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学位論文題目 Modeling Trend of Multiple Nonstationary Time Series

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論文内容の要旨

Decomposition of time series into the unobserved cyclical, trend, seasonal and irregular components is a conventional treatment for economic data. Many macroeconomic time series are nonstationary and have dominating trend components whose understanding is important for forecasting and economic policy making, etc. and in case of multiple series, it is necessary to understand the mutual hidden linear relationships among trends. Two competing views of this trending behavior are the deterministic and the stochastic trend models. In a multivariate context, however, more interesting problem is how these trends are related. We confine the study to the case of linear mean-nonstationary time series models with Gaussian noise, that is, time series with trends. The purpose of the thesis is to propose models to investigate the linear relationships among trend components of several series. Our model regresses the *level*, the *velocity* and the *acceleration* of the predictor trend series' on the dependent trend series.

Some recent works have paid attention to trend behavior and cyclical fluctuations around a trend to elucidate the current features of the time series of a system. System analysis through multivariate autoregression has been considered to analyze the cyclical activity of the series and the preliminary seasonal adjustment is a widely applied method for series with seasonalities. Those two methods have been combined with the stochastic difference model for the trend components to study the hidden mutual relationships among the cyclical fluctuations of the multivariate nonstationary time series (Kato, Naniwa and Ishiguro, 1995). The methodology of modeling trends in their work and in others in time series literature is not fully completed.

For this a linearly related trend (LRT) and a partially linear related trend (PLRT) models are introduced and in addition, we may estimate the latent linear relationships among trend components. They may also capture the long-run economic relationships. These trend models form an integrated part of the model of the mutually related time series, another part of which takes care of the short-term dynamics among the series. The other two specific objectives are (i) to evaluate the performance of the models through simulation studies, and (ii) to present some real applications of the models discussed here. The MIT and LRT models are nested within the PLRT model.

An introduction and a brief review related to the topic of the thesis has been given in chapter 1. The background related methods of time series analysis is also presented in chapter 2. A basic multivariate trend model for nonstationary time series is introduced in chapter 3. Three specific models of the basic model have been discussed. Cyclical components are modelled by multivariate AR process. A standard seasonal component model is used for seasonal components. These models are discussed very briefly in chapter 3. The time series models are thus named as multivariate AR with mutually independent trend and seasonal component (MARTS) model, multivariate AR with linearly related trend and seasonal component (MARLTS) model, and multivariate AR with partially linear related trend (MARPLTS) model. This enable us to evaluate and select the best model by information criterion (AIC).

These unobserved component models for cyclical, seasonal and the trend are cast into a state-space form. The trends together with the cyclical and seasonal variations of the original time series are efficiently estimated jointly at the same time by taking advantage of the Kalman filtering and the fixed interval smoother algorithms. The hyperparameters of our Bayesian models are estimated by numerical optimization procedure. The choice of the best model among the candidate models is realized by the minimum AIC procedure. The state space representation of the models and estimation procedure are discussed in

In chapter 4, we check the performance of our models and estimation procedure through several simulation studies. Incorporation of the relation among the trends into time series model might reduce the abundant flexibility of the model and might improve the reliability of the analysis. This feature of the model has been checked by system analysis (estimating the impulse response function of the multivariate AR model) through simulation studies. Two real applications of the models are given in chapter 5. Application to a semi-macroeconomic time series shows the usefulness of the proposed procedure. Another application to medical related data analysis also shows the wide range of the applicability of our method.

Sixteen two dimensional economic time series of inventory and price of manufacturing industries are also by fitted by the MARTS, MARLTS and MARPLTS models. The findings of these data analyses are provided in section 5.3. The dynamic structure of the mutual relationships between the cyclical components are explored by executing system analysis technique to the improved estimates of MAR model. Eleven out of sixteen data sets are found similar (open-loop) impulse response function that the inventory goes up with the price going up, i.e., this interpretes that the economy is booming and the price goes down when the stock of inventory goes up, i.e., the phase where economy is slowing down. This findings may support the economic insights of Japanese manufacturing sector. This model is not only useful to cast a light on the mechanism generating the trends, but also useful for improving estimates of the cyclical dynamic components. From the results of the semi-macroeconomic data, 14 out of 16 time series fit well by MARLTS model and this suggest that MARLTS model can be suitable for many economic time series analysis.

論文の審査審査結果の要旨

本論文は多変量時系列モデルにもとづいて、非定常時系列のトレンド間の関係を検出し定量的に把握するための方法を提案し、実データの解析によってその有効性を検証したものである。

従来、トレンドを持つ複数の時系列の間に成り立つ関係の分析手法としては共和分の概念に基づくものが広く用いられてきたが、本論文では、主として工学、自然科学の分野で利用されてきたデータの成分分解の方法を多次元に拡張することによって、より一般化した方法を提案している。本論文では、複数のトレンド成分間に「互に独立である」、「線型な関係がある」、「線型に関係する部分と独立な成分から成る」という3つの場合を想定し、モデル化することによってMIT (Mutually Independent Trend), LRT (Linearly Related Trend), PLRT (Partially Linearly Related Trend) の3つのモデルを定義している。このうちLRTとPLRTは新たに提案されたものであり、MITともあわせて情報量規準によるモデル選択を行うことによって識別の困難の問題を回避した。これによって、トレンド間の関係の検出が可能となったものであり、非定常現象の解明への実用的な方法が得られたものと評価できる。

実際、5.1節の喘息発作と公害物質濃度の変動の間の解析では、喘息患者数のトレンドと窒素酸化物濃度のトレンド変化率の間に線型の関係がある事を検出している。これは従来、トレンドの差分間の間の相関を見るという方法で発見されていた事実を追認したものであるが、提案する方法によって多変量間の関係の中・長期的なものと同期的なものに分解できる可能性を示した結果であるとともに、提案する方法が経済データに限らない応用範囲を持つを示している。5.2節は提案する方法によって、トレンド推定の精度が向上し、その結果トレンド廻りの定常的変動の関係が精度よくとらえられるようになったことを示している。5.3節では提案する方法を系統的に適用することによって、業種による在庫と卸売物価との関連性の違い、景気循環の主要因などを検出するための手段となりうることを示している。

以上のように、本論文で提案された方法は経済時系列のような非定常時系列のトレンド間の関係を検出し、分析する実用的な方法を与えたものとして貢献するところが大きいと判断される。

論文の内容の一部は、すでに国際学術誌に投稿済みであり、査読結果から適当な修正を行えば、採択が期待できると判断した。