University of Cologne

Department of Economics – Chair in Economics and Energy Economics

Quantitative Methods in Energy Economics

Winter Term 2019

Dr. Frank Obermüller

Schedule

11.10.2019 *14:00-15:30*	**Introductory Meeting** *KFR1, Institute of Energy Economics, Vogelsanger Str. 321a, 50827 Cologne*
18.10.2019 *09:00-17:00*	**Lecture Productivity Analysis** *KFR1*
08.11.2019 *14:00-16:00*	***Voluntary Programming Hour*** *If you have any particular questions on your project or on how to work with R, please join me at KFR 2, Institute of Energy Economics, Vogelsanger Str. 321a, 50827 Cologne*
11.11.2019	***Deadline Submission Paper I: Productivity Analysis*** Please submit your seminar paper by 23.59 to f.obermueller@hotmail.com **Mandatory**
15.11.2019 *09:00-15:00*	***Student Presentations I: Productivity Analysis*** *KFR1, exact time might vary depending on number of participants.* **Mandatory**
22.11.2019 *09:00-17:00*	**Lecture Electricity market optimization** *KFR1*
29.11.2019 *14:00-16:00*	***Voluntary Programming Hour*** *If you have any particular questions on your project or on how to work with GAMS, please join me at KFR 2*
09.12.2020	***Deadline Submission Paper II:*** **Electricity market optimization** Please submit your seminar paper by 23.59 to f.obermueller@hotmail.com **Mandatory**
13.12.2019 *09:00-15:00*	***Student Presentations II:*** **Electricity market optimization** *KFR1, exact time might vary depending on number of participants.* **Mandatory**

Course Objective

The objective of this course is to understand, implement and apply quantitative methods in energy economics. These methods allow fundamental insights for investment decisions e.g. of generation units (renewables, thermals) as well as operational decisions.

The course covers the fields of:

- (1) productivity analysis, i.e. benchmarking analyses which are used e.g. to determine the efficiency and thus the rate-of-return of the natural monopoly of transmission system operators.
- (2) electricity market optimization, i.e. applying dispatch models which allow to simulate the electricity system with its generating units to fulfill demand

The course aims on enabling the students to perform own analyses in the energy economic sector with these methods.

Course Summary

Course Requirements	The course is designed for Master students or PhD students with a background in energy economics. Each student is required to submit and present two short research proposals – one for each topic of "productivity analysis" and "energy market optimization". Each research proposal should not extent 2500 words (approx. 5 pages) which briefly states the purpose, an outline of the applied methodology and data, and a discussion of the results. Each presentation should be 15 mins with 5 mins discussion.
Language	English
Software	Students are required to use a suitable software for implementation and application of the quantitative methods. 1. Productivity analysis: I recommend using "R" as free statistical programming language, with existing packages for e.g. SFA and DEA. Other software as Stata or Python are suitable as well. (Link to "R": https://cran.r-project.org/bin/windows/) 2. Energy Market Optimization: It is recommended to install the free test Version of GAMS: https://www.gams.com/download/ The free Version with restricted number of variables and constraints is sufficient for the small test examples within the course.
Course structure	The course is split into two parts. The first part (first half of the sessions) are dedicated to the first topic of productivity analysis. The second part (second half of the sessions) are dedicated to the second topic of energy market optimization. Each part consists of a lecture day (covers theory), an on-your-own practical phase (method implementation, paper creation), and a presentation day (presentation and discussion of the paper).

Mode of Examination	combined examination The final grade consists of: • 25% Seminar Paper for EPA • 20% Presentation of seminar paper for EPA • 25% Seminar Paper for Energy Market Optimization • 20% Presentation of seminar paper for Energy Market Optimization • 10% Oral Discussion
Credits	6 ECTS
Lecturer	Dr. Frank Obermüller Mail: f.obermueller@hotmail.com
Organisation	M.Sc. Johanna Bocklet Mail: Johanna.bocklet@uni-koeln.de

Application

Master Students:

A maximum number of applicants of 16 students can be admitted to the course. Please register on KLIPS for the seminar as early as possible (first registration period).

After you receive a seat in the course, please make sure to register for the examination on KLIPS as well (use the Lehrveranstaltungsprüfung *"Quantitative Methods in Economics").* Only those, who have a seat in the seminar can register for the examination.

Once you have registered for the examination, the registration is binding and students who do not hand in a seminar paper or who do not present their paper will receive a failing grade. Thus, please make sure that you are able to attend the presentation days, before registering for the course.

PHD Students:

Please register by sending an Email to Johanna.bocklet@uni-koeln.de. Seats will be allocated on first come first serve basis.

Content

Part 1 – Empirical productivity analysis

Introduction:

Empirical productivity analysis is a suitable analysis and benchmarking methods to assess productivity of business units. One main application is for natural monopolies. Since natural monopolies do not fierce direct competition, productivity analysis is one option to assess their productivity. The distribution system operators in the energy system (electricity as well as gas) are a typical example for natural monopolies. The German regulator "Bundesnetzagentur" needs to assess the productivity of the distribution system operators in order to determine the allowed rate of return. Thus, the Bundesnetzagentur performs a productivity analysis and applies state-of-the-art benchmarking methods like Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). For each system operator, such as RheinEnergie or Stadtwerke München, it is highly relevant to achieve high results on the benchmarking to increase their rate-of-return. A deep understanding of

the drivers and methods in the benchmarking are therefore sufficient. This will be covered by the first part of the course.

Course agenda:

- Motivation and current Distribution System Operator (DSO) Regulation in Germany
- DEA: Basic Concepts, Additional topics, Case Studies
- SFA: Basic Concepts, Additional topics, Case Studies

Potential References (no must-read in advance):

- Bogetoft P. and Otto L. (2011), Benchmarking with DEA, SFA, and R, Springer.
- Coelli T., Prasada Rao D.S., O'Donnell C.J., and Battese G.E. (2005), An Introduction to Efficiency and Productivity Analysis 2nd Edition, Springer.
- Coelli T., Estache A., Perelman S., and Trujillo L. (2003), A Primer on Efficiency Measurement for Utilities and Transport Regulators, The World Bank.
- https://www.bundesnetzagentur.de/EN/Areas/Energy/Companies/GeneralInformationOnEnergyRegulation/GeneralInformationEnergyReg_node.html
- Agrell, Bogetoft, et al. (2008), Ergebnisdokumentation: Bestimmung der Effizienzwerte Verteilnetzbetreiber Strom, Sumicsid and EE2.
- Agrell, Bogetoft, et al. (2014), Effizienzvergleich für Verteilnetzbetreiber Strom 2013, Swiss Economics & Sumicsid (im Auftrag der BNetzA).

Part 2 – Energy market optimization

Introduction:

The energy market faces increased complexity due to recent changes, e.g. by renewable energies, batteries, industry participation and market integration. Energy system models can help to understand effects and development of the energy market. Those insights are relevant for decisions like power plant investments, grid reinforcements or portfolio extensions. In case a market participant wants to invest in a new wind energy park, hourly electricity prices as well as generation profiles are relevant for the profitability. The system operator needs to estimate whether the grid infrastructure can manage additional generation at this location. And the market regulator needs a good estimate on the long-run system adequacy (i.e. system stability) in case the wind generation pushes secured thermal generation out of the market. The course provides basic theory of the energy system as well as the method of electricity market optimization with GAMS to the students. Additionally, the course covers briefly current topics of energy market optimization such as the physical consideration of the grid via load-flow modeling, high numbers of scenarios as well as the linkage of electricity market models with energy systems (gas, heating, hydrogen, fuels). These extensions are relevant for current governmental studies like Netzentwicklungsplan, Ten-Year Net Development Plan and the Mid-Term Adequacy Forecast.

Course agenda:

- Motivation: Coal-phase out in Germany
- Basics in Optimization and GAMS
- Set up and application of an Electricity market model
- Case Study (Power Plant investment)
- Current concepts of electricity system optimization (nodal pricing, load-flow/ptdf, high scenario numbers, energy system modeling)

Potential References (no must-read in advance):

- Rosenthal, Richard E.: GAMS - A User's Guide, 2010. Kapitel 2.1
- Several working paper from EWI PhDs and others
- Netzentwicklungsplan (https://www.netzentwicklungsplan.de/de), TYNDP (https://tyndp.entsoe.eu/tyndp2018/), MAF (https://www.entsoe.eu/outlooks/midterm/)