The research into the financial dynamic style using a state-space model

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Abstract

The fund circulation is increasing in the domestic market of financial securities investment, this have frustrated investors a lot. Owing to the fuzziness of each investing objective, mismatched investment momentum of contract and the investors' demands, and merely publishing investment portfolio for 4 times, it is difficult to for investors to obtain relatively, practical investment portfolio modes. To solve this problem, this research systematically analyzed styles of treasury securities investors using financial profits style analysis, proposed a dynamic style analysis method based on Bayesian filtering, and state-space model. By introducing the examples, the results were assessed with a constraint. The combination model was conducted virtualization processing. The results show that dynamically assessing the financial investment style using the algorithm proposed is proved to be feasible.

*Keywords: f*inancial dynamic style, Kalman filter, state-space model

1 Introduction

Many studies on state-space style analysis in finance fields have been made. For instance, Ru Zhengliang proposed a recursive iteration method to predicate the likelihood function among errors by using Kalman filter and interval smoother in his research into a financial predicating method based state space. The method can acquire the parameter estimation values to the utmost through time sequence. In a certain interval, the new model exhibits higher predicating accuracy than that of traditional models. Miao Jingyi estimated the parameters problems, and conducted systematically sorting and analysis in the research parameter estimation based state-sapce method. His research lays a good foundation for the further research for this regard. Gu Lan applied time sequence into financial state space functions in the prediction analysis of time sequence in economy in 1990s. Afterwards, the state-space theory of Kalman filter was introduced in the model. In recent years, Zhang Jun and Ren Guan integrated the financial state-space equation in modern control theory and state-space technology of time sequence, developed a relatively perfect system. Based on the previous researches, this paper conducted further analysis and research on the financial dynamic style using state-space model. Learning nonlinear dynamical systems using an EM algorithm was proposed by Zoubin Ghahramani [1]. A new approach for filtering nonlinear Systems was proposed by Julier [2]. A new approach to linear filtering and prediction problems was proposed by Kalman [3]. A Novel approach to nonlinear/non-Gaussian Bayesian state estimation was proposed by N.J.Gordon [4]. The use of domestic and world market indexes in the estimation of time-varying betas was given by Miehael D [5]. Approximating the confidence intervals for sharp style weights was given by Lobosco [6]. Evaluating firms in financial distress was given by Nancy H [7]. Asset allocation-management style and performance measurement was given by Sharp [8]. Corporate governance and financial distress- evidence from Taiwan was given by Lee Tsun-Siou [9].B stability analysis of China's stock market was given by Xu Zhandong [10]. By analyzing the drawbacks of traditional theory models, the Research proposes a new method, and provides a theoretical supports to the relating research in future.

2 Financial style analysis based on state-space model

To overcome the shortfalls of traditional method, the authors introduce the filtering technology in Bayes and state-space modelling method to construct the framework model of analyzing new financial dynamical style. The model established can be used to conduct both static and dynamic analysis.

The analyzing model of profit style is considered as a factor model in fact. It takes fund as an investment portfolio with a known style index. However, style index is usually represented by a weight coefficient of investment portfolio.

The minimization of sample variance and residual sum of squares is usually acquired through parameter analysis in static financial analysis. Least square analysis and least square method are usually used in the analysis of hypothesis and weak market and. In the case of real constraint, strong financial analysis is a complex optimization way. In this research, the comprehensive analysis and application data of before and after sampling are applied. This model has been verified to be reasonable and effective through various tests. So it is required to establish a new analyzing model since inaccurate model is likely to lead to wrong results.

3 The construction of the state-space model

Measurement and state equations are used to construct a state-space model. Based on the conversion relation, the conversion methods in a certain state are investigated. The linear and non-linear are regarded as two major model types of state-space model.

Based on non-linear state-space model, we obtain

$$x_{t+1} = f_t(x_1) + \eta_t \tag{1}$$

$$y_t = h_t(x_t) + \varepsilon_t \tag{2}$$

The systematically analysis of the state estimation for a non-linear state-space in non-Gaussian system has been widely made by the scholars. By using the improved method of Kalman filter to solve the problems, the minimum variance principle of suboptimal filter denotes as EKF. This research uses the Gaussian distribution method to determine the noises and similar system and applies the algorithm of Kalman filter into the model. The linear function of unpredictable state vector on the conditions of observing time sequences is assumed as a linear state-space model. The movements comply with a first-order regression equation of a corresponding Gaussian state-space model is presented as

$$\underset{m\times 1}{x_{t+1}} = \underset{m\times m}{F_1}\ \underset{m\times 1}{x_t} + \underset{m\times 1}{c_1} + \underset{m\times 1}{\eta_1} \tag{3}$$

$$\underset{n\times 1}{y_t} = \underset{n\times m}{H_t}\ \underset{m\times 1}{x_t} + \underset{n\times 1}{d_t} + \underset{n\times 1}{\varepsilon_t} \tag{4}$$

where sequential changes of the state equation denotes as t; $t = 1,2,\cdots$, such change way is considered as an epitome of Markov model, can be used in the model proposed. The generation of describing observing vector is illustrated as observing equation; x_0 refers to initial state. ε_t and η_t are two independent Gaussian distribution parameters. Meanwhile their initial states are independent forms respectively.

$x_0 \sim N(x_{00}, p_{00})$, $\eta_i \sim iidN(0,Q)$,

$\varepsilon_i \sim iidN(0,R)$, $E[\varepsilon_i, \eta_s^{'}] = 0$, $E[\eta_i, x_0^{'}] = 0$

R_t , c_t , Q_t , H_t , d_t , F_t is called as a systematically matrix form.

The transfer and observing matrixes denote as F_t and H_t. The inherent components are expressed by c_t and d_t. Beside, the known modes are introduced into the model. The value is zero if it does not stand.

Bayes filtering solutions of Gaussian state space and linear space model using Kalman filter can be obtained. The state model is able to solve more practical problems in real life. Those problems are presented in the linear and non-Gaussian forms. The non-linear and non-Gaussian state models are introduced also. The change of a sensitive coefficient containing in time-dependent financial profit style can be illustrated by a state equation in the state-space model. The change of the state style can be therefore known. In this case, a random equation usually needs to be pointed out as

$$\beta_t = \beta_{t-1} + \eta_t \tag{5}$$

$$\eta_t \sim \text{iidN}(0,\sigma^2)6 \tag{6}$$

where Q refers to the diagonal matrix form. In addition, the model can be constructed using the reply ways of mean values.The profits behaviors in the portfolios for the financial style analysis cases correspond to three observing methods in observing equations, namely, $R_t^{'} = (R_{t1}, R_{t2}, \cdots R_{tm})$ so we obtain the following content. Based on the process above-mentioned, the model is usually established with both linear and non-linear constraints in the analysis of strong financial style. It is generally know that model is difficult to be built with linear constraint. Through conversion, the model required can be constructed in the case ranging from linear and non-linear, the nano observing equation is

$$R_t^c = \omega_{t1}R_{t1} + \omega_{t2}R_{t2} + ... + \omega_{tm}R_{tm}$$
$$+\varepsilon_t, \varepsilon_t \sim iidN(0,\sigma_g^2)$$

$$\omega_{tj} = \omega_{tj}(\beta_t) \equiv \frac{\exp(\beta_{tj})}{\sum_{i=1}^{m}\exp(\beta_{ti})}, j = 1,...,m \tag{7}$$

The models established include linear constraints in the analysis of hypothesis financial style. By resorting of data, we obtain:

$$\begin{pmatrix} R_t^c \\ 1 \end{pmatrix} = \begin{pmatrix} R_t^1 \\ l...1 \end{pmatrix}\beta_t + \begin{pmatrix} \varepsilon_t \\ 0 \end{pmatrix}, \begin{pmatrix} \varepsilon_t \\ 0 \end{pmatrix} \sim \text{iidN}(0,\sigma_g^2)$$

The equations show that the model obtained is linear. The difference lies in that there are two variables instead of a single variable. In this case, the linear constraint of the state equation can be meted. The time-dependent equation of the relating sensitive coefficient through conversion can be acquired in the analysis of the weak financial style

$$R_t^c = R_t^1\beta_1 + \varepsilon_t, \varepsilon_t \sim iidN(0,\sigma_g^2)$$

The weak style analyzing model is constructed using the smoother and Kalman filter methods. The symbols above-mentioned are represented. Namely,

$y_i = R_t^{'}x_t = \beta_t$, $H_t = R_t^{'}$, $F_t = I_{m\times m}$, $c_t = 0$,

$d_t = 0$, $R = \sigma_\eta^2$, $Q = \sigma_\eta^2$.

This Equation can be used to express a general state space. Kalman smoothing filter is initially used to predicating the introduced or corresponding observing values by logging in the state mode. Afterwards, those data are updated and the process is constantly proceeding with the variation of predicating forms of mode state and newly state data observed. The Equations corresponding to updated predicting modes are

$$x_{t+1|t} = F_t x_{t|t} + c_t$$

$$P_{t+1|t} = F_t P_{t|t} F_t^T + Q$$

$$y_{t|t-1} = H_t x_{t|t-1} + d_t$$

$$v_t = y_t + -y_{t|t\text{-}1}$$

$$S_t = E\left(v_t v_t^t\right) = H_t P_{t|t-1} H_t^T + R$$

$$K_t = P_{t|t-1} H_t^T S_t^{-1}$$

$$x_{t|t} = x_{t|t-1} + P_{t|t-1} H_t^T S_t^{-1} v_t$$

Kalman filter and smoother algorithms are combined to obtain the advancing flittering forms, the smoother equation is

$$P_{t|t} = P_{t|t-1} - P_{t|t-1} H_t^T S_t^{-1} H_t P_{t|t-1}$$

$$x_{t-1|\mathrm{T}} = x_{t-1|t-1} + J_{t-1}\left(x_{t|T} - x_{t|t\text{-}1}\right)$$

$$P_{t-1|t} = P_{t|-1|t-1} + J_{t-1}\left(P_{t|T} - P_{t|t-1}\right) J_{t-1}^T$$

$$P_{t,t-1|T} = P_{t|t} J_{t-1}^T + J_t\left(P_{t+1,t|T} - F_t P_{t|t}\right) J_{t-1}^T$$

The cross covariance, covariance and the state are expressed as

$$x_{t|T} = E\left(x_t \mid y_{t:T}\right)$$

$$P_{t|T} = E\left(\left(x_t - x_{t|t}\right)\left(x_t - x_{t|t}\right)^T \mid y_{t:\mathrm{T}}\right)$$

$$P_{t,t-1|T} = E\left(\left(x_t - x_{t|t}\right)\left(x_{t-1} - x_{t-1|t-1}\right)^T \mid y_{t:T}\right)$$

$$P_{T,T-1|T} = \left(I - K_T H_T\right) F_T P_{T-1|T-1}$$

The above equation is a filtering algorithm with backward smooth and advancing movements. The process is regarded as a Kalman smoothing filter algorithm. The algorithm is used to estimate the time-dependent weights through filtering in whole process. The process is the analysis of financial price with weak style in the case of negligence of positive constraints of weights. However, it is not less suitable to be applied in the current situation of China.

Extended Kalman filter is a non-linear state-space model in strong style analysis model, and mostly common-used method. It has been applied various fields. Taylor formula is used to expand it as the observing equations and the forms similar to the system linear as

$$x_{t+1} \approx f_t\left(x_{t|t}\right) + F_t\left(x_t - x_{t|t}\right) + \eta_t$$

$$y_t \approx h_t\left(x_{t|t-1}\right) + H_t\left(x_t - x_{t|t-1}\right) + \varepsilon_t$$

The corresponding linear form is presented as

$$F = \frac{\partial f_t\left(x_t\right)}{\partial x_t^t}\Big|_{x_t = x_{t|t}}$$

$$H = \frac{\partial h_t\left(x_t\right)}{\partial x_t^t}\Big|_{x_t = x_{t|t-1}}$$

Using the method, the standardized smoother and filtering algorithms can be realized. The updated equation can constitute the state-space model which can be realized by using smoother algorithm and Kalman filter, the state-space model on the condition of linear constraint is illustrated as

$$A_t x_t = q_t$$

Linear model can be used in Kalman filter algorithm after conversion. Based on the constraint above-mentioned, the state-space model using smoother algorithm and Kalman filter is

$$A_t a_{t|t} = q_t, A_t a_{t|\mathrm{T}} = q_t$$

The errors are tested to conduct basic step of Kalman filter, the likelihood equations of Kalman filter is

$$\ln L = \sum_{t=1}^{T} \ln L_t,$$

$$\ln L = -\frac{p}{2}\ln\left(2\pi\right) - \frac{1}{2}\ln\left(S_t\right) - \frac{1}{2} v_t^t S_t^{-1} v_t$$

The unknown systematic parameters are obtained through maximizing the likelihood functions.

4 Empirical verification

Further prove the superiority of this model, the real fund investment style is analyzed. By selecting several finance emergency management as research objectives, the data which are the latest two months are applied. Owing to incapability to acquire the real-time data of funds allocation for each style capital, a real investment portfolio with virtual reality is adopted to validate the effectiveness of the model. Three capitals which are the construction national debt, the growing indexes in construction large –cap and growing indexes in construction small–cap within two months are analyzed. The authors adjust the growing ranges and then calculate strong style. By using kalman particle extended filter method, the smoother and the filtering analysis are conducted based on hypothesis and weak finance styles. The results are shown in Figure 1.

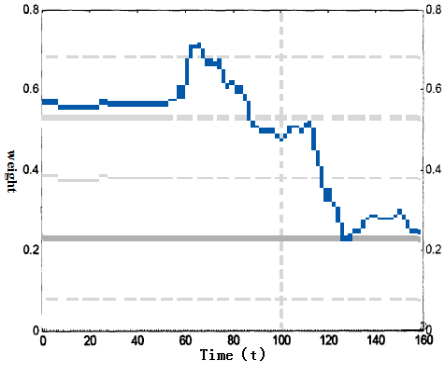

FIGURE 1 Dynamic change of the portfolio construction of market index weights configuration

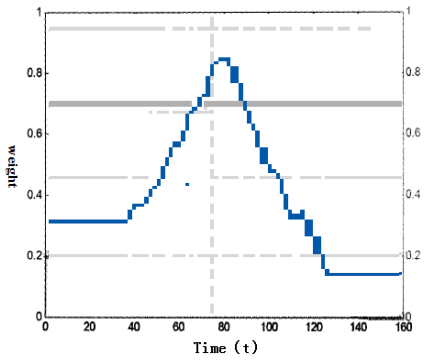

FIGURE 2 Dynamic changes for the construction of small-capPortfolio weighted index configure

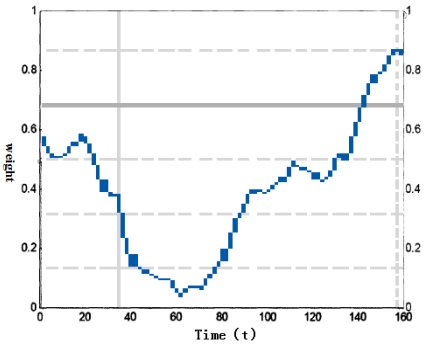

FIGURE 3 Index weights configure dynamic change of portfolio construction bonds

Although the varying range is prominent according to Figure 3, it is noted that the algorithm is more feasible scheme of estimating financial investment style in practical compared to the two algorithms abovementioned.

5 Conclusions

By analyzing the traditional market of finance securities investment, the research proposes the dilemma faced by investors. The analysis method of financial profit style is used to systematically analyze the investors' style on the treasury securities in China. The authors propose that the dynamic analysis method using Bayesian filtering and state-space model. The estimation is made with a certain constraint. By introducing examples, the research results show that most of construction investment funds present growing momentum. The model is proved to be effective and reasonable.

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