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Bootstrap Score Tests for Fractional Integration in Heteroskedastic ARFIMA Models, with an Application to Price Dynamics in Commodity Spot and Futures Markets*

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Abstract

Empirical evidence from time series methods which assume the usual I(0)/I(1) paradigm suggests that the efficient market hypothesis, stating that spot and futures prices of a commodity should co-integrate with a unit slope on futures prices, does not hold. However, these statistical methods are known to be unreliable if the data are fractionally integrated. Moreover, spot and futures price data tend to display clear patterns of time-varying volatility which also has the potential to invalidate the use of these methods. Using new tests constructed within a more general heteroskedastic fractionally integrated model we are able to find a body of evidence in support of the efficient market hypothesis for a number of commodities. Our new tests are wild bootstrap implementations of score-based tests for the order of integration of a fractionally integrated time series. These tests are designed to be robust to both conditional and unconditional heteroskedasticity of a quite general and unknown form in the shocks. We show that the asymptotic tests do not admit pivotal asymptotic null distributions in the presence of heteroskedasticity, but that the corresponding tests based on the wild bootstrap principle do. A Monte Carlo simulation study demonstrates that very significant improvements in finite sample behaviour can be obtained by the bootstrap *vis-à-vis* the corresponding asymptotic tests in both heteroskedastic and homoskedastic environments.

Keywords: Bootstrap; efficient market hypothesis; fractional integration; score tests; spot and futures commodity prices; time-varying volatility

J.E.L. Classifications: C12, C22, C58, G13, G14.

1 Introduction

A large body of empirical literature has developed aimed at assessing to what extent futures commodity markets are efficient. Suppose we let s_t denote the (log) spot price of a particular commodity at time t, and let $f_t^{(k)}$ denote the (log) price of the corresponding k-period futures contract at time t, with k a positive constant. Then, in its simplest form, the Efficient Market Hypothesis (EMH, hereafter) states that in a frictionless market $f_t^{(k)}$ is an unbiased predictor of s_{t+k}; that is,

$$f_t^{(k)} = E\left(s_{t+k}|\mathcal{I}_t\right), \tag{1.1}$$

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