



The Public Defense  
of the Doctoral Thesis in Economics  
by

Peter Farkas

on

Boundary Crossing Counting Processes  
Theory and Applications in Statistics and Finance

will be held on

Friday, January 15, 2015 at 1:30 pm

in the

FT room 809  
Central European University  
Nádor Street 9, Budapest

**Thesis Committee:**

Julius Horváth (Chair)

Andrzej Baniak (Internal member)

Robert Lieli (Internal member)

Attila Kincses (External member)

Ádám Szentpéteri (External member)

**Supervisors:**

László Mátyás (Supervisor)

Péter Kondor (Associate supervisor)

**Examiners:**

Robert Lieli,

Associate Professor of Economics, Central European University, Budapest  
and Senior Researcher, The National Bank of Hungary

(Internal Examiner)

Timo Teräsvirta, Professor of Economics,

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(External Examiner)

The doctoral thesis is available for inspection  
at the CEU Economics Department

## Abstract

This thesis presents some new results in the field of statistics and finance. As for the former, we discuss how to make nonparametric inference without relying on asymptotic approximation. As for the latter, we solve the optimal portfolio choice problem without describing security prices with a parametric model.

These results are accomplished by representing and analyzing the data using a new, state-dependent, perspective. More precisely, we relate to the sampling frequency in a new way. Let us consider the equation below:

$$\Delta X_t = X_t - X_{t-c},$$

where  $X_t$  is a stochastic process with memory and  $c$  is the sampling frequency. In many econometric studies, the data generating process is represented and analyzed as if it were sampled using some constant sampling frequency. Typically,  $c$  is chosen to be one, that is  $\Delta X_t = X_t - X_{t-1}$ , for data published with monthly frequency,  $c$  is equal to one months, for daily observations  $c$  is equal to one day.

This thesis takes an inverse approach. We represent and analyze the data generating process as if it were sampled by a specific random frequency. More precisely, we exogenously fix  $\Delta X_t = X_t - X_{t-c}$  to be either some predefined positive,  $U$ , or negative,  $L$ , number and allow the sampling frequency to vary.

$$\Delta X_t = X_t - X_{T^A} = \begin{cases} U \\ L \end{cases}$$

where  $T^A$ , as explained later, represents a boundary crossing moment. Thus, in our representation, the sampling frequency,  $c$ , is random and the data is represented using boundary crossing events. This representation requires us to introduce new stochastic processes which characterize these boundary crossing events.

This new perspective opens up new opportunities in the field of statistics and in finance. As for the former, using this representation, nonparametric inference can be made without relying on asymptotic approximation. As for the latter, we can solve the optimal portfolio choice problem without describing the security prices with a parametric model.

The thesis consists of three chapters. Each chapters is a self-standing article intended for publication in peer-reviewed journals. Thus, they are kept as separate entities. Consequently,

sometimes the content of the thesis is repetitive although an effort was made to reduce redundancy as much as possible.

The first chapter aims to provide a brief theoretical foundation hence its results are applied throughout the thesis. It also discusses univariate unit root testing from this new perspective. The next chapter extends some of the results of the first chapter to panel data settings. The last chapter applies the theoretical results of the first chapter to solve the optimal portfolio choice problem. The abstract of each chapters is as follows.

### **Ch.1: Counting Process Generated by Boundary Crossing Events: Theory and Applications in Nonparametric Statistics**

This chapter introduces and analyzes a new class of stochastic process, named the Boundary Crossing Counting (BCC) process. It shows how to obtain the upper and lower crossing distribution which counts how many times a stochastic process crosses some exogenously defined boundaries. Also, it derives the upper minus lower crossing distribution using a binomial grid. The methods of estimation are calibrated by comparing analytical and estimated BCC distributions. The next part of the chapter shows how to use boundary crossing events to test for unit roots. Our Monte Carlo studies show that the proposed test is more powerful than the Augmented Dickey-Fuller test or the Phillips-Perron test in time series settings when the error term has t-distribution and the time-dimension is relatively short. It is also more powerful than the Variance ratio test. We conclude with a financial application in which we show that based on Shiller's data, the excess total return based on S&P500 exhibits mean reverting behavior.

### **Ch.2: Testing for Unit Roots in Panel Data with Boundary Crossing Counts, which is joint work with Laszlo Matyas.**

This chapter introduces a new, distribution free, non-asymptotic, approach for unit root testing based on boundary crossing counts. Using this approach, we develop two versions of a panel unit root test. The first can be applied in the case of cross-sectionally independent panel data, while the second is designed for cross-sectionally dependent panels. As for the results, the first version of the newly proposed test dominates the IPS test and the Maddala-Wu test in case of relatively short, cross-sectionally independent panel data. The second version is more powerful than existing second generation panel data tests, such as Bai and Ng's PANIC unit root test or Pesaran's CADF test in case the data is generated by a multi-factor model and the time

dimension is relatively short. Next, we show that the unit root hypothesis cannot be rejected on real exchange rate data hence we do not find supportive evidence for the PPP hypothesis. Finally, we discuss various methodological issues related to this newly proposed test.

### **Ch.3: Portfolio Choice Without Distributional Assumptions: State-dependent Rebalancing in the Nonparametric Domain**

We solve the portfolio choice problem without distributional assumptions by extending the use of state-dependent rebalancing to nonparametric settings. We propose a specific, state-dependent rebalancing and show how it is related to the Kelly criterion. Under this rebalancing, the full distribution of the portfolio's terminal value can be approximated by a well-behaving and discrete probability distribution based on boundary crossings. When applied to parametric specifications under transaction costs, the method replicates the baseline results of the geometric Brownian motion. As for nonparametric applications, first, we show that the log-optimal allocation in the US was a leveraged purchase; next we find that leveraged returns were significantly different in various epochs. We continue by explaining how this newly-proposed method can be used for density forecast and conclude with some additional technical details.

# CURRICULUM VITAE

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## Education

2009 – 2015 Ph.D. Candidate in Economics, Central European University (CEU),  
Budapest, Hungary

2000 – 2005 MSc in Economics at the Corvinus University of Budapest, Hungary –  
majoring in Investment Analysis and Risk Management

2001 – 20015 Mathias Corvinus Collegium (<http://www.mcc.hu>), Budapest, Hungary

## Research Interest

Finance, focusing on optimal portfolio choice

Econometrics, focusing on distribution-free methods

Energy economics

## Publications and Conference Presentations

*Testing for Unit Roots in Panel Data with Boundary Crossing Counts* (CEU Working  
paper, [http://econpapers.repec.org/paper/ceueconwp/2015\\_5f5.htm](http://econpapers.repec.org/paper/ceueconwp/2015_5f5.htm))

*Counting Process Generated by Boundary-crossing Events. Theory and Statistical  
Applications* (CEU Working paper,  
[http://econpapers.repec.org/paper/ceueconwp/2013\\_5f4.htm](http://econpapers.repec.org/paper/ceueconwp/2013_5f4.htm))

International Association of Applied Econometrics, Poster Presentation, London,  
2014.

## Teaching experience and grants

Write-up Grant, CEU, November 2014 – March 2015

Macroeconomic Analysis (seminar), Mathias Corvinus Collegium, 2012  
Econometrics (teaching assistance, graduate level), CEU, 2011  
Macroeconomics (teaching assistance, graduate level), CEU, 2010-2011

### **Business affiliations**

2015 - Chief Economist at First National Utility Ltd., Budapest, Hungary  
2013 - Member of the Supervisory Board, Morando Venture Capital Ltd.  
2012 – 2013 Member of the Supervisory Board, MetaP Ltd.  
2008 – 2009 Manager for Product Development at Vertis Environmental Finance Ltd., Budapest, Hungary  
2004 – 2008 Manager for Product Development and actuarial analysis at Hild Life Annuity Services Ltd., Budapest, Hungary

### **Languages and informatics**

English (fluent), French (fair), Hungarian (native)  
Matlab, Clojure, R, Excel + VBA

### **Non-profit activities**

Helping innovators to put ideas into actions  
EVIME (<http://www.uwc.hu/>)

### **Personal**

Date of birth: November 7<sup>th</sup>, 1980  
Citizenship: Hungarian