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AR model to Estimate the Future Uranium Price

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1. Introduction

Uranium cost contributes between 5 and 20 % of the total electricity generation cost, which represents between 30 and 50 % of the total cost of the PWR fuel cycle [1]. Thus, uranium price is a significant cost driver to calculate the generation cost in the dynamic model. Uranium price recorded highest price in 2007 with approximately 140$/kgU. Since then, the price decreased and it is now maintained at approximately 60$/kgU. The reason that the price of uranium soared in 2007 is because of the imbalance between the uranium demand and supply. Uranium price can change due to various external factors in addition to the above mentioned imbalance of demand and supply. For example, since the Fukushima nuclear accident that took place in Japan, share of the nuclear power generation of the nuclear power generating nations in the EU including Germany decreased. As such, uranium demand was decreased, and the uranium price was decreased until May 2014 since the Fukushima nuclear accident has occurred. Moreover, uranium demand can decrease when nuclear power generation amount is decreased by Shale gas development or low oil price. However, Shale gas distribution is very vast until now, which means significant cost is expected in order to develop the infrastructure for gas development [2]. Thus, it is not yet affecting the share of the nuclear power generation amount significantly. Moreover, it is expected that the uranium price cannot be decreased from the long-term aspect since oil price decrease is limited in terms of time as well.

Accordingly, this paper utilized the time series analysis method which is a statistical method that uses the past data in order to forecast future uranium price. In other words, future uranium price was forecasted by utilizing the Autoregressive (AR) model.

2. Methods and Results

2.1 The trend of uranium price

Fig. 1 shows the uranium price time series data in graph.

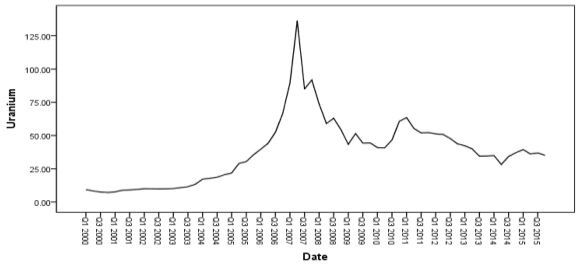

Fig. 1. The uranium price

2.2 Consumer price escalation rate model

In case of the nuclear fuel cycle cost calculation field that used dynamic model until now, uranium price of a certain standard year was set as shown on Equation (1) [3], and only the consumer price escalation rate was factored in to this value, to forecast future uranium price. This data is being used as the input data for the nuclear fuel cycle cost calculation. Since this paper considered only the consumer price escalation rate for this method, it was defined as so called "escalation rate model". When the standard year uranium price is calculated as the uranium price of the previous year in case of the consumer price escalation rate model, uranium price increased in a lineal manner. When the uranium price of a year is calculated as the standard year's uranium price, uranium price gets increased as the time moves towards the future. Accordingly, since uranium price that is forecasted with the consumer price escalation rate model continues to increase, a disadvantage is that significant difference with the actual uranium price of the future may result. However, escalation rate model is used often today since its advantage is that the future uranium price can be estimated promptly and roughly.

$$UP_t = UP_b(1+e)^{(t-b)} \quad (1)$$

Where UP_t = uranium price at t year, UP_b = uranium price at base year, e = escalation rate, b = base year

2.3 AR model

Autoregressive model is the statistical model in which the current values are affected by the values such as the values of the t-1 Year and t-2 Year of the past. It is like Equation (2) [4].

$$Y_t = \mu + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \dots + \alpha_p Y_{t-p} + \varepsilon_t \quad (2)$$

Where μ = y-intercept, α = coefficient, Y_{t-1} = random variable at time t-1, ε_t = error at time t

Accordingly, P[th]-order Autoregressive model is marked as AR (p). In other words, it is marked as AR (1) and expressed as shown on Equation (3) when the value of the previous period exerts important effect on the current value [5].

$$AR(1): Y_t = \mu + \alpha_1 Y_{t-1} + \varepsilon_t \qquad (3)$$

Where $\varepsilon_t \sim N(0, \sigma^2)$, N= normal distribution, σ = deviation.

2.4 AR Model's conformity

This paper drew out AR models to forecast future uranium price and verified models' conformity level. Table 1 shows the descriptive statistics quantity of the AR model. For the model to have reliability, t-value significance is not only 0.05 or less, but the significance of the Ljung-Box Q that signifies model's conformity level should be larger than 0.05. AR Model satisfied all the conditions

Table I: Statistics of AR model

Model parameters			Ljung-Box Q		
Coefficients		t-value (Sig.)	Statistics	DF	Sig.
Constant	34.325	2.876 (0.006)	8.333	17	0.95
AR Lag 1	0.903	17.614 (0.000)			

2.5 Forecasting uranium price results

This study used SPSS software to draw out time series analysis model. AR models was drawn out based on the data on the past uranium price. When model's conformity level was calculated by assuming confidence interval of 95%, AR Model was accepted. Fig. 2 is the graphs that show the uranium forecasting price trend of the AR Model.

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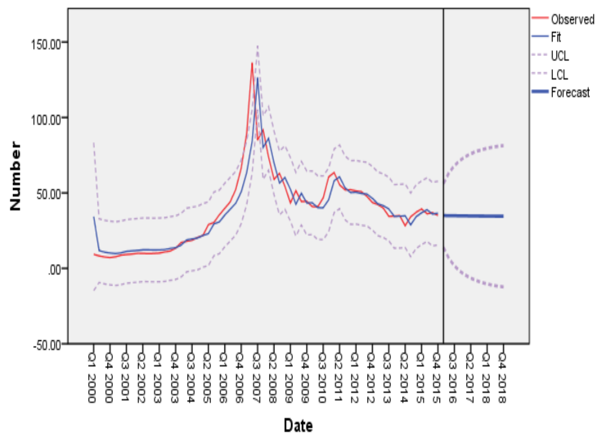

Fig. 2. The forecasting result of uranium price with AR Model until 2018

Moreover, Table 2 is the result of forecasting uranium price from 2016 to 2018 by entering in the price information from 2000 to 2015.

Table 2. The forecasting uranium price with AR model (unit: ￡(pound)/kgU)

Time	Uranium price
2016 1Q	35.02
2016 2Q	34.96
2016 3Q	34.90
2016 4Q	34.84
2017 1Q	34.79
2017 2Q	34.74
2017 3Q	34.70
2017 4Q	34.67
2018 1Q	34.63
2018 2Q	34.60
2018 3Q	34.58
2018 4Q	34.55

3. Conclusions

AR Model was used to forecast future uranium price, which showed that the forecasting margin of error of approximately 6% resulted compared to the uranium's actual price in 2015. Accordingly, it was proven that the value that estimated future uranium price by using AR model, which is a statistical method is close to the actual price compared to forecasting uranium price by factoring in merely the consumer price escalation rate, which is an existing engineering cost estimation method. Accordingly, it was analyzed that it is possible to calculate increasingly accurate nuclear fuel cycle cost when the future uranium price forecasted with the AR model is used as the input data of the nuclear fuel cycle cost calculation.

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