

Research Article

Modeling Markov Switching ARMA-GARCH Neural Networks Models and an Application to Forecasting Stock Returns

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The study has two aims. The first aim is to propose a family of nonlinear GARCH models that incorporate fractional integration and asymmetric power properties to MS-GARCH processes. The second purpose of the study is to augment the MS-GARCH type models with artificial neural networks to benefit from the universal approximation properties to achieve improved forecasting accuracy. Therefore, the proposed Markov-switching MS-ARMA-FI-GARCH, FI-GARCH, and FIAPGARCH processes are further augmented with MLP, Recurrent NN, and Hybrid NN type neural networks. The MS-ARMA-GARCH family and MS-ARMA-GARCH-NN family are utilized for modeling the daily stock returns in an emerging market, the Istanbul Stock Index (ISE100). Forecast accuracy is evaluated in terms of MAE, MSE, and RMSE error criteria and Diebold-Mariano equal forecast accuracy tests. The results suggest that the fractionally integrated and asymmetric power counterparts of Gray's MS-GARCH model provided promising results, while the best results are obtained for their neural network based counterparts. Further, among the models analyzed, the models based on the Hybrid-MLP and Recurrent-NN, the MS-ARMA-FIAPGARCH-HybridMLP, and MS-ARMA-FIAPGARCH-RNN provided the best forecast performances over the baseline single regime GARCH models and further, over the Gray's MS-GARCH model. Therefore, the models are promising for various economic applications.

1. Introduction

In the light of the significant improvements in the econometric techniques and in the computer technologies, modeling the financial time series have been subject to accelerated empirical investigation in the literature. Accordingly, following the developments in the nonlinear techniques, analyses focusing on the volatility in financial returns and economic variables are observed to provide significant contributions. It could be stated that important steps have been taken in terms of nonlinear measurement techniques focusing on the instability or stability occurring vis-a-vis encountered volatility. Further, the determination of stability or instability in terms of volatility in the financial markets gains importance especially for analyzing the risk encountered. In addition to impact of the magnitude and the size of shocks

on volatility, the financial returns are under the influence of sudden or abrupt changes in the economy. Hence, the volatility of economic data has been explored in econometric literature as a result of the need of modelling uncertainty and risk in the financial returns. The relationship between the financial returns and various important factors such as the trade volume, market price of financial assets, and the relationship between volatility, trade volume, and financial returns have been vigorously investigated [1–4].

The ARCH model introduced by Engle [5] and the Generalized ARCH (GARCH) model introduced by Bollerslev [6] are generally accepted for measuring volatility in financial models. GARCH models have been used intensively in academic studies. A tremendous amount of GARCH models exist and various studies provide extended evaluation of the development.

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Terry C. Jones



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Markov-switching GARCH Models and Applications to Digital Speech Processing Ari Abramson, Tekhniyon, Makhon tekhnologi le-Yisra'el. Fakultah le-handasat hashmal, 2007 Istanbul as a Global Financial Center Melike Bildirci, Murat Karagöz, Cemal Zehir, 2017-08-21 This book brings together analyses of a wide range of economic and financial subjects including any issue related to these broader concepts such as development banking crises energy and Islamic finance among others It offers a clear discussion of the current period of economic transition and the future prospects of developing countries in terms of financial and economic perspectives It will serve to raise awareness of the important opportunities and risks inherent in the global financial system and makes a valuable contribution to wider economic debates by identifying the priorities and policy prescriptions that will help countries to realise their potential The book will particularly appeal to academicians and students as well as researchers and professionals in the fields of economics finance and business It may also serve as a secondary textbook for courses about Eurasian countries in economics and finance departments of higher learning institutions Disruptive Innovation in Business and Finance in the Digital World J. Jay Choi, Bora Ozkan, 2019-10-21 This volume contains fourteen articles split across four parts exploring the debate around the topics of fintech AI blockchain and cryptocurrency Featuring a cast of global contributors this is an unmissable volume exploring the most current research on digital innovation in the financial and business worlds **Alternative Assets and Cryptocurrencies** Christian Hafner, 2019-07-26 Alternative assets such as fine art wine or diamonds have become popular investment vehicles in the aftermath of the global financial crisis Correlation with classical financial markets is typically low such that diversification benefits arise for portfolio allocation and risk management Cryptocurrencies share many alternative asset features but are hampered by high volatility sluggish commercial acceptance and regulatory uncertainties This collection of papers addresses alternative assets and cryptocurrencies from economic financial statistical and technical points of view It gives an overview of their current state and explores their properties and prospects using innovative approaches and methodologies Machine Learning, Optimization, and Data Science Giuseppe Nicosia, Varun Ojha, Emanuele La Malfa, Gabriele La Malfa, Giorgio Jansen, Panos M. Pardalos, Giovanni Giuffrida, Renato Umeton, 2022-02-01 This two volume set LNCS 13163 13164 constitutes the refereed proceedings of the 7th International Conference on Machine Learning Optimization and Data Science LOD 2021 together with the first edition of the Symposium on Artificial Intelligence and Neuroscience ACAIN 2021 The total of 86 full papers presented in this two volume post conference proceedings set was carefully reviewed and selected from 215 submissions These research articles were written by leading scientists in the fields of machine learning artificial intelligence reinforcement learning computational optimization neuroscience and data science presenting a substantial array of ideas technologies algorithms methods and applications **Business Periodicals Index**, 1999 Modelling Volatility with Markov-switching GARCH Models María Ferrer Fernández, 2022 **An Implementation**

of Markov Regime Switching GARCH Models in Matlab Thomas Chuffart, 2017 MSGtool is a MATLAB toolbox which provides a collection of functions for the simulation and estimation of a large variety of Markov Switching GARCH MSG models. Currently, the software integrates a method to select the best starting values for the estimation and a post-estimation analysis to ensure the convergence. The toolbox is very flexible and user-friendly with a large number of possible options. In this paper, we give some illustrative examples.

Marginal Likelihood for Markov-switching and Change-point GARCH Models Luc Bauwens, Jeroen V. K. Rombouts, Arnaud Dufays, CIRANO., 2011

A New Approach to Markov-Switching GARCH Models Markus Haas, 2010. The use of Markov switching models to capture the volatility dynamics of financial time series has grown considerably during past years in part because they give rise to a plausible interpretation of nonlinearities. Nevertheless, GARCH type models remain ubiquitous in order to allow for nonlinearities associated with time-varying volatility. Existing methods of combining the two approaches are unsatisfactory as they either suffer from severe estimation difficulties or else their dynamic properties are not well understood. In this article, we present a new Markov switching GARCH model that overcomes both of these problems. Dynamic properties are derived and their implications for the volatility process discussed. We argue that the disaggregation of the variance process offered by the new model is more plausible than in the existing variants. The approach is illustrated with several exchange rate return series. The results suggest that a promising volatility model is an independent switching GARCH process with a possibly skewed conditional mixture density.

Theory and Inference for a Markov Switching GARCH Model Luc Bauwens, Jeroen V. K. Rombouts, Arie Preminger, Ecole des hautes études commerciales (Montréal, Québec). Centre de recherche en e-finance, HEC Montréal. Centre de recherche en e-finance, 2007

Markov-Switching GARCH Models in R David Ardia, 2019. We describe the package MSGARCH which implements Markov switching GARCH models in R with efficient C object-oriented programming. Markov switching GARCH models have become popular methods to account for regime changes in the conditional variance dynamics of time series. The package MSGARCH allows the user to perform simulations as well as Maximum Likelihood and MCMC Bayesian estimations of a very large class of Markov switching GARCH type models. The package also provides methods to make single step and multi step ahead forecasts of the complete conditional density of the variable of interest. Risk management tools to estimate conditional volatility, Value at Risk, and Expected Shortfall are also available. We illustrate the broad functionality of the MSGARCH package using exchange rate and stock market return data.

Estimating and Testing Markov Switching Models with Economic and Financial Applications René Garcia, 1992

A Family of Markov-Switching GARCH Processes Ji-Chun Liu, 2012

Long Memory with Markov-Switching GARCH., 2008

Markov Switching Models for Volatility Monica Billio, 2013. This paper is devoted to show duality in the estimation of Markov Switching MS processes for volatility. It is well known that MS GARCH models suffer of path dependence which makes the estimation step unfeasible with usual Maximum Likelihood procedure. However, by rewriting the MS GARCH model

in a suitable linear State Space representation we are able to give a unique framework to reconcile the estimation obtained by the Kalman Filter and with some auxiliary models proposed in the literature Reasoning in the same way we present a linear Filter for MS Stochastic Volatility MS SV models on which different conditioning sets yield more flexibility in the estimation Estimation on simulated data and on short term interest rates shows the feasibility of the proposed approach

Long Memory with Markov-Switching GARCH ,2008 *Essays on Applications of Markov Regime Switching and Time-Varying Volatility Models in Finance and Macroeconomics* ,2007 Long Memory with Markov-Switching GARCH
Walter Krämer,2006 **Value-at-risk in a Markov Regime-switching GARCH Framework** Rasoul Sajjad,2007

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