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Profitability estimation of a Company in PT.ABCD using extended kalman filter

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Abstract. Profitability ratios are the ability or results achieved by a company in its sales of goods or services it produces in a certain period. Profitability ratios are required to record financial transactions usually assessed by investors and creditors (banks) to assess the amount of investment profits to be obtained by investors and the amount of corporate profits to assess the company's ability to pay debts to creditors based on the use level of assets and other resources so that the company efficiency can be seen. Profitability is an important factor in the company, so in this study estimation of company profitability is made. Profitability estimation in this paper used the Extended Kalman Filter (EKF) and Kalman Filter (KF)methods to obtain the accuracy of the estimation. Based on the analysis of the simulation results, the EKF and KF methods can be effectively implemented to estimate the profitability of a company so as to make the right policy in determining the amount of investment and company profits. Based on the results of the analysis on the simulation with 300, 400 and 500 iterations, it has an error of less than 2%.

1. Introduction

Gross profit margin is the profitability ratio to assess the percentage of gross profit from the revenue generated from sales. Gross profit which is affected by the cash flow statement describes the amount of profit gained by the company by considering the production costs of products or services.

Profitability can be interpreted as the results obtained by management effort on the funds invested by the company's owner. The objectives of profitability estimation for the company or outside parties are 1) to calculate or measure profits the company makes for a certain period, 2) to ssess the company's profit position of the previous year and that of the current year, 3) To assess the profit growth from time to time. Meanwhile, from the perspective of the benefits of perobalibility, it has several benefit, that is, 1) knowing the company's profit position of the previous year compared to that of the current, 2) knowing profit growth from time to time, 3) informing the company's net profit after tax deduction.

Considering the importance of the objectives and benefits of the profitability of a company, then we required a software for estimating profits of the company [1]. Several studies regarding estimations have been conducted. Several researches on estimation were conducted in several scientific fields, including estimation of blood stock [2], estimation of stock prices and oilprice [3,4], estimation of steam drum temperature [5], estimation of AUV and ASV trajectory [6,7,8], and estimation of missile trajectories [8]. The contribution of this paper was to compare the result of the company's profitability estimation by the EKF method and that by KF method, to conclude which method was the best for estimating the company's profitability.

2. Methods

The algorithm of *Kalman Filter* (KF) can be seen [1]:

1. Model system and measurement model.

$$x_{k+1} = A_k x_k + B_k u_k + G_k w_k \tag{1}$$

$$z_k = H_k x_k + v_k \tag{2}$$

$$x_0 \sim N(\bar{x}_0, P_{x_0});\ w_k \sim N(0, Q_k);\ v_k \sim N(0, R_k) \tag{3}$$

2. Initialization

$$\hat{x}_0 = \bar{x}_0 \tag{4}$$

$$p_0 = p_{x_0} \tag{5}$$

3. Time Update

Estimation : $\hat{x}_{k+1}^{-} = A_k \hat{x} + B_k u_k$ (6)

Error *covariance*: $P_k^{-} = A_k P_k A_k^T + G_k Q_k G_k^T$ (7)

4. Measurement Update

Kalman gain : $K_{k+1} = P_{k+1}^T H_{k+1}^T \left(H_{k+1} P_{k+1}^{-} H_{k+1}^T + R_{k+1}\right)^{-1}$ (8)

Estimation : $\hat{x}_{k+1} = \hat{x}_{k+1}^{-} + K_{k+1}\left(z_{k+1} - H_{k+1}\hat{x}_{k+1}^{-}\right)$ (9)

Error covariance $P_{k+1} = \left[I - K_{k+1} H_{k+1}\right] P_{k+1}^{-}$ (10)

And the Extended Kalman Filter (EKF) algorithm can be seen [10]:
Model system and measurement model

$$x_k = f(x_{k-1}, u_{k-1}, w_{k-1}) \tag{11}$$

$$z_k = h(x_k, v_k) \tag{12}$$

$$x_0 \sim N(\bar{x}_0, P_{x_0}),\ w_k \sim N(0, Q_k),\ v_k \sim N(0, R_k) \tag{13}$$

1. Initialization
   $\hat{x}_0 = \bar{x}_0$
   $P_0 = P_{x_0}$
2. Time Update
   Estimation: $\hat{x}_k = f(\hat{x}_{k-1}, u_{k-1}, 0)$ (14)
   Error covariance:$P_k^{-} = A_k P_{k-1} A_k^T + W_k Q_{k-1} W_k^T$
3. Measurement Update
   Kalman Gain:$K_k = P_k^{-} H_k^T [H_k P_k^{-} H_k^T + V_k R_k V_k^T]^{-1}$

Estimation :$\hat{x}_k = \hat{x}_k^{-} + K_k\left(z_k - h(\hat{x}_k^{-}, 0)\right)$

Error covariance: $P_k = (I = K_k H_k) P_k^{-}$

3. Simulation Result

In this paper the probability estimation was made by applying the Extended Kalman Filter (EKF) and Kalman Filter (KF) method with 300, 400 and 500 iterations. The simulation used the initial value of the profitability. Profit data of PT. The ABCDs as shown in Table 1 are interpolated by Mathematica software resulting in a profit function in equation (15).

The estimation of profitability was made by applying the Extended Kalman Filter (EKF) and Kalman Filter (KF) method with 300, 400 and 500 iterations. This simulation used $\Delta t = 0{,}1$ and the initial value of the profit of company. The profit data at PT. The ABCDs in Table 1 are interpolated with Mathematica software so that it produces a profit function in equation (15).

Table 1. PT.ABCD's (in million) Profit Data

Month	Company profit
Jan-2016	311
Feb-2016	275
Mar-2016	281
Apr-2016	286
May-2016	289
Jun-2016	264
Jul-2016	312
Aug-2016	293
Sep-2016	298
Oct-2016	279
Nov-2016	325
Dec-2016	297
Jan-2017	319
Feb-2017	304
Mar-2017	377
Apr-2017	285
May-2017	289
Jun-2017	286
Jul-2017	332
Aug-2017	288
Sep-2017	322
Oct-2017	331
Nov-2017	323
Dec-2017	329

Then, the data are interpolated using Mathematica software, so as to obtain the company's profit function as follows:

$$f(x) = 124{,}6x^2 - 379{,}53x + 7235{,}33$$
$$f'(x) = 249{,}2x - 379{,}53 \quad (15)$$

Figures 1, 2 and 3 indicate that the estimation results have a fairly small error, by the application of either the KF method or the EKF method. The estimated profitability by EKF had an accuracy of around 97%, whereas that by KF had an accuracy of 93%. In term of iteration comparison, the estimation using 500 iterations had higher accuracy than those using 300 and 400 iterations as seen in table 2. But the weakness of the estimation with 500 iterations in term of the simulation time took longer longer time compared to those using 300 and 400 iterations. The error of EKF obtained is 0.1552 in the simulation with 500 iterations. Whereas with 400 iterations it produces an error of 0.1743, and the error obtained in the that with 300 iterations is 0.1987 as shown in Table 2. Further, the comparison of the estimation results with 300, 400 and 500 iterations, Table 2 shows that the simulation with 500 iterations has a higher accuracy than those with 300 and 400 iterations. In general, conclusion can be drawn that the EKF and KF methods can be effectively inplemented to estimate the company's profitability.

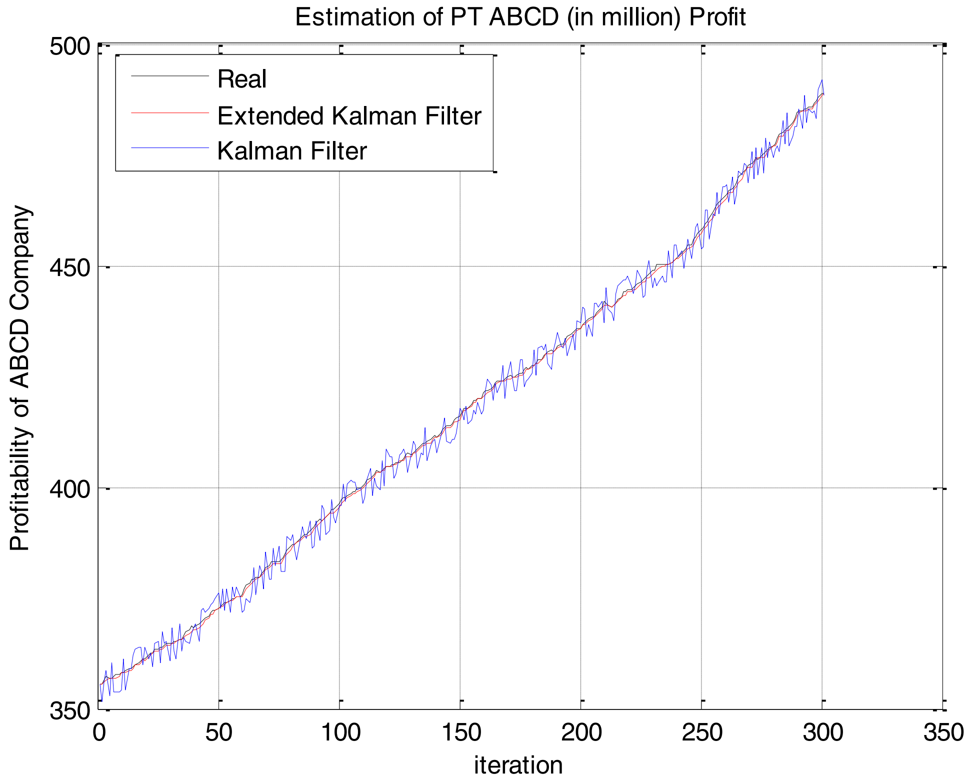

Figure 1.Estimation of PT. ABCD Profit with 300 iterations

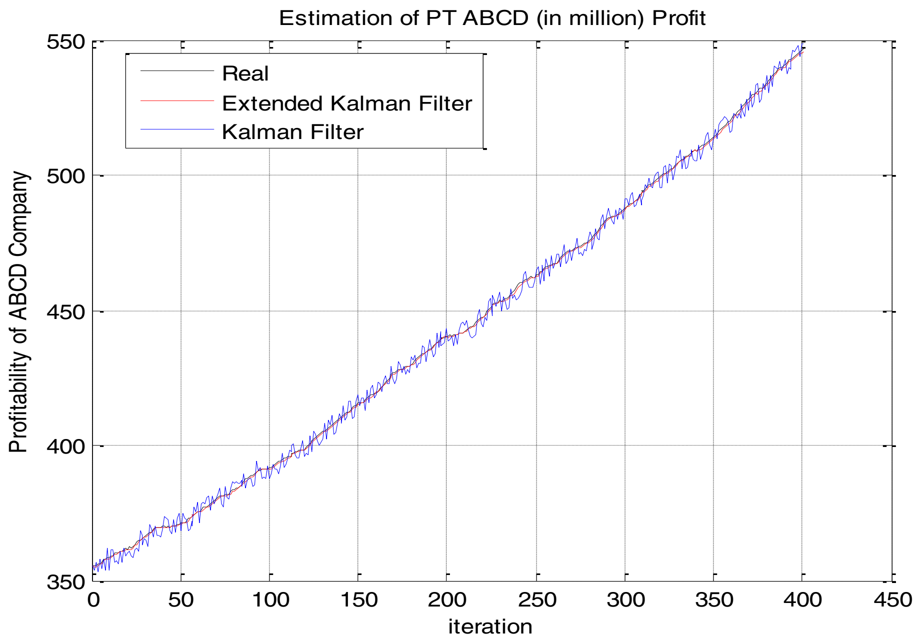

Figure 2. Estimation of PT. ABCDProfit with 400 iterations

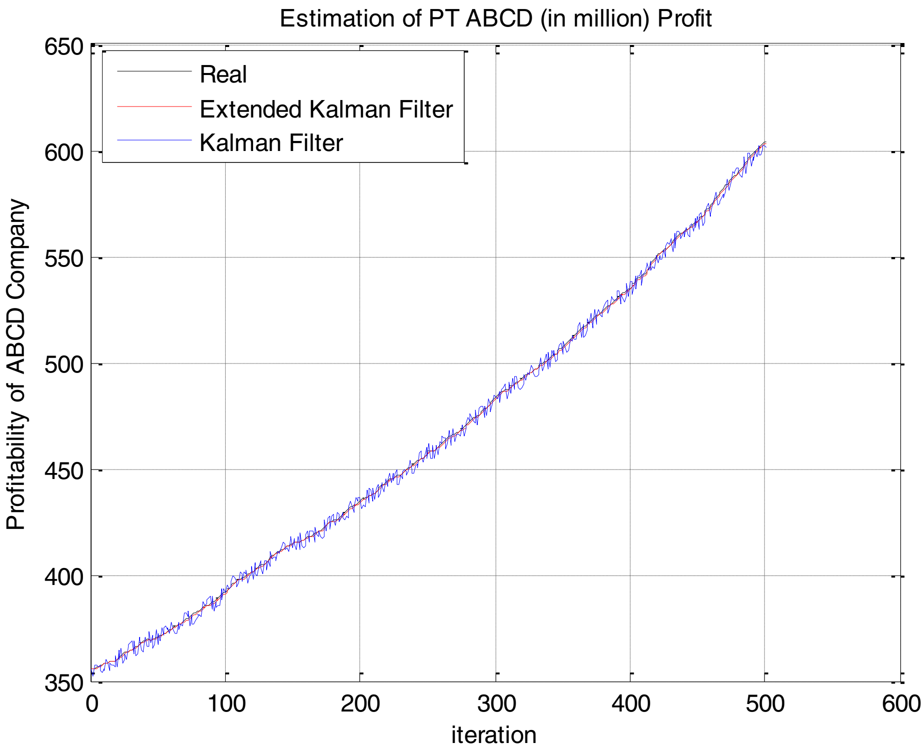

Figure 3. Estimation of PT. ABCD Profit with 500 iterations

The comparison of the estimation results with 300, 400 and 500 iterations as follow in Table 2:

Table 2. Comparison of RMSE values using EKF and KF Methodsby 300, 400 dan 500 iterations

	300 iterations		**400 iterations**		**500 iterations**	
	EKF	**KF**	**EKF**	**KF**	**EKF**	**KF**
Company profit	0.1987	0.28563	0.1743	0.2759	0.1552	0.2544
Simulation time	4.5312 s	6.2189 s	8.3557 s	10.347 s	11.721 s	13.5521 s

Further, the comparison of the estimation results having 300, 400 and 500 iterations as seen in Table 2 shows that using 500 iterations had the highest accuracy to estimate the profit of a company. In terms of simulation time, by using 300 iterations it was faster time than it was by using 400 and 500 iterations because the number of iterations greatly affects computation time. From the results of the analysis, the simulations having 300, 400 and 500 iterations had an error of less than 3%, so the EKF and KF methods could be implented as one method of estimating company profits.

4. Conclusion

Based on the results of the simulation analysis, in general the EKF and KF methods could be effectrively applied as an estimation method of profitability with quite high accuracy. It suggested that the EKF had much higher accuracy than the KF either with 300, 400 l, or 500 iterations.. It could be concluded that the EKF and KF methods could be used to estimate profit of company with high accuracy. The EKF method had an error of less than 2%, and The KF had less than 7%. In general, conclusion can be drawn that the EKF and KF methods can be effectively inplemented to estimate the company's profitability.

Open problem. How to implemented Particle Filter for estimation of profitability.

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