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## Theory and algorithm of state space model and its application in financial econometrics

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### ABSTRACT

Because the time series of financial econometrics has feature of nonlinearity and is nongaussian as well as the latent variable and time-varying parameters. The standard quantitative analysis model in the practice is very difficult. This thesis manages to base on the theory of recurrence Bayes filtering theory and integrate the state space model of modern statistical calculation. The thesis studies the theory and algorithm of state space model, and through the comparison and check in the simulation experiment we find that the application of state space model in financial econometrics is the best.

### KEYWORDS

Basic knowledge of music; Market requirement; Exploration and practice of patterns of employment.



## INTRODUCTION

The classical econometric models are mostly established on the assumption of liner and Gaussian distribution. However, a lot of researches show that financial time series generally owns some distinct features violating these classical assumptions. With the progress of science and technology, the era of information has coming and the development of network technique is very quick. In different businesses and organizations there are different units which are emphasis on different goals. So they also have internal systems and resources of information. And their distribution generally depends on the distribution of business or professional knowledge. So in different environments, different businesses would adopt different concepts to model their informational resources according to their focuses and goals and realize the management of internal resources of their own businesses. But despite of the same system, different departments or units do not share their information. So to some extent, there are some wastes of information and there are obstacles in information sharing owing to the different models of each unit. At present, how to realize the sharing and exchanging of information so that effectively use these resources is a serious problem.

State space is a hot concept in China, and is considering as the foundation of information resource management and sharing. It is the data of data, and also the basis of organization, storage, find, searching and application message resources. And state space model is a common model of state space, and is a tool and method of distributing and isomerize informational resources. The state space model based on its body can more effectively improve the information sharing and semantic expression. Semantic expression is the state of motion and variation form of entity and is considered as the information understood by computer rather than the non-design relation between information and procedure. So the state space model based on its body can provide users the ability of searching and collecting information whose expressing pattern is state space model by its body. But in this form there is a problem that now the assumption of the information sharing based on its body is a concentrated body which causes large costs for the maintenance. Besides, in the network, the informational resources of departments are maintained by node and the concentrated body is not real. So the assumption is not invalid. Design a model conforming to the information sharing service and requirement and facing the sharing of semantic information and introduce the model's structure and related state space model and finally proposes the standard of state space model to support the metadata model. That is the fluctuation of financial time series in some periods is serious and relatively quiet in other periods.

## THE THEORY OF STATE SPACE MODEL

Since 1960s, the foundation of theory of state space control, it has gained wide attention and has been researched widely and achieved excellently in the field of spaceflight. Because informational resources are constituted by many departments, the data format is different and owns isomerism. In order to realize the informational interconnection, interflow and application, we adopt the agreed standard model in the design of state space model. Secondly, generally the design of state space model should contains so many fields of informational resources and the distribution is wide. So in the certain range, the design of state space model is universal and not only contains the object as much as possible but also adapt to different special requirements. Thirdly, in the environment covered state space model, user can finish the searching of information resource and can access these resources in the scope of authority. Fourthly, the information resource in the sharing scope is complex. When we design the state space model, we should ensure the intelligibility of the information resource which means that the computer programs should understand the information in the level of connotation. That is offering ability of introducing information resource facing the semantics to meet requirements of different users. Finally, the state space model also can expandable and support the interconnection, interflow and application.

State space model is designed to base on the semantic nerve of a covering and practice. This semantic nerve of a covering is based on the information resource central network and to manage the distribution and isomerize of information resource. Information resource central network is similar to the peer-to-peer network in the wide area and is formed by the technically mutual independent information resource central networks. And the semantic nerve of a covering can through the metadata find, organize and use the information resource so that information resources of different departments in different environment is connected and achieved the goal of realizing effective and safe information science.

Considering the time series  $\{y_t, t = 1, \dots, T\}$  general nonlinear and non- Gaussian state space model:

$$\begin{cases} x_t = f(x_{t-1}, v_t) \\ y_t = h(x_t, \omega_t) \end{cases} \quad (1)$$

Including  $x_t$  is the unknown state variable of ns,  $y_t$  is the observational variable of  $n_m$ ;

Like the ARMA model, it can stand for the form of state space and here the state variable do not have the specific economic connotation but to explain the complex forming process of observational variable. The dimension of state variable is determined by the specific problem and requirements.

## ANALYSIS OF FEATURES OF TRENDS OF FUND BASED ON STATE SPACE MODEL

Because informational resources are constituted by many departments, the data format is different and owns isomerism. In order to realize the informational interconnection, interflow and application, we adopt the agreed standard model in the design of state space model. Secondly, generally the design of state space model should contains so many fields of informational resources and the distribution is wide. So in the certain range, the design of state space model is universal and not only contains the object as much as possible but also adapt to different special requirements. Thirdly, in the environment covered state space model, user can finish the searching of information resource and can access these resources in the scope of authority. Fourthly, the information resource in the sharing scope is complex. When we design the state space model, we should ensure the intelligibility of the information resource which means that the computer programs should understand the information in the level of connotation. That is offering ability of introducing information resource facing the semantics to meet requirements of different users. The results of model is shown as TABLE 1.

**TABLE 1 : The results of model**

Model	MAE	MSE
historic volatility pricing model	1.276856	0.734329
concealed volatility pricing model	0.074315	0.013024
practical filter pricing model	0.003836133	0.0000498

In our security market, the issue of fund is increasing and investor need the detailed information of each fund and then they can establish the best fund combination. However, some fund' object is vague and even pursue the investment violating the agreement. Through the analysis of requirements of state space model, we can divide the state space into three levels: the first level is rules and methods which should be followed by MST in the standard design and set the certain information. It is also called state space model level which is an abstract state space regulating the function, form, semantic grammar of metadata from a higher level. The second level is the definition of state space model which describes the standard gather of the specific object in the information resources. This level can be called standard level of state space model which is MST mentioned above. There is different MST according to different types of information resource in different environment. Standard level of state space model is grammar rules when it fully describes the certain information resource. Here the grammar rule adapts to the specific information resource's data gathering, semantic definition and rule and application of computer. When the MST is determined, various kinds of users should follow the standard state space containing specific information resource. The third one is to record the metadata. The record of state space is the application of state space which is based on the data model and can be used to describe the specific information resource object. The record of state space should not only describe the specific information resource but location and manage the information resource. In this way, it facilitate user to find resource state space and to gain and use information resource object.

State space is a kind of structural data and in which information can be understood and disposed by computer. And it can describe the certain kind of information resource which offers location and management of information resource. And it can enable user exactly search the information. This thesis aims to construct a sharing platform of information resource whose basis is planning and standard information resource metadata structure. And the state space model built on the state space is an abstract metadata which are rule and method followed by standard design of state space standard model which refers to the custom made model of certain information resource. In this thesis, we add the design of body to the semantic information of metadata. This semantic method can better describe the state space so that realizing the combination and sharing of state space. The concept of body is introduced that means that the standard model of metadata based on the understanding of related field need be introduced by body. So before design state space model, we should firstly understand the concepts related to body. And, income analysis theory is also called "duck theory". Practically, style analysis based income belongs to the restrained recurrent model shown as TABLE 2.

**TABLE 2 : Results of recurrent model**

Confidence level	Average VaR	Failure	Traffic light	J region
90%	0.0159	55	Green	[0.8760, 0.9040]
95%	0.0204	31	Green	[0.9294, 0.9506]
99%	0.0288	14	Yellow	[0.9646, 0.9794]

In the past, the style analysis based income is assuming the style of fund investment will not change. And as a concept, the body first appeared in philosophic field. And from the philosophy, it pays attention to the objective things which are specific explanation of the objectives. Divorced from the philosophic field, the definition of body is varied, and including a concept that is agreed by the most people that is "body is the standard explanation of conceptual system which is specific, formalized and sharable." which comes from R.Studer. Generally, the definition of body is in science and with the

development of science and technology, body has imported into computer field. And it is more and more used in artificial intelligence. In the knowledge project, body refers to the particular terms added a series of supposed gather which is related to the connotation and particular terms is used to describe the certain condition. Generally, body describes the classified hierarchical structure of the concept while the condition we faced is complex. Body need to base on the classified level assume a group of forums to limit the connotation. This concept is definite by the formula (2):

$$O = \{C, R, F, A, I\} \tag{2}$$

O in formula (2) is body itself, including C, R, F, A, I five basic elements. And C refers to the connotation in a board sense which forms tasks and functions into a level structure according to the specific structure; R refers to the relation of each connotation; F is a kind of R which stands for a special relation and also is an element determined by the prior element; A refers to that the connotation should satisfied the forum or the forum satisfied by the R and it will not change; I refers to the gathering of connotations of body. Obviously, checking model is important, because the wrong model will lead to wrong judgment.

### ANALYSIS OF FEATURES BASED ON STATE SPACE MODEL

From definitions above, it is not difficult to see that actually body is a conceptual model which is gathering of concept or the definitions and relations of concepts. It is an abstraction of phenomenon in the real world. These phenomena are generally called concepts by us and we use specific constraint condition to definite the concepts of the model. These gatherings are not made out of whole cloth but admmissive in special fields. As the model which can share the information resource in semantic level, its conceptual level structure is better and meanwhile supports the logical language largely. Besides, this model plays an important role in other fields, especially in the description of state space and process of application of semantization.

State space is consisted of two forums: one is state equation and the other is observation equation. The state equation refers to the method of transferring from the current state to the next state which is equal to the transferring relation; while the observation equation refers to the relation observed actually between independent variable dependent variable.

$$\begin{aligned} x_{nT} &= E(x_i | y_{i:T}) \\ P_{nT} &= E((x_i - x_{ni})(x_i - x_{ni})^T | y_{i:T}) \\ P_{i, i-nT} &= E((x_i - x_{ni})(x_{i-1} - x_{i-1| i-1})^T | y_{i:T}) \end{aligned} \tag{3}$$

The research has introduced the connotation of body in detail, while the thesis designs the state space model which is based on the design of body facing the semantic information resource. The information resource is consisted of information units and through the research of entity in state space describes the information resource. According to concept above, we can use formula (4) to design the model of metadata:

$$MD := \langle E, A, L, H^C, R, I, F, P \rangle \tag{4}$$

In formula (4), E refers to the gathering of entity of state space; A is the gathering of basic property and according property in entity; L refers to the gathering of range, HC is an expression of relations among the entities which is a kind of partial ordering relation that can be transferred; R is different from the R in body, and is an incidence relation among entities which ensure the completeness of information are also binary; I refers to the gathering of entity in state space; F is the expression of function set in the message unit and the function set contains the attribute function, attribute value function, Information unit instantiation function and relation instantiation function; finally P is the gather of constraint function refers that information entity should obey the limitation of value and cardinal number. This research contains the data from January 9 of 2004 to March 30 of 2007. And the frequentness is weeks which are 160 weeks.

### CONCLUSION

The main goal of this thesis is to study the theory and algorithm of state space model and its application in financial econometrics. Firstly it studies the theory and the algorithm of modern financial econometrics. Because time series of the financial algorithm owns nonlinearity and non-Gaussian as well as latent variable and parameter time-varying, the standard quantitative analysis model is practically different. The thesis manages to base on the recurrence Bayes filtering theory and integrate the state space model of modern statistical calculation. It also studies the theory and algorithm of state space model and compares them through the simulation experiment. The theory of state space model is also better applied in the financial algorithm. Then through the integration of Bayes's smooth and EM theory, and further study the parameter question of state space model. Third, according to the liner and nonlinear problem, it imports the analysis and simulation algorithm, making theoretical derivation and computer simulation. The fourth is to reconstruct the model of the traditional measurement model

according to the state space method, and offers solutions to some important questions in finance and analysis them by practical cases.

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