
The Public Defense
of the Doctoral Thesis in Economics

by

**Péter Zsohár**

on

# Three Essays in Industrial Organization

will be held on

Thursday, November 29, 2018 at 10:00 a.m.

in

Quantum Room (101), Nádor 15
Central European University
Nádor street 9, H-1051 Budapest, Hungary

**Thesis committee:**

László Mátyás (Chair)
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Sergey Lychagin (Internal member)

**Supervisor:**

Miklós Koren

**Examiners:**

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Sergey Lychagin, Assistant Professor, Central European University (Internal examiner)

The doctoral thesis is available for inspection
at the CEU Department of Economics and Business.

**Abstract**

The thesis consists of three chapters. The first two papers are related to the economic policy question of Network Neutrality, while the third paper studies competition on the retail gasoline market. The three papers build on a diverse set of tools. The first chapter is a computational theory paper where the main emphasis is on a new theoretical modeling framework. The second chapter involves empirical data analysis and numerical methods to conduct counterfactual analysis related to an actual economic policy matter. The third chapter is a methodological paper where I develop and demonstrate the working of a new empirical framework.

**Chapter 1 – Net Neutrality in a Dynamic Platform Market Environment**

The contribution of this paper is a dynamic industry model that enables researchers and policy makers to directly analyze the anecdotal positive feedback loop (the so called "virtuous cycle") that lies at the heart of the Federal Communication Commission's (FCC) Open Internet Order that aims to establish the highly debated net neutrality principle as an effective rule on the Internet. The discrete time multi-agent dynamic stochastic game is an extended version of the framework of Ericson and Pakes (1995) and consists of two types of players (i) two Content Providers (CPs) differentiated by their product quality and (ii) a single Internet Service Provider (ISP) characterized by an actual network capacity. Both types have costly dynamic controls over their states. Agents' per-period payoffs represent profits from a platform market game. The novelty in my approach is that it allows for (i) both the no termination fee and the no paid priority forms of net neutrality, (ii) endogenous price setting and side-payments among agents in the stage game, (iii) dynamic restructuring of the industry as a response to the change in regulation, and (iv) direct analysis of the effects of net neutrality on the virtuous cycle. Although these features allow for more realistic interactions among agents they come at the price of analytic tractability. Hence, the model is solved numerically for a range of parameters by standard Newton-Raphson and Gaussian methods. Then I compare equilibrium strategies under four different regimes (i) net neutrality, (ii) termination fee, (iii) paid priority, and (iv) simultaneous termination and priority fees. In the comparisons I focus on three key

outcomes: investment to network capacity, innovation on the content provider side and consumer welfare.
**Keywords:** net neutrality, dynamic game, dynamic programming

### Chapter 2 – Counterfactual Analysis of Net Neutrality in a Calibrated Model

The Federal Communication Commission's (FCC) Open Internet Order seeks to regulate the Internet relying on an anecdotal feedback loop, the Virtuous Circle. Despite the scale of the issue there is very little or no empirical evidence that supports the claims of proponents or opponents of the proposed regulation. This paper makes an attempt to produce comparable ballpark figures for the potential economic effects of net neutrality in the United States. I use the model developed in my first chapter to study the outcomes of the counterfactual regulatory regimes in consideration. In order to reflect the actual market environment and to accommodate a greater number of firms it is necessary to increase the state space. However, this inflates the computational burden dramatically and deterministic solution methods are no longer applicable. For the dynamic game I propose a reinforcement learning algorithm closely following the stochastic algorithm of Pakes and McGuire (2001) but modified to handle the two types of agents in my model. To solve the stage game I use a parallelized homotopy algorithm to increase efficiency and robustness to different sets of parameter values. Then I calibrate the fundamental parameters of the model using various public data sources to match key observed moments. Using the computed equilibrium policies from all regulatory regimes I compare the alternative outcomes.
**Keywords:** net neutrality, counterfactual analysis, reinforcement learning, homotopy method

### Chapter 3 – Delineation of Market Areas Using Sparse Learning and Spatial Regularization

Market definition is a key part in industrial economic analyses both in antitrust and business cases. However, current state-of-the-art methods require either too strong assumptions about the market environment or too many proprietary data sources. These features

may make them unattractive or even inapplicable in court cases or in the everyday business setting. This paper applies modern statistical methods to analyze the mutual influence among prices of competing products. The key idea is to apply spatial regularization via the fused lasso to filter the noisy price data and to get rid of spurious associations. Then the procedure described in the paper can be used to identify market boundaries and to analyze the existence of pricing pressure in arbitrary product or geographic spaces. The main advantages of the method are (i) it is simple, (ii) it requires only publicly available data, (iii) it doesn't rely on any specific theoretical model, and (iv) it extends the current bivariate time-series analysis based methods to high dimensional settings with many products. To demonstrate the potential usefulness the method is applied to weekly consumer prices of gasoline stations in Hungary to highlight markets that could be potentially harmed by a hypothetical merger between to competitors.
**Keywords:** market definition, spatial pricing pressure, fused lasso, gasoline

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## Personal Information

Date and place of birth: 1984, New York, NY. Male. Hungarian citizen.

## Education

**Ph.D. in Economics**, Central European University (Hungary), 2018 (expected)
Primary fields: Industrial Organization, Applied Econometrics
Secondary field: Computational Methods
Advisor: prof. Miklós Koren

**Visiting Student**, Harvard University, Cambridge, MA, 2012-2013
Invited and supervised by prof. Ariel Pakes
Completed the Industrial Organization and Econometrics sequences

**M.Sc. in Quantitative Economics**, Corvinus University of Budapest (Hungary), 2008
Major: Operations Research

## Special Training

- Dynamic Programming, prof. John Rust, Cemmap, London, UK, 2015
- Empirical Models of Differentiated Products, prof. Steven Berry, Cemmap, London, UK, 2015
- Competition Policy Case Study Series, prof. Gergely Csorba, CEU, Budapest, Hungary, 2013
- Advanced Topics in Industrial Organization, prof. Paulo Somaini, MIT, Cambridge, MA, 2013
- Identification in Structural Econometrics, prof. Andrew Chesher, CEMMAP and UCL, London, UK, 2011
- Empirical Analysis of Market Outcomes, prof. Ariel Pakes, CEMFI, Madrid, Spain, 2011
- Structural Estimation for Industrial Organization, prof. Victor Aguirregabiria, Barcelona GSE, Spain, 2011

## Work Experience

**Data Scientist**, QuantCo, 2015-2017 (USA, part time), 2017-Present (Germany, full time)

**Freelance Business Consultant**, 2013-2015 (Hungary)

**Research Assistant**

- Prof. Miklos Koren, 2010-2011 and 2014-2016
- Prof. Ariel Pakes, Spring, 2013
- Hungarian Academy of Sciences, Computation and Automation Institute, 2007-2008

**Business Analyst**, Thesys Labs Ltd. (Hungary), 2008-2009

**Data Mining Analyst**, T-Systems – IQSYS Co. (Hungary), Summer Intern 2008

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## Teaching

**Lecturer**, Operations Research, Corvinus University of Budapest, Spring, 2007

**Teaching Fellow**

- Fall, 2011: Industrial Organization, International Economic Policy
- Fall, 2010: Mathematical Methods for Economists, Calculus
- 2006-2008: Operations Research, Optimization Models

## Research

**Publication**

„Short introduction to the Generalized Method of Moments", Hungarian Statistical Review, 90, 150-70, Dec 2012

**Working Papers**

„Counterfactual Analysis of Net Neutrality in a Calibrated Model", Oct 2017

„Net Neutrality in a Dynamic Platform Market Environment", Sep 2017

„Delineation of Market Areas Using Sparse Learning and Spatial Regularization", Aug 2017

„Identification with simple instruments in a semiparametric discrete choice model of Pakes and Porter (2013)", Oct 2013

„Geographical analysis of retail gasoline prices", Institute of Economics - Hungarian Academy Of Sciences discussion paper, with Gabor Bekes and Miklos Koren, May 2011, in Hungarian

## Presentations

- $16^{th}$ International Symposium on Dynamic Games and Applications, Amsterdam, 2014
- Central European University, Ph.D. workshop, 2010, 2011, 2012, 2013, 2014
- Harvard University, Industrial Organization Lightning Talks workshop, 2012
- Annual Conference of the Hungarian Society of Economists, 2011
- Hungarian Academy of Sciences - Decision Theory Seminar, 2008

## Grants

- Researcher Mobility Grant, PADS, Central Bank of Hungary, 2015-2016
- Rosztoczy Foundation Scholarship (USA), 2012-2013
- CERGE-EI Teaching Grant (CZ), 2010-2011
- Full Doctoral Fellowship, Central European University, George Soros Foundation, 2009-2012
- Young Researcher Fellowship, Hungarian Academy of Sciences, 2007-2008

## Computing Skills

Experienced: Python (PyData), R (Tidyverse)
Good working knowledge: Matlab, SQL

## Languages

Fluent: Hungarian, English
Intermediate: German, Russian

## Other Interests

Avid trail runner
Amateur jazz musician

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