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## The JLS model with ARMA/GARCH errors

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**Abstract:** Prior to crashes, the stock index price time series is characterised by the Log-Periodic Power Law (LPPL) equation of the Johansen–Ledoit–Sornette (JLS) model, which leads to a critical point indicating a change to a new market regime. In this paper, we describe the hierarchical diamond lattice, upon which the JLS model is derived, using the diamond lattice operation  $D_i$  and derive the recursion for the coefficients of the growth function in a diamond lattice rooted at the main root vertex  $r_m$ . Further, to verify the adequacy of the JLS model, we analyse the model’s residuals and propose its generalization, using the ARMA/GARCH error model. We determine the ARMA/GARCH orders using the extended autocorrelation function (EACF) method and compare the results with those of the Akaike and Bayesian Information Criteria. Using the data for 33 major world stock indices we show, that proposed generalization of the JLS model in general performs better in predicting the market regime changes and has also the ability to recognise false bubble identification, indicated by the JLS model.

**Keywords:** Graph operations, hierarchical diamond lattice, JLS model, financial bubbles and crashes, ARMA/GARCH errors.

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## JLS model z ARMA/GARCH napakami

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**Povzetek:** Pred poki je časovna vrsta cene borznega indeksa karakterizirana z Log-Periodic Power Law (LPPL) enačbo Johansen–Ledoit–Sornette (JLS) modela, ki vodi do kritične točke, ki kaže spremembo k novemu režimu trga. V tem članku opišemo hierarhično karo mrežo, iz katere je izpeljan JLS model z uporabo operacije  $D_i$  na karo mreži, in izpeljemo rekurzijo za koeficiente funkcije rasti v karo mreži, vkoreninjeni pri glavnem korenskem vozlišču  $r_m$ . Nadalje, da bi preverili ustreznost JLS modela, analiziramo modelove residue in predlagamo njegove posplošitve, uporabljajoč ARMA/GARCH model napak. Določimo ARMA/GARCH rede z uporabo razširjene metode avtokorelacijske funkcije (EACF) in primerjamo rezultate s tistimi, dobljenimi z Akaike in Bayesovim informacijskim kriterijem. Z uporabo podatkov za 33 večjih svetovnih borznih indeksov pokažemo, da predlagana posplošitev JLS modela v splošnem bolje napoveduje režim tržnih sprememb in ima tudi sposobnost prepoznati lažno identifikacijo mehurčkov, kot jo kaže JLS model.

**Ključne besede:** Operacije na grafih, hierarhična karo mreža, JLS model, finančni mehurčki in poki, ARMA/GARCH napake.

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