Testing rational speculative bubbles in Central European stock markets

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December 6, 2012

Motivation

- Rational speculative bubbles are one of the cornerstones of the financial theory
- No deliberate and conventional empirical solution of detection and prediction
- Asset bubbles in emerging markets, such as China, MENA region countries, Thailand
- European emerging markets undergone a rapid growth in 2004-2007
- Market inefficiency of Central European stock markets
- No empirical research on asset bubbles in European emerging markets

Rational speculative bubble model (1)

Assumptions

- Investors' behaviour is rational
- Market with symmetric information
- Stock prices constantly deviate from their fundamental value
- Expected return of an asset is equal to the required return (efficient market condition): $E(R_{t+1}) = r_{t+1}$
- Asset return: $R_{t+1} = \frac{p_{t+1} - p_t + d_{t+1}}{p_t}$
- Current price of the stock equals the sum of the expected future price and the dividends discounted at the return required by investors:

$$p_t = \frac{E_t(p_{t+1} + d_{t+1})}{1 + r_{t+1}}$$

Rational speculative bubble model (2)

Efficient market hypothesis

$$p_t = \sum_{i=1}^{\infty} \frac{E_t(p_{t+i} + d_{t+i})}{\prod_{j=1}^{i}(1+r_{t+j})}$$

Expected discount value of an asset in the indefinite time converges to zero:

$$\lim \frac{E_t(p_{t+i})}{\prod_{j=1}^{i}(1 + r_{t+j})} = 0$$

Fundamental value of asset is determined by future payments of dividends:

$$p_t = \sum_{i=1}^{\infty} \frac{E_t(d_{t+i})}{\prod_{j=1}^{i}(1+r_{t+j})}$$

Rational speculative bubble model (3)

Bubble factor

Rejecting the assumption of zero convergence leads to an infinite number of solutions:

$$p_t = p_t^* + b_t \text{ and } E_t(b_{t+1}) = (1 + r_t)b_t$$

Price changes $\varepsilon_{t+1} = R_{t+1} - r_{t+1}$ emerge from two unobservable sources:

- changes in fundamental value $\mu_{t+1} = p^*_{t+1} + d_{t+1} - (1 + r_{t+1})p^*_t$
- changes in the size of bubble $\eta_{t+1} = b_{t+1} - (1 + r_{t+1})b_t$

Rational speculative bubble model (4)

Formation of price changes with possible bubble innovations

Given the probability π,
the observable price change $\varepsilon_{t+1} = \mu_{t+1} + \eta_{t+1}$ equals the sum of the change in fundamental value and changes of the bubble size:

$$\begin{aligned} \varepsilon_{t+1} &= \mu_{t+1} + \tfrac{\pi}{1-\pi}((1+r_{t+1})b_t - a_o) \quad \text{with probability } \pi \\ &= \mu_{t+1} + (1+r_{t+1})b_t + a_o \quad \text{with probability } 1-\pi \end{aligned}$$

where $a_0 \geq 0$ is an initial bubble value (allows for continuously repeating periods of bubble shrinking and expanding)

Choising a test procedure

Empirical tests of stock market bubbles

- variance bound test
- two-step test (West 1987)
- cointegration test
- regime switching test
- duration dependence test
- Kalman filter
- Hurst exponent persistence test

Choising a test procedure

Critique

- Majority of tests directly compares actual prices with fundamentals
- Effectivity of such tests depends on the specification of fundamentals
- Gurkaynak (2005) in the review of asset bubble test techniques:

> *"For almost every study that finds a bubble, there is another one that relaxes some assumption on the fundamentals and fits the data equally well without resorting to a bubble."*

- Test procedure should not be determined to capture fundamental value accurately

Non-parametric duration dependence test

McQueen and Thorley (1994)

If securities prices exhibit bubble behavior, then runs of positive abnormal returns will reveal negative duration dependence with an inverse relation of a run ending and the length of run

$$h_{i+1} < h_i,$$

where $h_i = P(\varepsilon_t < 0 \,|\, \varepsilon_{t-1} > 0, \varepsilon_{t-2} > 0, \ldots, \varepsilon_{t-i} > 0, \varepsilon_{t-i-1} < 0)$

Non-parametric duration dependence test

Estimation procedure

1. Transform time series of abnormal returns into two series of run lengths of positive and negative abnormal returns
2. Count number of runs of particular length i (N_i) and number of runs with a length greater than i (M_i)
3. Sample hazard rate for certain run length: $\hat{h}_i = N_i/(N_i + M_i)$
4. Hazard function $h_i = P(I = i \,|\, I \geq i)$ is defined by $h_i = f_i/(1 - F_i)$
5. Log-likelihood $L(\Theta|S_T) = \sum_{i=1}^{\infty} N_i \ln h_i + M_i \ln(1 - h_i)$
6. Choose a functional form of the hazard function (exponential, Weibull, extreme-value)

Non-parametric duration dependence test

Critique

Duration dependence test is sensitive to the choice of

- sample period
- method by which abnormal returns are identified
- stocks' weight in portfolios or indices chosen to represent the market
- periodicity - daily, weekly or monthly returns

Data

PX, WIG20 and BUX index movements (scaled)

Methodology

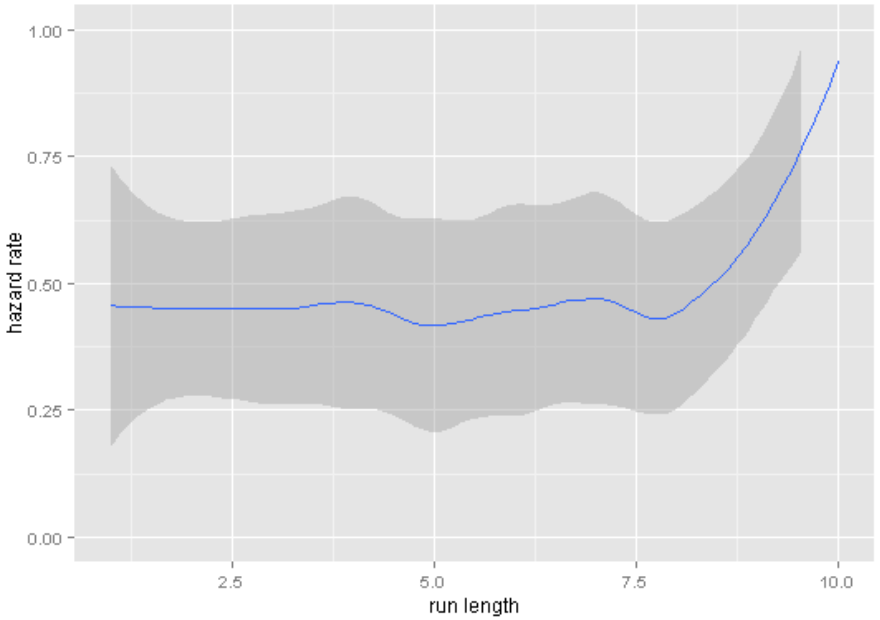
1. Weekly prices are calculated as an arithmetic mean of within-the-week daily prices
2. Prices are transformed into continuously compounded returns
3. Abnormal return are identified as error terms from an autoregressive model $AR(p)$ on normal returns with a dividend price ratio as an independent variable
4. Duration dependence test:

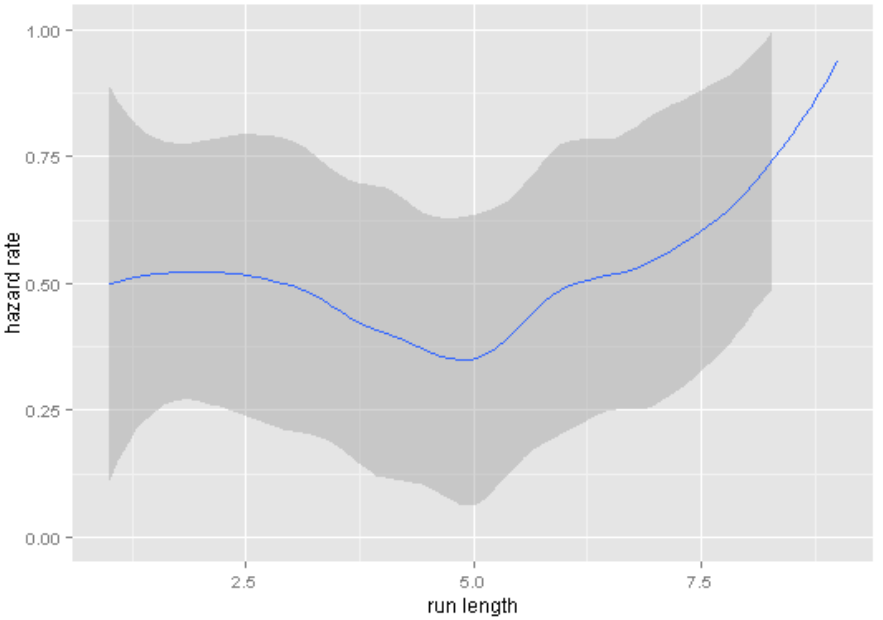
$$h_i = \frac{1}{1 + e^{-(\alpha + \beta \ln i)}}$$

We are maximizing log-likelihood function with respect to α and β
H_0: $\beta = 0$ (constant hazard rates)
H_1: $\beta < 0$ (decreasing hazard function)

Results: stock indices

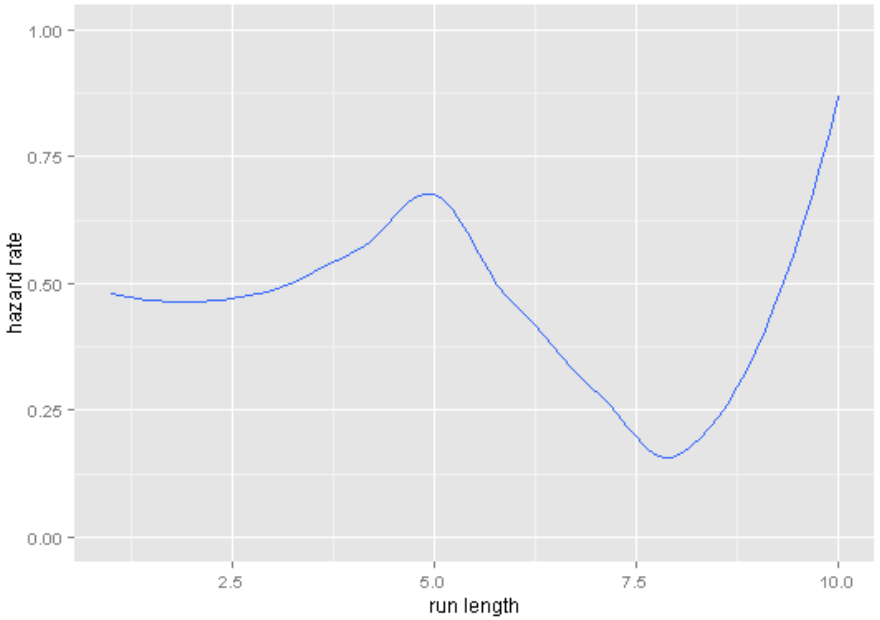
Smoothed hazard functions for stock indices PX and WIG20

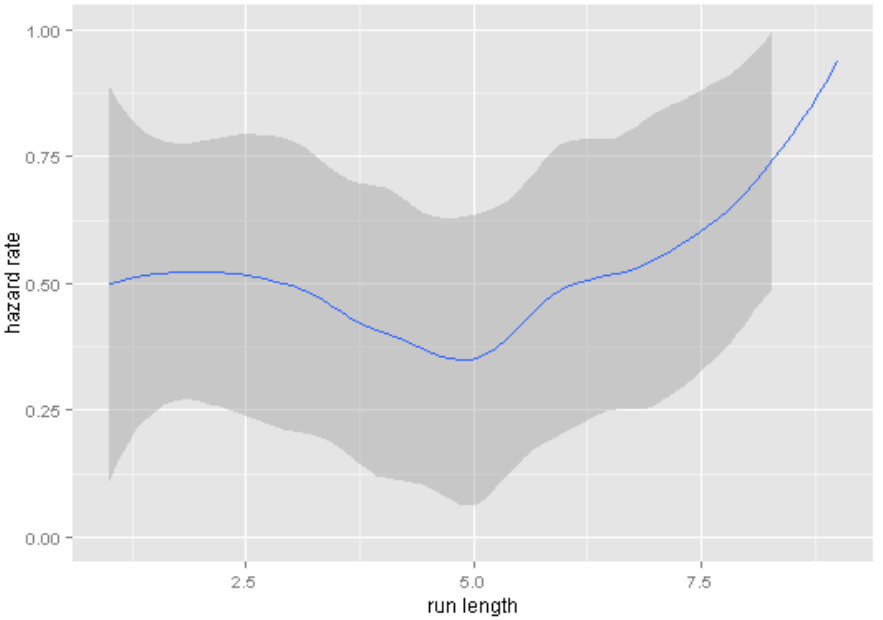




Results: stock indices

Smoothed hazard functions for stock indices BUX and WIG20





Results: individual stocks

Results of duration dependence test are indicative of the presence of bubbles in few cases:

- Czech stock market
  - KIT Digital (IT company)
- Polish stock market in the pre-crisis period
  - chemical sector: Boryszew and PKN Orlen
  - telecommuncations sector: TVN
- Hungarian stock market
  - energy sector: EST Media (technologies of energy efficiency) and PannErgy (renewable energy resources)

Cocnlusions

- Creation of bubbles in the chosen Eastern European market was probably prevented by availability of Czech, Polish and Hungarian highly capitalized stocks in the more developed stock markets, such as US, UK and Germany
- Studied Eastern European stock markets are not completely free of bubbles
  - We evidenced the existence of a rational speculative bubble in the Polish stock market in the period of its to-date biggest growth and narrowed it to the chemical sector
- Stock of leading-edge companies exhibit bubble behavior
  - Bubbles are found in stocks representing new business sectors, such as cloud-based software and services, renewable energy resources and energy efficiency technologies