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Recurrent neural network for dynamic portfolio selection

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Abstract

In this paper, the dynamic portfolio selection problem is considered. The Elman network is first designed to simulate the dynamic security behavior. Then, the dynamic covariance matrix is estimated by the cross-covariance matrices. Finally, the dynamic portfolio selection model is formulated. In addition, a numerical example is used to demonstrate the proposed method and compare with the vector autoregression (VAR) model. On the basis of the numerical example, we can conclude that the proposed method outperform to the VAR model and provide the accurate dynamic portfolio selection.

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1. Introduction

The mean–variance approach was proposed by Markowitz to deal with the portfolio selection problem [1]. A decision-maker can determine the optimal investing ratio to each security based on the sequent return rate. The formulation of the mean–variance method can be described as follows [1–3]:

$$\begin{aligned}
 & \min \sum_{i=1}^n \sum_{j=1}^n \sigma_{ij} x_i x_j \\
 & \text{s.t.} \quad \sum_{i=1}^n \mu_i x_i \geq E, \\
 & \quad \sum_{i=1}^n x_i = 1, \\
 & \quad x_i \geq 0 \quad \forall i = 1, \dots, n,
 \end{aligned} \tag{1}$$

where μ_i denotes the expected return rate of the i th security, σ_{ij} denotes the covariance coefficient between the i th security and the j th security, and E denotes the acceptable least rate of the expected return.

On the basis of Eq. (1), it can be seen that the conventional portfolio selection problem above is considered as a static situation. However, this assumption is truly against our intuition i.e. we always vary our optimal portfolio selection with time. Although many methods including vector autoregression (VAR) [3,4] and generalize autoregressive conditional heteroskedastic (GARCH) [5–7] has been proposed to deal with the dynamic portfolio selection problem, several restricted assumptions, such as stationary time series, independent variables, and the linear relationship among variables, make these models impractical. The purpose of this paper is to propose a non-parameter and non-linear method to deal with the dynamic portfolio selection problem.

In this paper, a dynamic portfolio selection model is proposed by incorporating the recurrent neural network (RNN) [8,9] and the cross-covariance matrices [4]. The dynamic expected return rate is first derived using the Elman network [8]. Then, the cross-covariance matrices are calculated to estimate the covariance matrix among securities.

The remainder of this paper is organized as follows. The dynamic portfolio selection model is proposed in Section 2. A numerical example, which is used to illustrate the proposed method and compare with the VAR method, is presented in Section 3. Discussions and conclusions are in the last section.

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