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Computational Statistics & Data Analysis 50 (2006) 3702–3720
COMPUTATIONAL STATISTICS & DATA ANALYSIS
www.elsevier.com/locate/csda

Multivariate discount weighted regression and local level models

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Received 14 June 2005; accepted 2 July 2005
Available online 27 July 2005

Abstract

The technique of multivariate discount weighted regression is used for forecasting multivariate time series. In particular, the discount regression model is modified to cater for the popular local level model for predicting vector time series. The proposed methodology is illustrated with London metal exchange data consisting of aluminium spot and future contract closing prices. The estimate of the measurement noise covariance matrix suggests that these data exhibit high cross-correlation, which is discussed in some detail. The performance of the proposed model is evaluated via an error analysis based on the mean of squared forecast errors, the mean of absolute forecast errors and the mean of absolute percentage forecast errors. A sensitivity analysis shows that a low discount factor should be used and practical guidelines are given for general future use.

Keywords: Time series; Dynamic linear models; Kalman filter; State space models; Discount weighted regression; Bayesian forecasting; Local level models

1. Introduction

Multivariate time series have, recently, received significant development from both theoretical and practical standpoints. Whittle (1963), Hannan (1970) and Lütkepohl (1993) examine the widely used stationary VARMA models for observation vectors, whilst Lütkepohl (1993, Chapter 13), West and Harrison (1997, Chapter 16) and Durbin and

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doi:10.1016/j.csda.2005.07.003

Koopman (2001, Chapter 3) give detail consideration of state space or dynamic linear models. These models provide a sound statistical framework with inclusion of practical modelling mechanisms such as feed-forward and feed-back intervention. However, in most multivariate models the noise covariance matrices have to be assumed known, if tractability is desired. Local level models constitute the simplest class of dynamic models with significant application. Enns et al. (1982), Machak et al. (1983), Harvey (1986, 1989, Chapter 8) and Durbin and Koopman (2001, p. 44) discuss multivariate local level models, although the problem of the specification of the noise covariance matrices does not receive much attention. Sequential Markov chain Monte Carlo techniques (Doucet et al., 2001) as well as EM algorithm techniques (Durbin and Koopman, 2001) are available in multivariate time series, but their efficiency needs to be studied when the dimension of the vector of the observations is large and when online forecasting is on demand. The only tractable multivariate dynamic model, which assumes a prior inverted Wishart distribution for the measurement noise covariance matrix, is the so-called matrix dynamic linear model, reported in West and Harrison (1997, Section 16.4) and applied in Salvador et al. (2003) and Salvador and Gargallo (2004).

Brown (1962) introduces exponential weighted regression (EWR), which has been found to be a popular forecasting procedure due to its simplicity and operational adaptability. Harrison and Akram (1983) generalize the EWR to make the method applicable to correlated observations and these authors give several results comparing their method with the usual ARIMA time series models (Chatfield, 2001). Ameen and Harrison (1984) develop a variant of EWR, in which the modeller can use several weights to the forecasts and the resulting discount weighted regression (DWR) techniques have been applied to real time series data in Harrison and Johnson (1984). The latter authors appreciate the fact that in practice the measurement variance will be unknown and they use a Bayesian procedure to estimate this unknown variance. The method of DWR has been discussed and reviewed in Ameen (1988) and Goodwin (1997) and it is found to be a useful practical tool for time series forecasting. A multivariate and matrix-variate version of DWR are developed in Triantafyllopoulos and Pikoulas (2002) and these authors give an estimate of the measurement covariance matrix based on least-squares estimation methods.

In this paper, using discount weighted regression, we provide an efficient methodology for estimation and forecasting for the multivariate local level model. The measurement covariance matrix of the noise vector is assumed unknown and it is estimated from the data using a standard maximum likelihood procedure. As a practical illustration of the proposed methodology we consider data consisting of aluminium spot and future contract prices. It is our belief that these data are interesting for two reasons: they have strong similarities with international exchange rates data and they are not often discussed in the literature.

This paper is organized as follows. Section 2.1 gives the general description of discount regression as developed in Triantafyllopoulos and Pikoulas (2002). Section 2.2 shows that multivariate local level models with unknown noise covariance matrices can be analyzed with discount regression techniques. The proposed local level model is illustrated by analyzing London metal exchange data in Section 3. Conclusions follow in Section 4 and the proofs are given in the Appendix.