Testing for nonlinearities in German bank stock returnsa

Reinhold Kosfeld1, Sophie Robé2

1 Universität Kassel, Fachbereich Wirtschaftswissenschaften, 34109 Kassel, Germany
2 Commerzbank, Neue Mainzer Straße 32-36, 60261 Frankfurt am Main, Germany

First version received: May 1999/Final version received: October 2000

Abstract. In this paper nonlinear structures in German bank stock returns are investigated in a stochastic modelling framework. In the first step we show the existence of a nonlinear return structure by means of the McLeod-Li and the BDS test. In the second step we focus our analysis on the kinds of nonlinearity actually present in bank stock data. On the basis of the Hsieh test it is possible to discriminate with high power additive from multiplicative dependencies to provide guidance for the choice of an adequate class of stochastic models. It is shown that the multiplicative dependencies predominating the bank stock returns can be captured by low order GARCH models.

Key words: Return structures, nonlinearity tests, nonlinear modelling

JEL classification: C12, E44, G14

1. Introduction

The last two decades have seen the development of new techniques and models for analysing nonlinear relationships in financial time series. Recent work (see e.g. Brock, Hsieh and Le Baron, 1992) presents strong evidence that the assumption of nonlinearity is justified at least in modelling time variation in the second-order moments measuring the risk of financial investments. The classes of autoregressive conditional heteroskedasticity models (ARCH models) (Engle, 1982) and generalized autoregressive conditional heteroskedasticity models (GARCH models) (Bollerslev, 1986) designed to capture

---

a This paper has been presented at the Whitsun Conference of the German Statistical Society, Section Empirical Economic Research and Applied Econometrics, May, 26–28, 1999, Heidelberg.

To get more insight into valuation processes in the financial sector of the economy we investigate the bank segment of the German stock market with respect to nonlinear dependencies present in the return generation process. The return series are subjugated to extensive testing procedures. To disentangle the effects arising together from linear and nonlinear dependencies the data are linearly filtered in the first step with the aid of ARMA models. If ARMA modelling is successful, any remaining structures in the ARMA residuals must be nonlinear in their nature. Nonlinearities in the time series are at first diagnostically exposed with the aid of the McLeod-Li test (McLeod and Li, 1983). The findings are strongly corroborated by the BDS test (Brock, Dechert, and Scheinkman, 1987) which has high power against uncorrelated, but not independent stochastic processes (Brock, Hsieh, and LeBaron, 1992, pp. 62). However, both tests lack the ability to reveal the kind of nonlinear dependency with which we have to deal. It is not possible to discern whether the nonlinearity is deterministic or stochastic in nature, nor can we distinguish between multiplicative and additive dependencies. Since we are concerned with finding return structures in a stochastic modelling framework it is the latter issue that matters here. The kind of stochastic nonlinearity can be discovered on the basis of the Hsieh test (Hsieh, 1989). Although the Hsieh test has a high power in discriminating additive from multiplicative dependencies it has scarcely been used as a diagnostic tool for nonlinear stochastic modelling.

We wish to examine whether nonlinear stochastic models are able to cope with the nonlinear return structures found in the bank stock data. Within the nonlinear stochastic modelling framework a differentiation between multiplicative and additive dependence is of great importance when choosing an adequate model. Multiplicative dependence means that the nonlinearity enters through the variance into the return generating process, in contrast to an additive nonlinear dependence which affects the mean of the process. Due to their design, GARCH models are able to capture multiplicative nonlinear return structures. In our investigation the question of the occurrence of supplementary additive dependencies obtains a high stress, which means that hybrid nonlinear models like the GARCH-in-the-mean model (GARCH-M model) could gain prominence, rather than purely additive nonlinear models.