the price of monthly frozen meat purchases in 2017 at Jakarta can be seen in Fig. 3.

The fluctuation of national meat requirement caused by the pattern of meat consumption of Indonesian people who consume more meat at certain times such as Idul Fitri, Christmas and New Year, as indicated in Fig. 4 and Fig. 5 (Source: PUSDATIN (reproduced)).

After the transformation of data then tested its stationery, the next step is to test the normality of data. In this study, normality test using Anderson Darling (AD) approach. Anderson Darling Test is a test of normality that resembles the Kolmogorov Smirnov Test and Cramer Von Mises Test, which are both based on Empirical Distribution Function (EDF).

Fig. 6 shows that the data spreads around the diagonal line and follows the direction of the diagonal line. From the value of Anderson Darling (AD) of 0.533 with p-value 0.170, the comparison of p-value and AD value with α is 0.170 and 0.533> 0.05 (alpha used in the study) so that the data is normally distributed.

3.1. Forecast Result

3.1.1. Moving Average

Fig. 7 is the output of forecast using the Moving Average method with length of 12, found that the MAPE value of 2.91, the MAD value of 0.256 and the MSD value of 0.118.

3.1.2. Winters Method

Fig. 8 is a forecast processed output using the Winters Method of smoothing constants, where each level (α), trend (γ) and seasonal (δ) are 0.2. It was found that the MAPE value was 1,371, the MAD value was 0.117 and the MSD value was 0.04838.

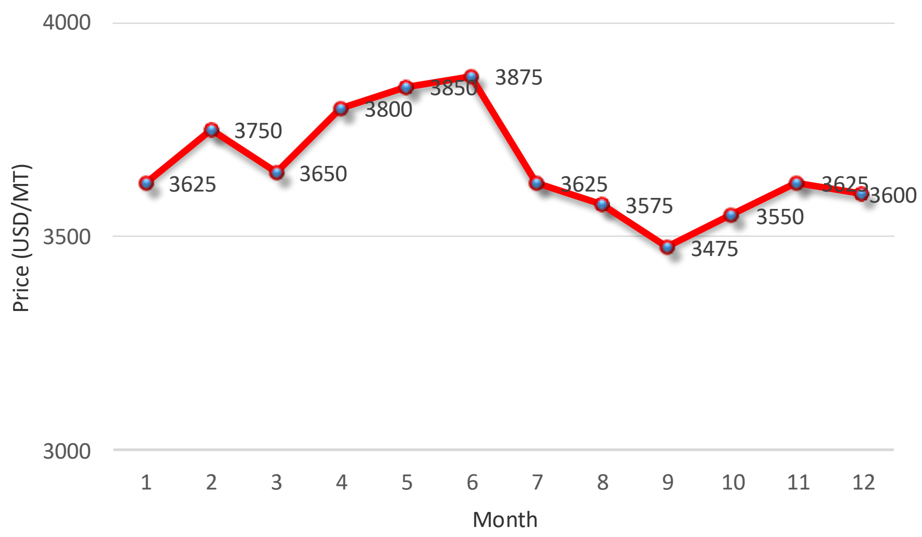

Fig. 3. Fluctuation of buying price of frozen meat in cost and freight (CIF) term

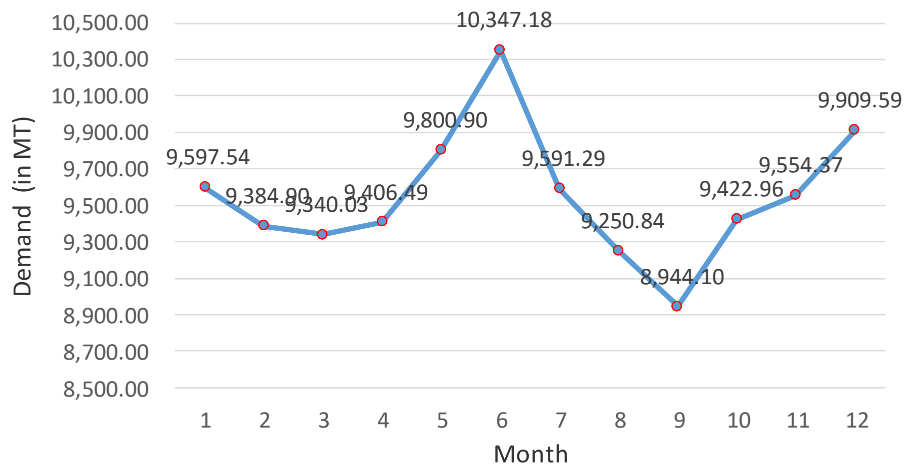

Fig. 4. Fluctuation demand of frozen meat in Indonesia with year period of 2017

From the two forecast methods, Winters Method yields MAPE, MAD and MSD values lower than the Moving Average method. This means that Winters Method can produce better forecasts than the Moving Average Method, because the margin of error between the forecast and the real number is smaller. Therefore, we use forecasting data produced by Winters Method for simulation. Table 3 shows consumption data per month resulted from forecast for the year of 2018.

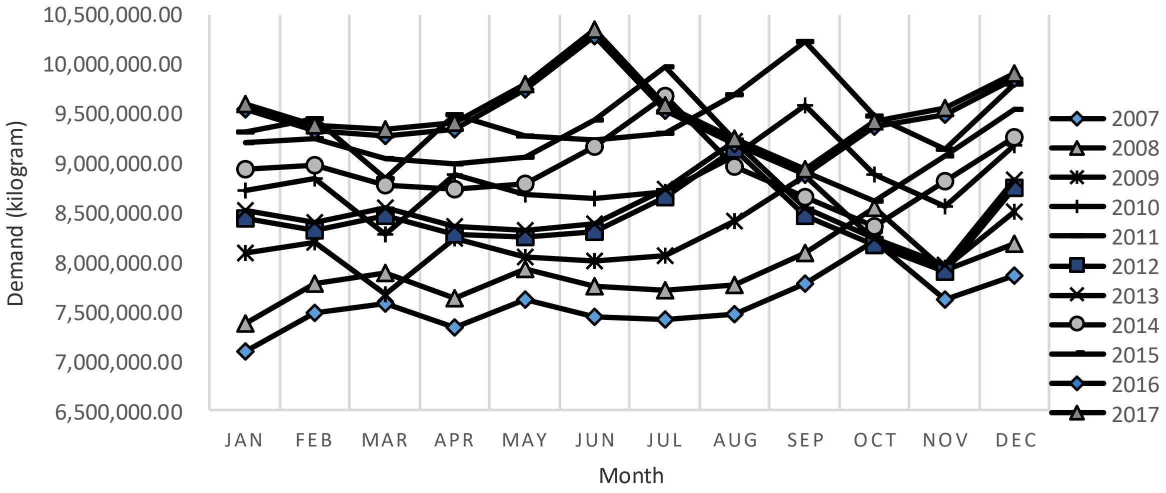

Fig. 5. National frozen meat demand with year period of 2007 – 2017

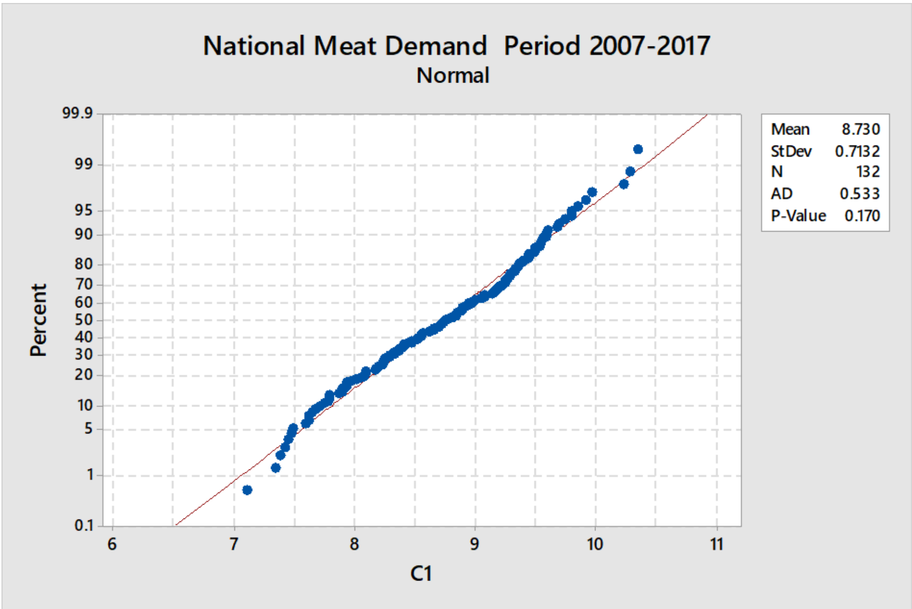

Fig. 6. Normality test of demand data output from Minitab 18 software

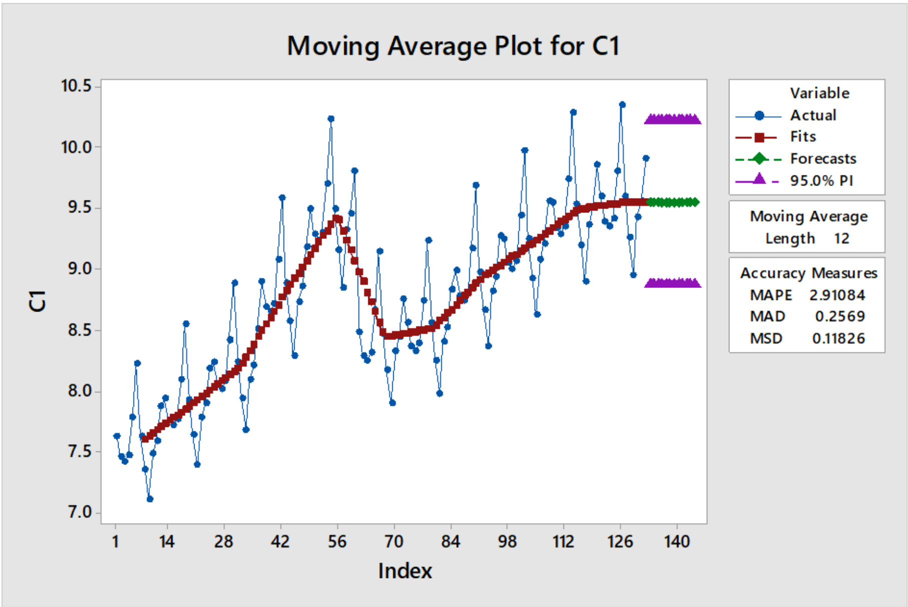

Fig 7. Forecast result using moving average output from Minitab 18 software

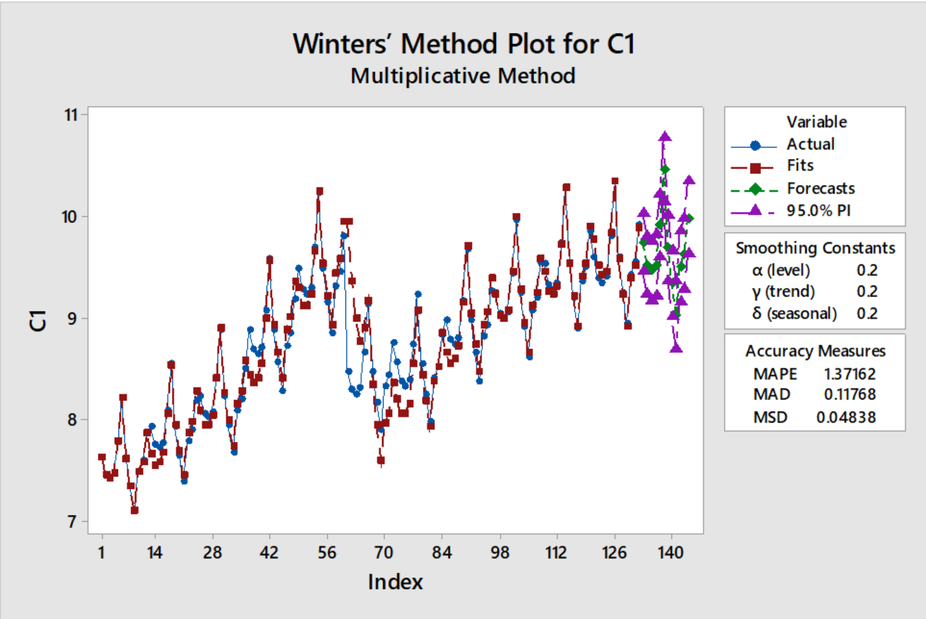

Fig. 8. Forecast result using winters method output from Minitab 18 software

Table 3. Consumption data per month resulted from forecast

Month	Consumption
January	9,742,164.66
February	9,516,818.88
March	9,462,392.64
April	9,521,362.98
May	9,912,535.56
June	10,457,180.82
July	9,686,566.26
August	9,336,828.42
September	9,022,086.36
October	9,500,372.46
November	9,628,821.36
December	9,983,556.36
Total	**115,770,687**

3.2. Monte Carlo Simulation for Purchase Price

Monte Carlo simulation is applied to determine the purchase price data in the year to be simulated, the price data is taken from the history of purchase price 3 years earlier to determine the price in the year to be simulated. Price history data are presented in Table 4. The data in Table 4 is made interval value, as shown in Table 5.

Based on data on Tables 4 and 5, the possible distribution data for the purchase price can be constructed. The result is listed in Table 6. Further, it is generated in random number to make uncertainty of purchase price [14]. The random number data can be seen in Table 7. The probability interval data is based on the cumulative probability data in Table 8. Table 9 shows data of purchase price simulation for 12 months.

3.3. Inventory Control Simulation

From the simulation, we get the total cost values which are different each scenario. Scenario III results in the lowest total cost of Rp. 6,038,499,272,931,- compared to total cost resulted by Scenario I of Rp. 6.074.162.437.002,- Scenario II is Rp. 6.052.312.201.581,- Scenario IV is Rp. 6,106,848,070,522,- Scenario V is Rp. 6,045,421,679,444,-. The complete result for each scenario is listed in Table 10.

This shows that the difference of purchasing policy will affect the total cost incurred to buy and store meat, so the policies taken by the company and government in the effort to provide frozen meat for the community must be done effectively and efficiently in order to meet the needs of the community at a price affordable.

Table 4. Purchase price data (2015-2017)

2015	2016	2017
3,600	3,575	3,625
3,750	3,675	3,750
3,600	3,625	3,650
3,825	3,750	3,800
3,775	3,800	3,850
3,875	3,825	3,875
3,625	3,700	3,625
3,575	3,550	3,575
3,525	3,525	3,475
3,575	3,575	3,550
3,575	3,575	3,625
3,600	3,625	3,600
***) Unit USD per Metrix Ton**		

Table 5. Data interval value

Interval No.	Interval Values		Mean Interval Values
1	3,475	3,542	3508
2	3,543	3,609	3576
3	3,610	3,677	3644
4	3,678	3,745	3711
5	3,746	3,812	3779
6	3,813	3,875	3844

4. Conclusion

The result of simulation can provide optimal value to control the procurement of frozen meat for meeting national needs. The scenario that has minimum cost is Scenario #3 (total purchase of optimization result without safety stock and without price contract). Future research can be performed by increasing the complexity of the problems in the simulation, e.g. by considering other forecasting methods and comparing them against one and another, as well as analyzing the results.

Table 6. Distribution of probability

Interval no.	Interval values		Frequency	Probability of Occurrence	Cumulative Probability	Mean values
1	3,475	3,542	3	0.08	0.08	3,508
2	3,543	3,609	13	0.36	0.44	3,576
3	3,610	3,677	8	0.22	0.67	3,644
4	3,678	3,745	1	0.03	0.69	3,711
5	3,746	3,812	6	0.17	0.86	3,779
6	3,813	3,875	5	0.14	1.00	3,844

Table 7. Random number generated for Monte Carlo simulation

RN	1	2	3	4	5	6	7	…..	49	50
Jan	0.6867	0.4274	0.4795	0.6444	0.2447	0.7306	0.7692	……	0.9992	0.1415
Feb	0.3840	0.0096	0.4890	0.0487	0.9467	0.0950	0.7849	……	0.0657	0.6848
Mar	0.8036	0.5219	0.0343	0.9144	0.0423	0.8979	0.9308	……	0.5050	0.3653
Apr	0.4927	0.0072	0.2182	0.5262	0.6944	0.5363	0.1688	……	0.0693	0.4760
Mei	0.6867	0.4274	0.4795	0.6444	0.2447	0.7306	0.7692	……	0.9992	0.1415
Jun	0.3840	0.0096	0.4890	0.0487	0.9467	0.0950	0.7849	……	0.0657	0.6848
Jul	0.8036	0.5219	0.0343	0.9144	0.0423	0.8979	0.9308	……	0.5050	0.3653
Ags	0.4927	0.0072	0.2182	0.5262	0.6944	0.5363	0.1688	……	0.0693	0.4760
Sep	0.6867	0.4274	0.4795	0.6444	0.2447	0.7306	0.7692	……	0.9992	0.1415
Okt	0.3840	0.0096	0.4890	0.0487	0.9467	0.0950	0.7849	……	0.0657	0.6848
Nov	0.8036	0.5219	0.0343	0.9144	0.0423	0.8979	0.9308	……	0.5050	0.3653
Des	0.4927	0.0072	0.2182	0.5262	0.6944	0.5363	0.1688	……	0.0693	0.4760

Table 8. Probability data interval

Interval no.	Prob. Intervals		Mean values
1	0.00	0.08	3,508
2	0.09	0.44	3,576
3	0.45	0.67	3,644
4	0.68	0.69	3,711
5	0.70	0.86	3,779
6	0.87	1.00	3,844

Table 9. Data of purchase price simulation for 12 months

INTERVAL NO.	1	2	3	4	5	6	7	…..	49	50	ROW. AVG
1	3644	3711	3576	3779	3576	3576	3644	…	3644	3576	3614
2	3576	3644	3644	3644	3644	3576	3844	…	3576	3844	3548
3	3576	3779	3779	3644	3844	3576	3508	…	3576	3576	3587
4	3576	3844	3576	3508	3576	350	3644	…	3779	3576	3508
5	3779	3576	3576	3576	3644	3779	3576	…	3844	3576	3614
6	3779	3844	3508	3644	3844	3576	3508	…	3576	3576	3548
7	3779	3844	3844	3644	3644	3576	3844	…	3844	3779	3587
8	3576	3644	3779	3644	3844	3779	3644	…	3644	3779	3508
9	3844	3844	3576	3844	3644	3508	3576	…	3644	3576	3614
10	3844	3576	3779	3644	3644	3644	3508	…	3576	3576	3548
11	3844	3576	3844	3644	3576	3644	3779	…	3576	3576	3587
12	3576	3508	3644	3644	3576	3644	3576	…	3576	3508	3508

Table 10. Result of simulation with each scenario

Scenario	Purchasing Cost	Transportation Cost	Holding Cost	Total Cost
I	5,892,670,508,130	150,000,000,000	31,491,928,872	6,074,162,437,002
II	5,862,973,061,557	150,000,000,000	39,339,140,024	6,052,312,201,581
III	5,861,568,782,476	150,000,000,000	26,930,490,437	6,038,499,272,913
IV	5,951,931,052,797	150,000,000,000	4,917,017,725	6,106,848,070,522
V	5,890,504,661,719	150,000,000,000	4,917,017,725	6,045,421,679,444

References

1. R. Priyanto, *Improving productivity and meat quality of local beef cattle through fattening on cereals based feed with different energy levels.* Indonesia Agric. Sci. J. 20 (2015) 108-114.
2. R.H. Matondang, S. Rusdiana, *Strategic steps in achieving beef self-sufficiency.* J. Agric. Dev. 32 (2013) 131-139.
3. N. Prukpaiboon, W. Tharmmaphornphilas, *Inventory management for stochastic demand and lead time products,* Int. J. Mech. Prod. Engin. 3 (2015) 41-46.
4. I.M. Hakim, P. Larassati, *Inventory determination model for packaging materials with various demand data distributions in chemical company"* 7th Int. Seminar Ind. Eng. Manag., 2015, pp 58-64.
5. D. Nakandala, H. Lau, J.Zhang, *Optimization model for transportation planning with demand uncertainties,* Ind. Manag. Data Syst. 114 (2014) 1229-1245.

6. D.P. Koumanakos, *The effect of inventory management on firm performanc*e, Int. J. Prod. Perform. Manag. 57 (2008) 355-369.
7. H.A. Taha. *Operations Research: An Introduction, 8 th* ed., Pearson Prentice Hall, New Jersey, 2007.
8. Z. Li, Jin, *Optimization of reorder point strategy of assembly manufacturer with random variables,* Int. J. Business Manag. 8 (2013) 89-95.
9. C. H. Wang, M. H. Chao, I. M. Huang, *Capital investment in setup cost reduction for a lot-size, reorder point model, J. Inform.Opt.Sci.* 27 (2006) 249-258.
10. M. F. El-Wakeel. *Constrained backorders inventory systems with varying order cost: Lead time demand uniformly distributed*, *J. King Saud Univ. Sci*. 24 (2015) 285-288.
11. S. T. Karris. *Introduction to Simulink with Engineering Applications*, Orchard Publications, 2006.
12. A. K. Palit, D. Popovic, *Computational Intelligence in Time Series Forecasting*, London: Spinger, 2005.
13. Ministry of Agriculture, "*Agricultural Minister Decree No 13,"* Ministry of Agriculture, 2010.
14. S. Tuzunturk, A.E. Senaras, K. Sezen, *Forecasting water demand by using Monte Carlo simulatio*n, Akademik Bakis Dergisi 49 (2015) 25-43.