Profitability estimation of XYZ company using H-infinity and Ensemble Kalman Filter

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Abstract. One strategy for a company to develop and grow bigger and stronger in competition is by business expansion. According to Moin (2010:2), there are two strategic ways to maintain and expand a business, that is, an internal expansion strategy by building a new business or business unit from scratch and an external expansion strategy in the form of a business merger by buying an existing company through a merger, acquisitions and consolidations which are fast-track to new markets. Profitability is a factor that gets important attention because it can attract investors to make investment in the company. Profit is the gab beetwen revenue and expenses in a certain period in a company.It has very important role for either internal or external of the company. One way to reduce the risk of company losses is by using an estimation method to find out the company's estimated profit for the next month or next year. In this study the estimation method for travel company was used, that is, by using the Ensemble Kalman Filter (EnKF) and H-infinity, as a policy making chart in order to maintain and increase company profits. Based on the analysis of results computation with 100, 200 and 300 iterations, it showed an error of less than 3%.

1. Introduction

During Volatility Uncertainty Complexity Ambiguity (VUCA) era, running business has become more challenges due to external situation that cannot be predicted such as Covid-19. Whatever the situation business must go on with science data decision making tools to maximize revenue or minimize cost. Moreover, the development of technology potentially increases number of competitors. More competitors means more potential reducing company profit due to less revenue. In other side a company should increase its revenue as the balance of increasement expenses that always increase every year. The gap between revenue and expeses is profit. To develop or expand the business, a company should maintain or increase its profit performance. It is very important not only for internal purpose (company performance) but also for external purpose (bank, tax, etc.). Accuracy in profit estimationis very important to make business decision in the future. It is also affects the trust of the business partner in business collaboration when we can provide trustable figures. That is why there is a need calculation model is required to estimate profitability of the company for the right direction in business decision making.

Profitability ratio is the results achieved by the company in its products or services sales. Estimation methods usedwere the H-Infinity method and the Ensemble Kalman Filter (EnKF) by applying the principle of continuous prediction and correction. Estimation is required because a problem can sometimes be solved using previous data related to the problem [1]. The methods used for estimation were H-Infinity and Ensemble Kalman Filter (EnKF). Several studies have developed

the Kalman Filter development method for stock estimation [2,3,9], world oil price [4,5,6] or company profit [7,8].

The aim of this paper is to estimate the function of profit]obtained from the Mathematica simulation software simulated with the Matlab software. In this study, the H-Infinity and Ensemble Kalman Filter (EnKF) methods were implemented and compared in estimating profit, which can be taken into consideration in making planning guidelines in efforts to achieve the company's objectives effectively and efficiently.

2. Method

The algorithm of Ensemble Kalman Filter (EnKF) can be as below [1]:

Model system and measurement model

$$x_{k+1} = f(x_k, u_k) + w_k \quad (1)$$

$$z_k = Hx_k + v_k \quad (2)$$

$$w_k \sim N(0, Q_k),\ v_k \sim N(0, R_k) \quad (3)$$

1. Initialitation

Generate N *ensemble* as the first guess $\bar{x}_0$

$$x_{0,i} = [x_{0,1} \quad x_{0,2} \quad \dots \quad x_{0,N}] \quad (4)$$

The first value: $\hat{x}_0 = \frac{1}{N}\sum_{i=1}^{N} x_{0,i}$ (5)

2. Time Update

$$\hat{x}_{k,i}^{-} = f\left(\hat{x}_{k,-1,i}, u_{k-1,i}\right) + w_{k,i} \quad (6)$$

where $w_{k,i} = N(0, Q_k)$

Estimation : $\hat{x}_k^{-} = \frac{1}{N}\sum_{i=1}^{N} \hat{x}_{k,i}^{-}$ (7)

Error *covariance*:

$$P_k^{-} = \frac{1}{N-1}\sum_{i=1}^{N}\left(\hat{x}_{k,i}^{-} - \hat{x}_k^{-}\right)\left(\hat{x}_{k,i}^{-} - \hat{x}_k^{-}\right)^T \quad (8)$$

3. Measurement Update

$$z_{k,i} = Hx_{k,i} + v_{k,i}\ \text{, where } v_{k,i} \sim N(0, R_k) \quad (9)$$

Kalman gain :$K_k = P_k^{-}H^T(HP_k^{-}H^T + R_k)^{-1}$ (10)

Estimation:$\hat{x}_{k,i} = \hat{x}_{k,i}^{-} + K_k\left(z_{k,i} - H\hat{x}_{k,i}^{-}\right)$ (11)

$$\hat{x}_k = \frac{1}{N}\sum_{i=1}^{N} \hat{x}_{k,i} \quad (12)$$

Error covariance :$P_k = [I - K_kH]P_k^{-}$ (13)

and H-Infinity algorithm can be as below [10]:

1. Model system and measurement model

$$x_k = A_k x_{k-1} + C_{b,k}^n f_k^b dt + g^n dt$$
$$z_k = C_{n,k}^b v^n + \upsilon_{v,k} = C_{b,k}^n x_k + \upsilon_{v,k}$$

2. Initialization

$$\hat{x}_0 = \bar{x}_0$$
$$P_0 = P_{x_0}$$

3. Time Update

Estimation : $\hat{x}_{k-1}^{+} + C_{b,k}^n f_k^b + g^n dt$

Error covariance :$P_k^{-} = P_{k-1}^{+} + Q_{k-1}$

4. Measurement Update

$$\Gamma_k = \left[I - \gamma P_k^- + C_{b,k}^n R_k^- C_{n,k}^b P_k^-\right]^{-1}$$

Kalman Gain $: K_k = P_k^- \Gamma_k C_{b,k}^n R_k^{-1}$

Estimation $: \hat{x}_k^+ = \hat{x}_k^- + K_k\left(z_k - C_{n,k}^b \hat{x}_k^-\right)$

Error covariance $: P_k^+ = P_k^- \Gamma_k$

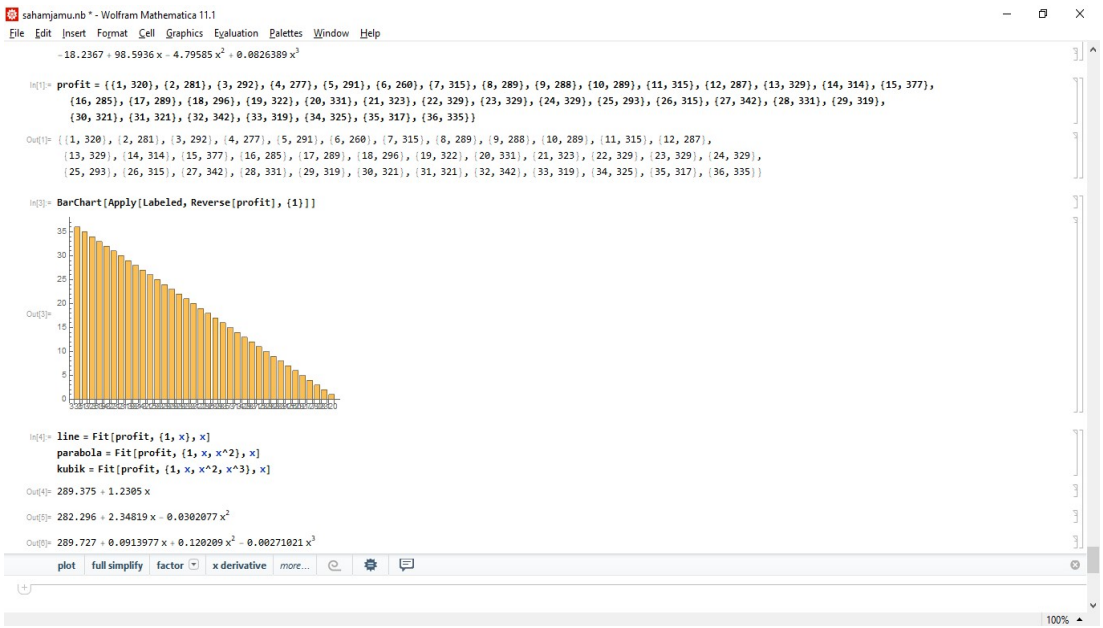
3. Simulation Result

The application of the EnKF and H-infinity algorithms to the profit function in equation (14) with 100, 200 and 300 iterations had a fairly small error. That is, the EnKF method had an error of about 3%, while the H-infinity method had an error of around 8%.

In this paper, a comparison of numerical computation results obtained by the EnKF and the H-Infinity was made to find out which method suitable for implementation in estimating a company's profit.

Table 1. Profit Data of XYZ Company (in million).

Month	Closing Price		
	2017	**2018**	**2019**
January	320	329	293
February	281	314	315
March	292	377	342
April	277	285	331
May	291	289	319
June	260	296	321
July	315	322	321
August	289	284	342
September	288	322	319
October	289	331	325
November	315	323	317
December	287	329	335



After that, the result of Mathematica software simulation for profit function, as follows:

$$f(x) = 192{,}8x^2 - 415{,}72x + 6771{,}5$$
$$f'(x) = 385{,}6x - 415{,}72 \quad (14)$$

In Figure 1, the simulation results with (100 iterations and 200 ensembles) and (100 iterations and 300 ensembles) show that the results by the EnKF algorithm have high accuracy because they are nearly the same as those in the real data graphs. In contrast, the results by the H-infinity algorithm have a bigger error of about 8%, and we can observe in more detailed in the comparison of the two methods in Table 2.

In term of iteration comparison, the estimation using 300 iterations had higher accuracy than those using 100 and 200 iterations as seen in table 2. However, the weakness of the estimation with 300 iterations in term of the simulation time took more time compared to those using 100 and 200 iterations.

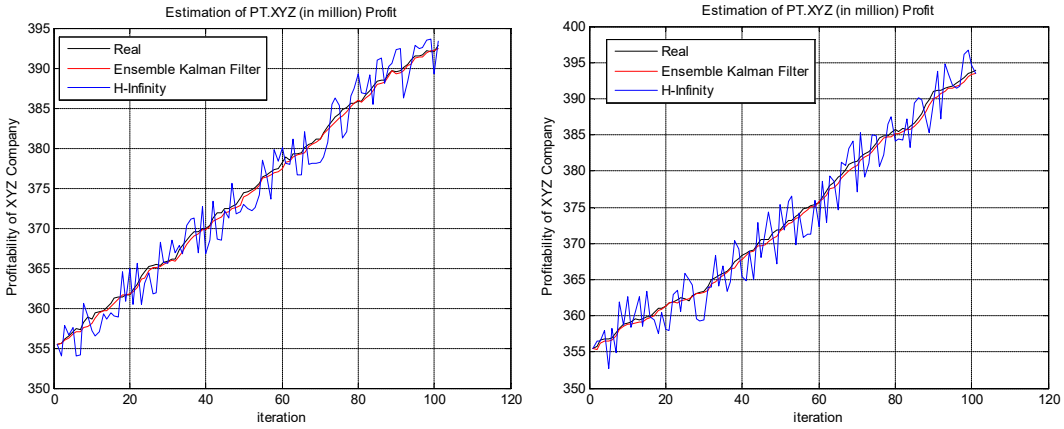


Figure 1. Estimation Result of PT. XYZ Profit with 100 iterations a) 200 ensemble, b) 300 ensemble.

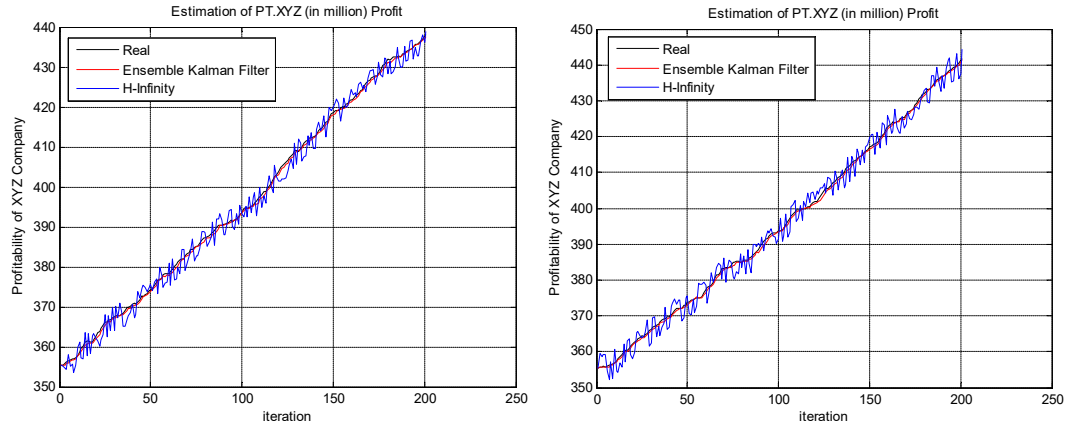


Figure 2. Estimation Result of PT. XYZ Profit with 200 iterations a) 200 ensemble, b) 300 ensemble.

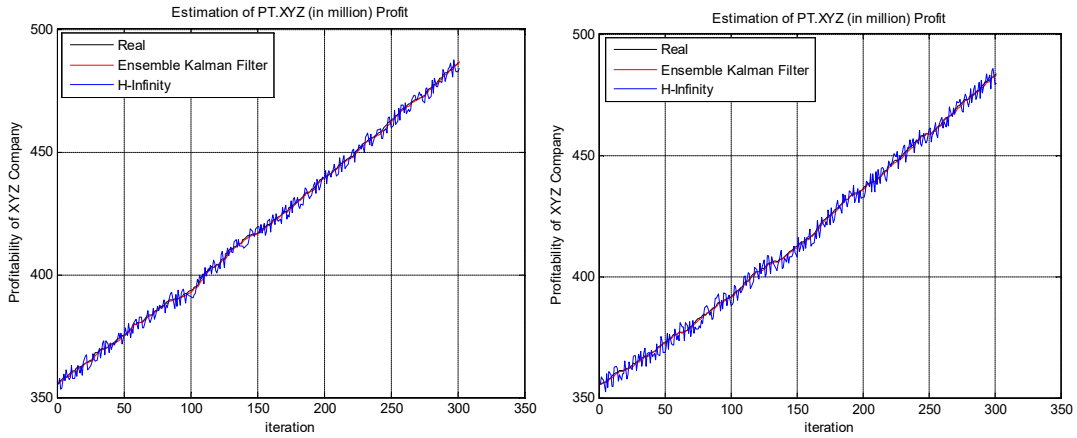


Figure 3. Estimation Result of XYZ Company Profit with 300 iterations a) 200 ensemble, b) 300 ensemble.

The iteration changes in Figures 2 and 3, that is, 200 and 300 iterations clearly show an improvement in the accuracy of the two methods. So, in the case of this profit estimation, the addition to the number of iterations in numerical computation is effective to reduce errors, and we can also see that in the table 2.The comparison of the estimation results with 100, 200 and 300 iterations as follow in Table 2:

Table 2. Comparison of RMSE values using EnKF and H-infinity Methods by 100, 200 and 300 iterations with 200 ensemble.

	100 iterations		**200 iterations**		**300 iterations**	
	EnKF	**H-Infinity**	**EnKF**	**H-Infinity**	**EnKF**	**H-Infinity**
Company profit	0.1752	0.2912	0.1511	0.2711	0.1327	0.2431
time	5.418 s	7.3128 s	9.2234 s	11.256 s	12.691s	14.445 s

In general, the EnKF method is more accurate than the H-infinity. Likewise, the simulation time is faster. In Figure 1-3, it can be seen that both methods are quite feasible to develop in company estimation to support company stakeholders in decision making for an effective policy that can increase company profits.

4. Conclusion

Looking at the results of the discussion above and the comparison of errors in table 2, it can be concluded that the EnKF method is more accurate than the H-infinity with an error difference of about 5 – 8%. Not only in table 2 but also Figures 1 -3 can it be said that both methods are reliable enough to be applied in company's estimation to support the company stakeholders in decision making for a policy that can increase company profits.

Open Problem 1. How to implemented Particle Filter for estimation of profitability.

Acknowledgement

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