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Utilization of Genetic Algorithm to Improve Forecasting Accuracy with an Application to the Sanitary Materials Data

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Abstract— In industries, how to improve forecasting accuracy such as sales, shipping is an important issue. There are many researches made on this. In this paper, a hybrid method is introduced and plural methods are compared. Focusing that the equation of exponential smoothing method(ESM) is equivalent to (1,1) order ARMA model equation, new method of estimation of smoothing constant in exponential smoothing method is proposed before by us which satisfies minimum variance of forecasting error. Generally, smoothing constant is selected arbitrarily. But in this paper, we utilize above stated theoretical solution. Firstly, we make estimation of ARMA model parameter and then estimate smoothing constants. Thus theoretical solution is derived in a simple way and it may be utilized in various fields. Furthermore, combining the trend removing method with this method, we aim to improve forecasting accuracy. An approach to this method is executed in the following method. Trend removing by the combination of linear and 2nd order non-linear function and 3rd order non-linear function is executed to the manufacturer's data of sanitary materials. The weights for these functions are set 0.5 for two patterns at first and then varied by 0.01 increment for three patterns and optimal weights are searched. Genetic Algorithm is utilized to search the optimal weight for the weighting parameters of linear and non-linear function. For the comparison, monthly trend is removed after that. Theoretical solution of smoothing constant of ESM is calculated for both of the monthly trend removing data and the non-monthly trend removing data. Then forecasting is executed on these data. The new method shows that it is useful for the time series that has various trend characteristics and has rather strong seasonal trend. The effectiveness of this method should be examined in various cases.

Key Words—minimum variance, exponential smoothing method, forecasting, trend, sanitary materials.

I. INTRODUCTION

Under the circumstance of globalization, Competition among companies became much more severe than usual. Shortening the lead time and decreasing stocks are urgent issues. To cope with these, forecasting of demand is essential. Higher accuracy of forecasting is required. If it is not executed well, it causes a huge stock and/or causes lack of goods. Therefore how to make a correct forecasting is a great concern. Many methods for time series analysis have been presented such as Autoregressive model (AR Model), Autoregressive Moving Average Model (ARMA Model) and Exponential Smoothing Method (ESM)^{[1]-[4]}. Among these, ESM is said to be a practical simple method.

For this method, various improving method such as adding compensating item for time lag, coping with the time series with trend^[5], utilizing Kalman Filter^[6], Bayes Forecasting^[7], adaptive ESM^[8], exponentially weighted Moving Averages with irregular updating periods^[9], making averages of forecasts using plural method^[10] are presented. For example, Maeda^[6] calculated smoothing constant in relationship with S/N ratio under the assumption that the observation noise was added to the system. But he had to calculate under supposed noise because he could not grasp observation noise. It can be said that it doesn't pursue optimum solution from the very data themselves which should be derived by those estimation. Ishii^[11] pointed out that the optimal smoothing constant was the solution of infinite order equation, but he didn't show analytical solution. Based on these facts, we proposed a new method of estimation of smoothing constant in ESM before^{[12][13]}. Focusing that the equation of ESM is equivalent to (1,1) order ARMA model equation, a new method of estimation of smoothing constant in ESM was derived.

In this paper, utilizing above stated method, a revised forecasting method is proposed. In making forecast such as production data, trend removing method is devised. Trend removing by the combination of linear and 2nd order non-linear function and 3rd order non-linear function is executed to the manufacturer's data of sanitary materials. These are used for medical use. The weights for these functions are set 0.5 for two patterns at first and then varied by 0.01 increments for three patterns and optimal weights are searched. Genetic Algorithm is utilized to search the optimal weight for the weighting parameters of linear and non-linear function. For the



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comparison, monthly trend is removed after that. Theoretical solution of smoothing constant of ESM is calculated for both of the monthly trend removing data and the non-monthly trend removing data. Then forecasting is executed on these data. This is a revised forecasting method. Variance of forecasting error of this newly proposed method is assumed to be less than those of previously proposed method. The rest of the paper is organized as follows. In section 2, ESM is stated by ARMA model and estimation method of smoothing constant is derived using ARMA model identification. The combination of linear and non-linear function is introduced for trend removing in section 3. The Monthly Ratio is referred in section 4. Forecasting Accuracy is defined in section 5. Optimal weights are searched in section 6. Forecasting is carried out in section 7, and estimation accuracy is examined.

II. DESCRIPTION OF ESM USING ARMA MODEL

In ESM, forecasting at time $t + 1$ is stated in the following equation.

$$\hat{x}_{t+1} = \hat{x}_t + \alpha(x_t - \hat{x}_t) \quad (1)$$

$$= \alpha x_t + (1 - \alpha)\hat{x}_t \quad (2)$$

Here,

\hat{x}_{t+1} : forecasting at $t + 1$

x_t : realized value at t

α : smoothing constant ($0 < \alpha < 1$)

(2) is re-stated as

$$\hat{x}_{t+1} = \sum_{l=0}^{\infty} \alpha(1-\alpha)^l x_{t-l} \quad (3)$$

By the way, we consider the following (1,1) order ARMA model.

$$x_t - x_{t-1} = e_t - \beta e_{t-1} \quad (4)$$

Generally, (p, q) order ARMA model is stated as

$$x_t + \sum_{i=1}^p a_i x_{t-i} = e_t + \sum_{j=1}^q b_j e_{t-j} \quad (5)$$

Here,

$\{x_t\}$: Sample process of Stationary Ergodic Gaussian Process $x(t) \quad t = 1, 2, \dots, N, \dots$

$\{e_t\}$: Gaussian White Noise with 0 mean σ_e^2 variance

MA process in (5) is supposed to satisfy convertibility condition. Utilizing the relation that

$$E[e_t | e_{t-1}, e_{t-2}, \dots] = 0$$

we get the following equation from (4).

$$\hat{x}_t = x_{t-1} - \beta e_{t-1} \quad (6)$$

Operating this scheme on $t + 1$, we finally get

$$\begin{aligned} \hat{x}_{t+1} &= \hat{x}_t + (1 - \beta)e_t \\ &= \hat{x}_t + (1 - \beta)(x_t - \hat{x}_t) \end{aligned} \quad (7)$$

If we set $1 - \beta = \alpha$, the above equation is the same with (1), i.e., equation of ESM is equivalent to (1,1) order ARMA model, or is said to be (0,1,1) order ARIMA model because 1st order AR parameter is -1 . Comparing with (4) and (5), we obtain



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$$\left. \begin{aligned} a_1 &= -1 \\ b_1 &= -\beta \end{aligned} \right\}$$

From (1), (7),

$$\alpha = 1 - \beta$$

Therefore, we get

$$\left. \begin{aligned} a_1 &= -1 \\ b_1 &= -\beta = \alpha - 1 \end{aligned} \right\} \quad (8)$$

From above, we can get estimation of smoothing constant after we identify the parameter of MA part of ARMA model. But, generally MA part of ARMA model become non-linear equations which are described below.

Let (5) be

$$\tilde{x}_t = x_t + \sum_{i=1}^p a_i x_{t-i} \quad (9)$$

$$\tilde{x}_t = e_t + \sum_{j=1}^q b_j e_{t-j} \quad (10)$$

We express the autocorrelation function of \tilde{x}_t as \tilde{r}_k and from (9), (10), we get the following non-linear equations which are well known.

$$\left. \begin{aligned} \tilde{r}_k &= \begin{cases} \sigma_e^2 \sum_{j=0}^{q-k} b_j b_{k+j} & (k \leq q) \\ 0 & (k \geq q+1) \end{cases} \\ \tilde{r}_0 &= \sigma_e^2 \sum_{j=0}^q b_j^2 \end{aligned} \right\} \quad (11)$$

For these equations, recursive algorithm has been developed. In this paper, parameter to be estimated is only b_1 , so it can be solved in the following way.

From (4) (5) (8) (11), we get

$$\left. \begin{aligned} q &= 1 \\ a_1 &= -1 \\ b_1 &= -\beta = \alpha - 1 \\ \tilde{r}_0 &= (1 + b_1^2) \sigma_e^2 \\ \tilde{r}_1 &= b_1 \sigma_e^2 \end{aligned} \right\} \quad (12)$$

If we set

$$\rho_k = \frac{\tilde{r}_k}{\tilde{r}_0} \quad (13)$$

the following equation is derived.

$$\rho_1 = \frac{b_1}{1 + b_1^2} \quad (14)$$

We can get b_1 as follows.



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$$b_1 = \frac{1 \pm \sqrt{1 - 4\rho_1^2}}{2\rho_1} \quad (15)$$

In order to have real roots, ρ_1 must satisfy

$$|\rho_1| \leq \frac{1}{2} \quad (16)$$

From invertibility condition, b_1 must satisfy

$$|b_1| < 1$$

From (14), using the next relation,

$$(1 - b_1)^2 \geq 0$$

$$(1 + b_1)^2 \geq 0$$

(16) Always holds.

As

$$\alpha = b_1 + 1$$

b_1 is within the range of

$$-1 < b_1 < 0$$

Finally we get

$$\left. \begin{aligned} b_1 &= \frac{1 - \sqrt{1 - 4\rho_1^2}}{2\rho_1} \\ \alpha &= \frac{1 + 2\rho_1 - \sqrt{1 - 4\rho_1^2}}{2\rho_1} \end{aligned} \right\} \quad (17)$$

which satisfies above condition. Thus we can obtain a theoretical solution by a simple way. Focusing on the idea that the equation of ESM is equivalent to (1, 1) order ARMA model equation, we can estimate smoothing constant after estimating ARMA model parameter. It can be estimated only by calculating 0th and 1st order autocorrelation function.

III. TREND REMOVAL METHOD

As trend removal method, we describe the combination of linear and non-linear function.

[1] Linear function

We set

$$y = a_1x + b_1 \quad (18)$$

as a linear function.

[2] Non-linear function

We set

$$y = a_2x^2 + b_2x + c_2 \quad (19)$$

$$y = a_3x^3 + b_3x^2 + c_3x + d_3 \quad (20)$$

as a 2nd and a 3rd order non-linear function. (a_2, b_2, c_2) and (a_3, b_3, c_3, d_3) are also parameters for a 2nd



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and a 3rd order non-linear functions which are estimated by using least square method.

[3] The combination of linear and non-linear function.

We set

$$y = \alpha_1(a_1x + b_1) + \alpha_2(a_2x^2 + b_2x + c_2) + \alpha_3(a_3x^3 + b_3x^2 + c_3x + d_3) \quad (21)$$

$$0 \leq \alpha_1 \leq 1, 0 \leq \alpha_2 \leq 1, 0 \leq \alpha_3 \leq 1, \alpha_1 + \alpha_2 + \alpha_3 = 1 \quad (22)$$

as the combination linear and 2nd order non-linear and 3rd order non-linear function. Trend is removed by dividing the original data by (21). The optimal weighting parameter $\alpha_1, \alpha_2, \alpha_3$, are determined by utilizing GA. GA method is precisely described in section 6.

IV. MONTHLY RATIO

For example, if there is the monthly data of L years as stated bellow:

$$\{x_{ij}\} (i = 1, \dots, L) (j = 1, \dots, 12)$$

Where, $x_{ij} \in R$ in which j means month and i means year and x_{ij} is a shipping data of i -th year, j -th month. Then, monthly ratio $\tilde{x}_j (j = 1, \dots, 12)$ is calculated as follows.

$$\tilde{x}_j = \frac{\frac{1}{L} \sum_{i=1}^L x_{ij}}{\frac{1}{L} \cdot \frac{1}{12} \sum_{i=1}^L \sum_{j=1}^{12} x_{ij}} \quad (23)$$

Monthly trend is removed by dividing the data by (23). Numerical examples both of monthly trend removal case and non-removal case are discussed in 7.

V. FORECASTING ACCURACY

Forecasting accuracy is measured by calculating the variance of the forecasting error. Variance of forecasting error is calculated by:

$$\sigma_\varepsilon^2 = \frac{1}{N-1} \sum_{i=1}^N (\varepsilon_i - \bar{\varepsilon})^2 \quad (24)$$

Where, forecasting error is expressed as:

$$\varepsilon_i = \hat{x}_i - x_i \quad (25)$$

$$\bar{\varepsilon} = \frac{1}{N} \sum_{i=1}^N \varepsilon_i \quad (26)$$

VI. SEARCHING OPTIMAL WEIGHTS UTILIZING GA

A. Definition of the problem

We search $\alpha_1, \alpha_2, \alpha_3$ of (21) which minimizes (24) by utilizing GA. By (22), we only have to determine α_1 and α_2 . σ_ε^2 ((24)) is a function of α_1 and α_2 , therefore we express them as $\sigma_\varepsilon^2(\alpha_1, \alpha_2)$. Now, we pursue the following:

$$\text{Minimize: } \sigma_\varepsilon^2(\alpha_1, \alpha_2) \quad (27)$$

$$\text{subject to: } 0 \leq \alpha_1 \leq 1, 0 \leq \alpha_2 \leq 1, \alpha_1 + \alpha_2 \leq 1$$



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We do not necessarily have to utilize GA for this problem which has small member of variables. Considering the possibility that variables increase when we use logistics curve etc in the near future, we want to ascertain the effectiveness of GA.

B.The structure of the gene

Gene is expressed by the binary system using {0,1} bit. Domain of variable is [0,1] from (22). We suppose that variables take down to the second decimal place. As the length of domain of variable is 1-0=1, seven bits are required to express variables. The binary bit strings <bit6, ~, bit0> is decoded to the [0,1] domain real number by the following procedure.^[14]

Procedure 1: Convert the binary number to the binary-coded decimal.

$$\begin{aligned} & \left((bit_6, bit_5, bit_4, bit_3, bit_2, bit_1, bit_0) \right)_2 \\ &= \left(\sum_{i=0}^6 bit_i 2^i \right)_{10} \\ &= X' \end{aligned} \tag{28}$$

Procedure 2: Convert the binary-coded decimal to the real number.

The real number
 $= (\text{Left hand starting point of the domain}) + X' ((\text{Right hand ending point of the domain}) / (2^7 - 1))$ (29)

The decimal number, the binary number and the corresponding real number in the case of 7 bits are expressed in Table 6-1.

Table 6-1: Corresponding table of the decimal number, the binary number and the real number

The decimal number	The binary number							The Corresponding real number
	Position of the bit							
	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	0.00
1	0	0	0	0	0	0	1	0.01
2	0	0	0	0	0	1	0	0.02
3	0	0	0	0	0	1	1	0.02
4	0	0	0	0	1	0	0	0.03
5	0	0	0	0	1	0	1	0.04
6	0	0	0	0	1	1	0	0.05
7	0	0	0	0	1	1	1	0.06
8	0	0	0	1	0	0	0	0.06
...								...
126	1	1	1	1	1	1	0	0.99
127	1	1	1	1	1	1	1	1.00

1 variable is expressed by 7 bits, therefore 2 variables needs 14 bits. The gene structure is exhibited in Table 6-2.



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Table 6-2: The gene structure

α_1							α_2						
Position of the bit													
13	12	11	10	9	8	7	6	5	4	3	2	1	0
0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1

C. The flow of Algorithm

The flow of algorithm is exhibited in Figure 6-1.

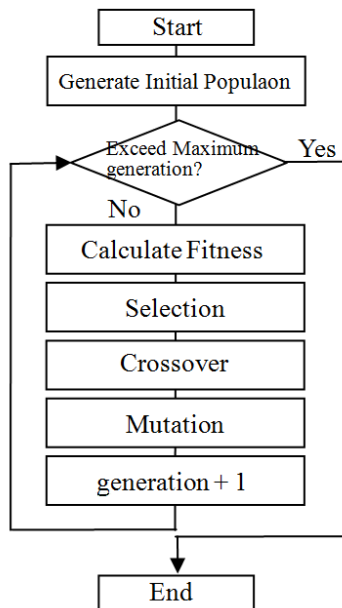


Fig-1: The flow of algorithm

A. Initial Population

Generate M initial population. Here, $M = 100$. Generate each individual so as to satisfy (22).

B. Calculation of Fitness

First of all, calculate forecasting value. There are 36 monthly data for each case. We use 24 data (1st to 24th) and remove trend by the method stated in section 3. Then we calculate monthly ratio by the method stated in section 4. After removing monthly trend, the method stated in section 2 is applied and Exponential Smoothing Constant with minimum variance of forecasting error is estimated. Then 1 step forecast is executed. Thus, data is shifted to 2nd to 25th and the forecast for 26th data is executed consecutively, which finally reaches forecast of 36th data. To examine the accuracy of forecasting, variance of forecasting error is calculated for the data of 25th to 36th data. Final forecasting data is obtained by multiplying monthly ratio and trend. Variance of forecasting error is calculated by (24). Calculation of fitness is exhibited in Figure 2.



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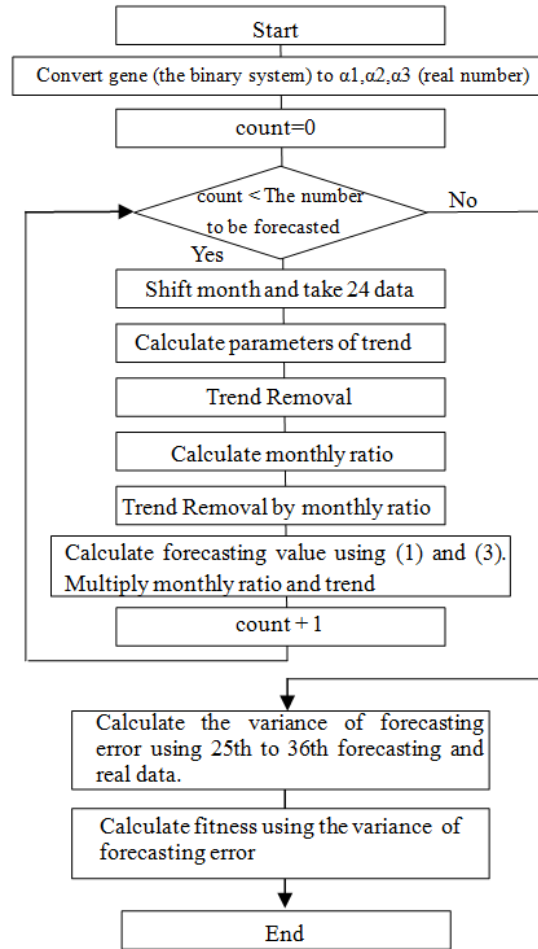


Fig 2: The flow of calculation of fitness

Scaling^[15] is executed such that fitness becomes large when the variance of forecasting error becomes small. Fitness is defined as follows.

$$f(\alpha_1, \alpha_2) = U - \sigma_\varepsilon^2(\alpha_1, \alpha_2) \quad (30)$$

Where U is the maximum of $\sigma_\varepsilon^2(\alpha_1, \alpha_2)$ during the past w Generation. Here, w is set to be 5.

C. Selection

Selection is executed by the combination of the general elitist selection and the tournament selection. Elitism is executed until the number of new elites reaches the predetermined number. After that, tournament selection is executed and selected.

D. Crossover

Crossover is executed by the uniform crossover. Crossover rate is set as follows.

$$P_c = 0.7 \quad (31)$$

E. Mutation

Mutation rate is set as follows.

$$P_m = 0.05 \quad (32)$$



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Mutation is executed to each bit at the probability P_m , therefore all mutated bits in the population M becomes $P_m \times M \times 14$.

VII. NUMERICAL EXAMPLE

A. Application to the manufacturer's data of sanitary materials

Manufacturer's data of sanitary materials from September 2009 to August 2012 are analyzed. Furthermore, GA results are compared with the calculation results of all considerable cases in order to confirm the effectiveness of GA approach. First of all, graphical charts of these time series data are exhibited in Figure 3-5.

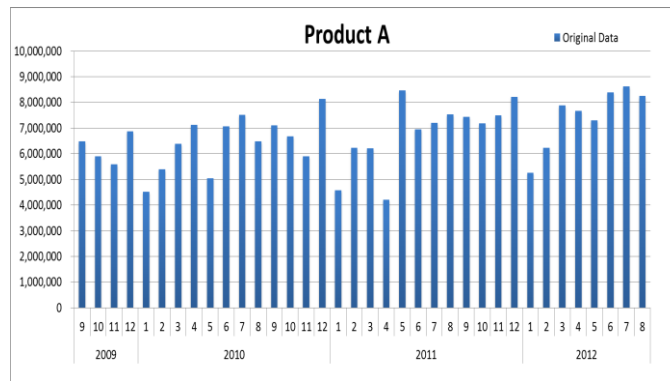


Fig 3: Product A

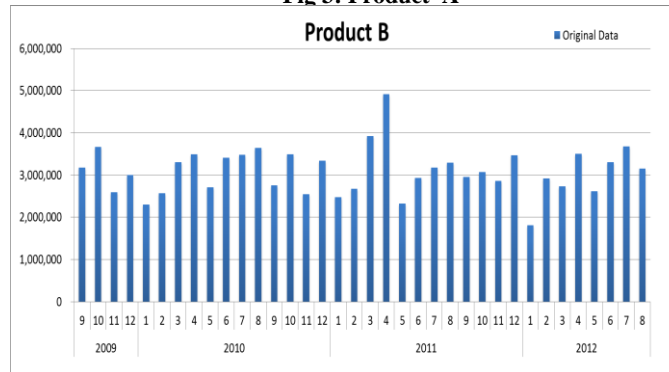


Fig 4: Product B

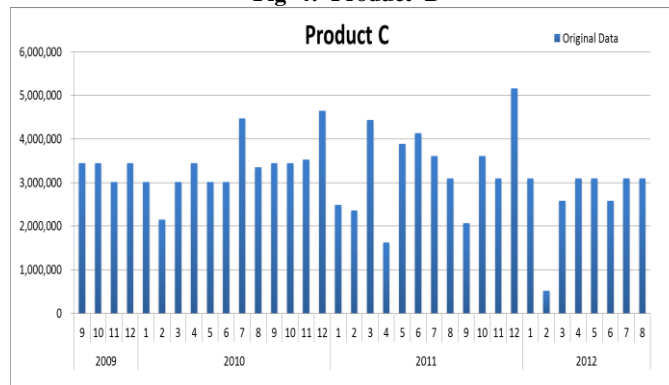


Fig 5: Product C

B. Execution Results

GA execution condition is exhibited in Table 7-1.



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Table7-1: GA Execution Condition

GA Execution Condition	
Population	100
Maximum Generation	50
Crossover rate	0.7
Mutation ratio	0.05
Scaling window size	5
The number of elites to retain	2
Tournament size	2

We made 10 times repetition and the maximum; average, minimum of the variance of forecasting error and the average of convergence generation are exhibited in Table 7-2 and 7-3.

Table7-2: GA execution results (Monthly ratio is not used)

	The variance of forecasting error			Average of convergence generation
	Minimum	Maximum	Average	
Product A	1,228,777,654,816	1,544,340,093,206	1,258,711,086,945	18.0
Product B	530,006,241,123	592,188,429,652	535,855,279,545	14.0
Product C	2,075,183,264,171	2,452,659,744,554	2,108,449,357,497	12.0

Table7-3: GA execution results (Monthly ratio is used)

	The variance of forecasting error			Average of convergence generation
	Minimum	Maximum	Average	
Product A	828,013,457,221	1,365,117,049,702	877,315,666,438	12.5
Product B	260,551,407,491	313,041,456,849	270,401,037,370	16.0
Product C	1,144,918,216,365	1,476,595,861,649	1,174,359,823,002	6.0

In all cases, the variance of forecasting error for the case monthly ratio is used is smaller than the case monthly ratio is not used. The minimum variance of forecasting error of GA coincides with those of the calculation of all considerable cases and it shows the theoretical solution. Although it is a rather simple problem for GA, we can confirm the effectiveness of GA approach. Further study for complex problems should be examined hereafter.

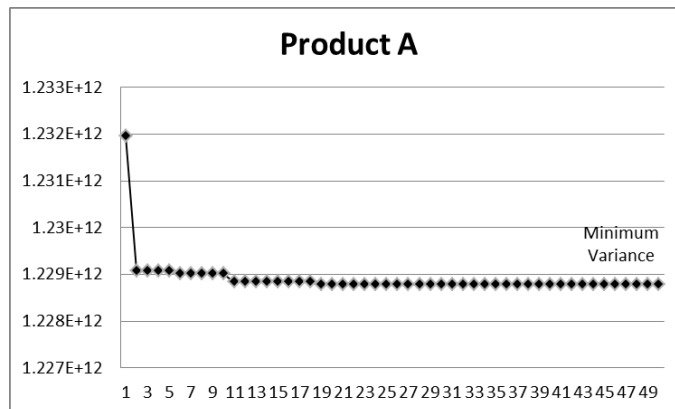


Fig 6: Product A (Monthly ratio is not used)



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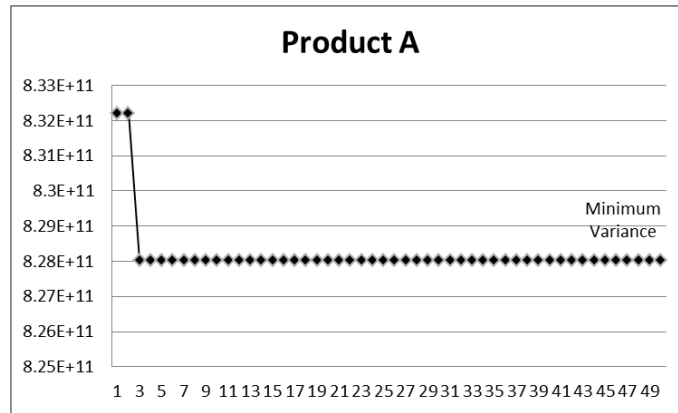


Fig 7: Product A (Monthly ratio is used)

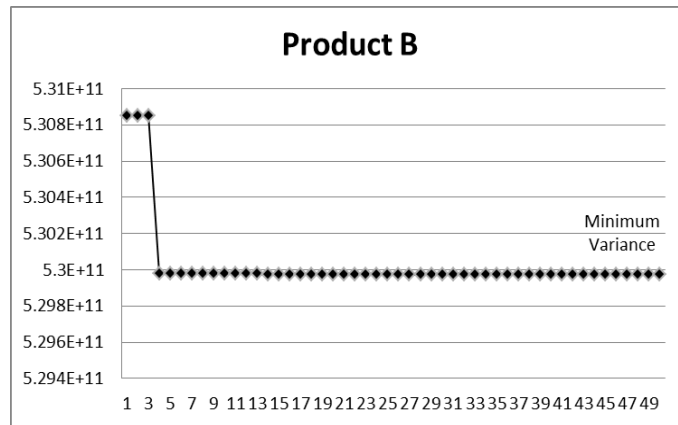


Fig 8: Product B (Monthly ratio is not used)

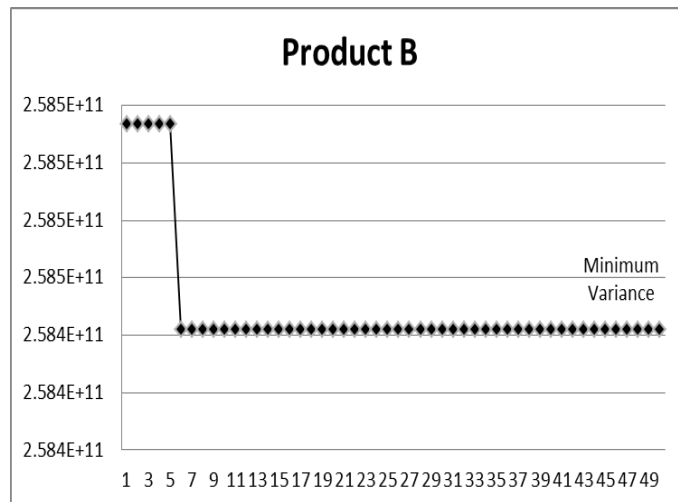


Fig-9: Product B (Monthly ratio is used)



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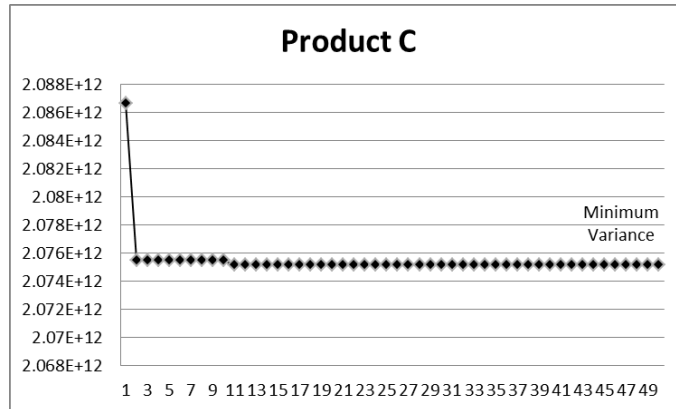


Fig 10: Product C (Monthly ratio is not used)

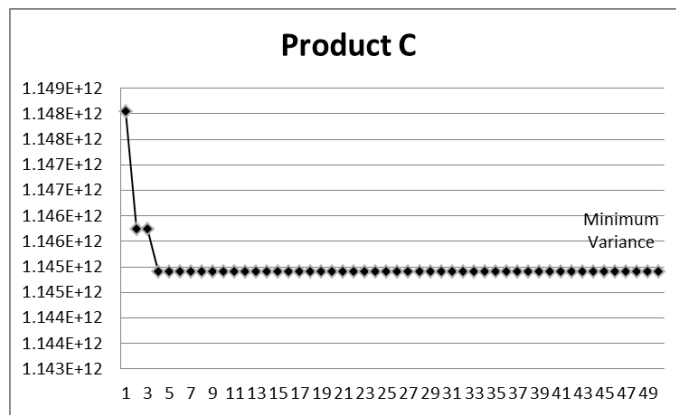


Fig 11: Product C (Monthly ratio is used)

Next, optimal weights and their genes are exhibited in Table 7-4, 7-5.

Table7-4: Optimal weights and their genes (Monthly ratio is not used)

Data	α_1	α_2	α_3	position of the bit													
				13	12	11	10	9	8	7	6	5	4	3	2	1	0
Product A	0	1.00	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Product B	0.38	0.62	0	0	1	1	0	0	0	0	1	0	0	1	1	1	1
Product C	1.00	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Table7-5: Optimal weights and their genes (Monthly ratio is used)

Data	α_1	α_2	α_3	position of the bit													
				13	12	11	10	9	8	7	6	5	4	3	2	1	0
Product A	0	1.00	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Product B	0.06	0.94	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0
Product C	0.50	0.50	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1



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In the case monthly ratio is used, the 1st+2nd order function model is best in Product B and Product C, while the linear function model is best in Product A. Parameter estimation results for the trend of equation (21) using least square method are exhibited in Table 7-6 for the case of 1st to 24th data.

Table7-6: Parameter estimation results for the trend of equation (21)

Data	a_1	b_1	a_2	b_2	c_2	a_3	b_3	c_3	d_3
Product A	43209.10957	5856643.297	1333.16432	9880.001554	6001069.432	567.0224981	-19930.17936	226879.5116	5503507.19
Product B	12078.85565	2983007.054	50.89560657	10806.646549	2988520.745	-249.7081938	9414.952874	-84756.86028	3207639.685
Product C	12459.34348	3155302.373	-397.7965947	22404.25835	3112207.742	-256.3640436	9215.855041	-75706.26115	3337167.19

Trend curves are exhibited in Figure 12-14.

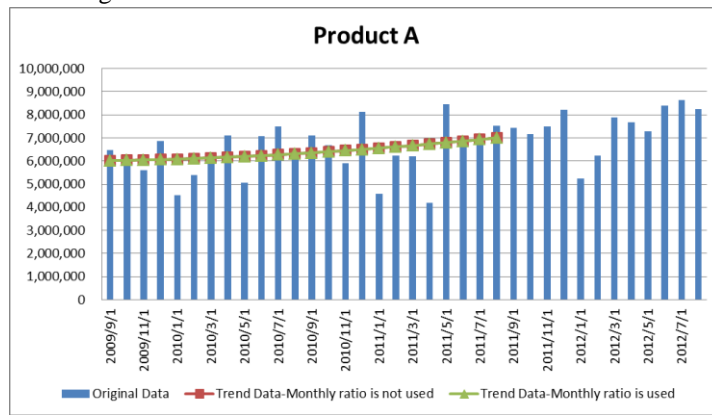


Fig 12: Trend of Product A

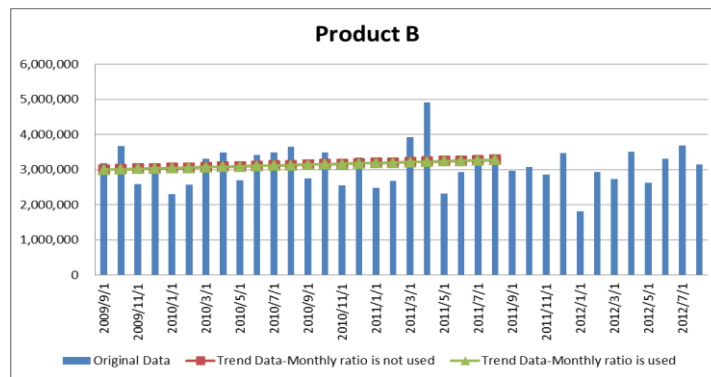


Fig 13: Trend of Product B

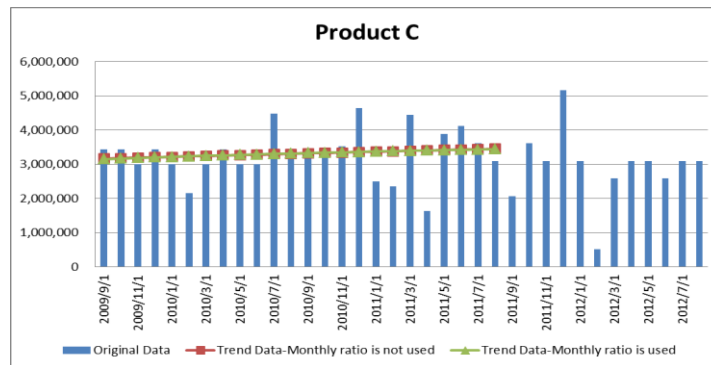


Fig 14: Trend of Product C



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Calculation results of Monthly ratio for 1st to 24th data are exhibited in Table 7-7.

Table 7-7: Parameter Estimation result of Monthly ratio

Date.	1	2	3	4	5	6	7	8	9	10	11	12
Product A	1.098	1.012	0.920	1.192	0.721	0.912	0.985	0.889	1.030	1.073	1.118	1.052
Product B	0.970	1.162	0.832	1.021	0.767	0.839	1.151	1.329	0.796	1.001	1.046	1.086
Product C	1.063	1.058	0.999	1.228	0.838	0.681	1.118	0.766	1.029	1.061	1.204	0.955

Estimation result of the smoothing constant of minimum variance for the 1st to 24th data are exhibited in Table 7-8, 7-9.

Table 7-8: Smoothing constant of Minimum Variance of equation (17) (Monthly ratio is not used)

Date	ρ_1	α
Product A	-0.264784	0.713479
Product B	-0.066020	0.933690
Product C	-0.265585	0.712456

Table 7-9: Smoothing constant of Minimum Variance of equation (17) (Monthly ratio is used)

Date,	ρ_1	α
Product A	-0.397581	0.505003
Product B	-0.224571	0.762793
Product C	-0.423242	0.447613

Forecasting results are exhibited in Figure 7-21 - 7-25.

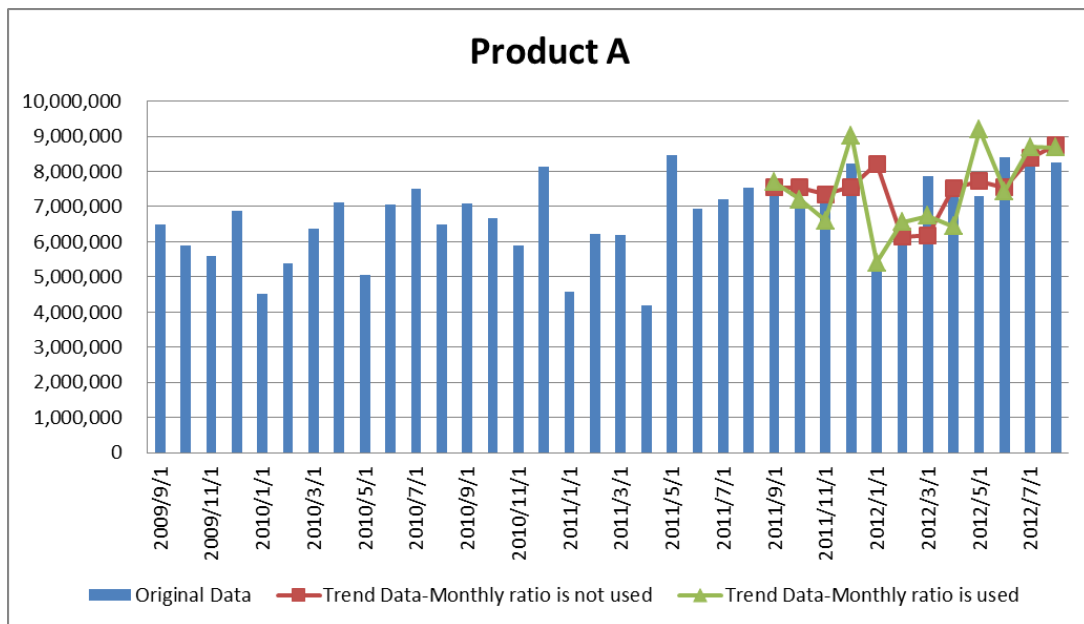


Fig 15: Forecasting Result of Product A



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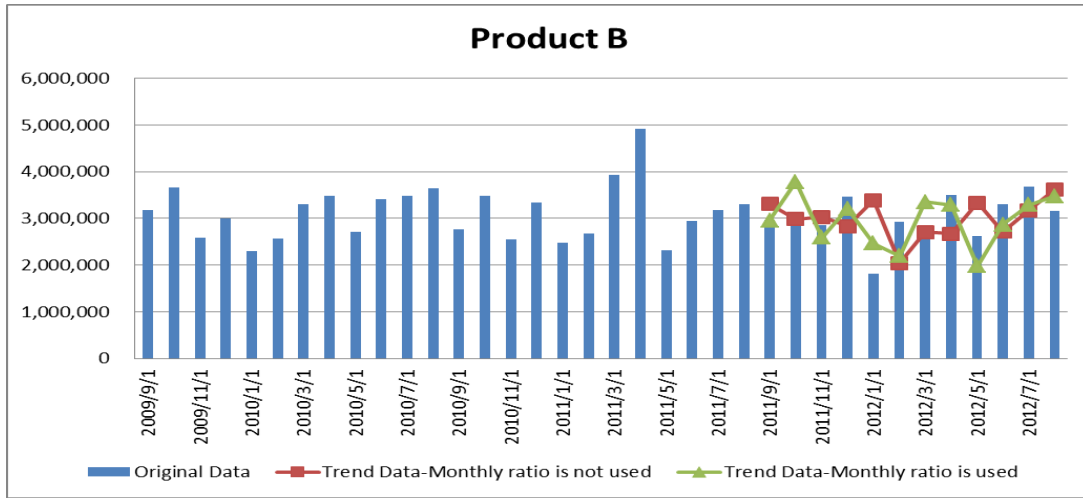


Fig 16: Forecasting Result of Product B

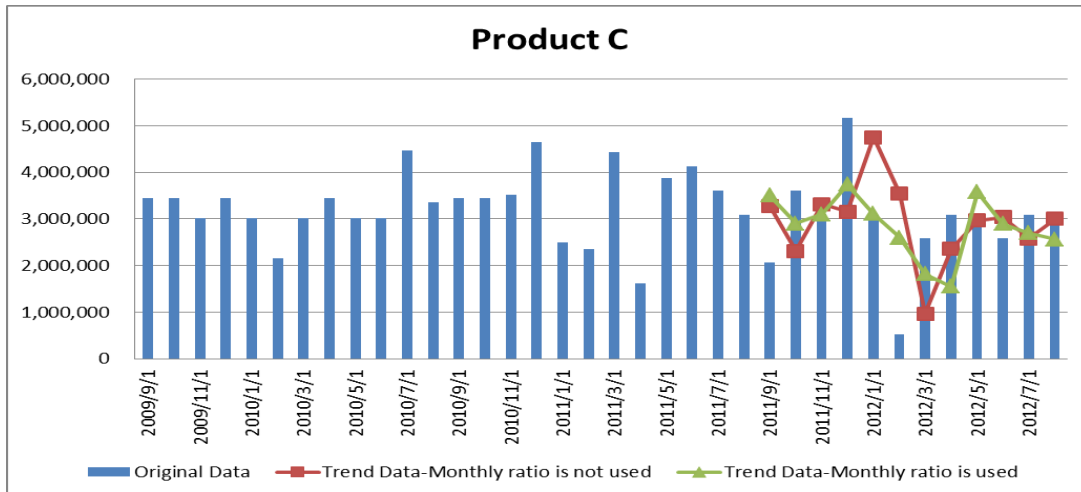


Fig 17: Forecasting Result of Product C

C. Remarks

In all cases, the variance of forecasting error for the case monthly ratio is used is smaller than the case monthly ratio is not used. In the case monthly ratio is used, the 1st+2nd order function model is best in Product B and Product C, while the linear function model is best in Product A. The minimum variance of forecasting error of GA coincides with those of the calculation of all considerable cases and it shows the theoretical solution. Although it is a rather simple problem for GA, we can confirm the effectiveness of GA approach. Further study for complex problems should be examined hereafter.

VIII.CONCLUSION

Correct Forecasting is inevitable in Supply Chain Management. Focusing on the idea that the equation of exponential smoothing method(ESM) was equivalent to (1,1) order ARMA model equation, a new method of estimation of smoothing constant in exponential smoothing method was proposed before by us which satisfied minimum variance of forecasting error. Generally, smoothing constant was selected arbitrary. But in this paper, we utilized above stated theoretical solution. Firstly, we made estimation of ARMA model parameter and then estimated smoothing constants. Thus theoretical solution was derived in a simple way and it might be utilized in various fields.

Furthermore, combining the trend removal method with this method, we aimed to improve forecasting accuracy.



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An approach to this method was executed in the following method. Trend removal by a linear function was applied to the manufacturer's data of sanitary materials. The combination of linear and non-linear function was also introduced in trend removal. Genetic Algorithm was utilized to search the optimal weight for the weighting parameters of linear and non-linear function. For the comparison, monthly trend was removed after that. Theoretical solution of smoothing constant of ESM was calculated for both of the monthly trend removing data and the non monthly trend removing data. Then forecasting was executed on these data. In all cases, the variance of forecasting error for the case monthly ratio is used is smaller than the case monthly ratio is not used. In the case monthly ratio is used, the 1st+2nd order function model is best in Product B and Product C, while the linear function model is best in Product A. The new method shows that it is useful for the time series that has various trend characteristics. It is our future works to ascertain our newly proposed method in many other cases. The effectiveness of this method should be examined in various cases.

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