



Ruhr  
Graduate  
School  
in Economics

Ruhr Graduate School in Economics  
University of Duisburg-Essen

# 14th Ruhr Graduate Summer School

UNIVERSITÄT  
DUISBURG  
ESSEN

*Open-Minded*

Essen, Germany

September 17– 21, 2018

## TRADE AND CLIMATE POLICY ANALYSIS USING GTAP-IN-GAMS AND MPSGE

Instructors:

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## ➤ Objectives

Over the last decades computable general equilibrium (CGE) models have become a widespread tool for the economic impact assessment of policy regulation. The quintessence of CGE analysis is the combination of general equilibrium theory with economic data to derive quantitative insights into the efficiency effects and distributional implications of policy. Prominent fields of application include the quantitative assessment of trade reforms and international climate policy agreements.

This workshop provides a practical guideline to CGE modeling of open economies using data of the Global Trade Analysis Project (GTAP) which includes detailed national accounts on production and consumption together with bilateral trade flows for a large number of countries. The workshop will discuss alternative approaches to study the implications of trade policy shocks and climate policy regulation in a general equilibrium framework: (i) the widespread Armington assumption that goods of different origin command different prices, (ii) the alternative notion of Heckscher-Ohlin that goods of different origin are homogenous, and (iii) monopolistic-competition models that are central to the new trade theories that include variety impacts through firm entry and exit, as well as selection effects in a heterogeneous-firms context based on the seminal work by Melitz. Numerical models for these complementary approaches to policy analysis of open economies will be developed and applied. Key applications will consider sub-global climate policy designs as well as standard economic integration scenarios, nationalistic movements that back away from current commitments to cooperative trade, as well as bilateral tariff wars.

The primary objective is to provide a solid foundation to access powerful CGE techniques in the context of the contemporary policy environment of international trade and greenhouse emission abatement strategies. For model implementation and data management we use the General Algebraic Modeling System (GAMS) which is a convenient model language for the development of large-scale mathematical programs and the processing of extensive datasets.

The course will start with the fundamental conditions defining an economic equilibrium. Exploiting the complementarity features of economic equilibria we will formulate economic equilibrium problems as mixed complementarity problems (MCP) to accommodate situations where prices or quantities can drop to zero (e.g., trade reversal due to tariff changes). We initially demonstrate the attractiveness of the mixed complementarity approach vis-à-vis the standard formulation of economic equilibrium problems as a (nonlinear) system of equations along simple partial equilibrium models of global trade followed by general equilibrium extension to demonstrate the implementation of basic international trade issues (e.g., tariffs and quotas). To gain policy-relevant insights applied (computable) equilibrium analysis involves the use of empirical data. We show how we can calibrate (parameterize) models to benchmark data (input-output table, social accounting matrices, etc.).

Before we switch from more stylized models to large-scale models of applied policy analysis we introduce MPSGE (Mathematical Programming System for General Equilibrium analysis), a meta-language – building on MCP – that greatly facilitates the implementation of large-scale CGE models. We then discuss in more detail the implementation of a blueprint multi-sector, multi-region CGE model using empirical data for national accounts and bilateral trade flows from the GTAP database. We will explain the structure of the GTAP dataset and show how the data can be easily made amenable for applied policy analysis using multi-sector, multi-region CGE models implemented in GAMS.

The standard trade model gets extended with satellite energy flow and CO<sub>2</sub> emission data to accommodate impact analysis of standard climate policy measures such as emission taxes and (tradable) quotas. Following a discussion of emission leakage and competitiveness issues in the context of sub-global climate policies, the standard trade models are further refined in order to investigate the implications of border adjustment policies for emission- and trade-intensive industries such as tax rebates or import tariffs. Beyond climate policy design, another thematic focus of the workshop is on economic integration under current threats to cooperative international trade and environmental policy. To provide the basis for subsequent large-scale applications we discuss and implement alternative theoretical approaches to study international trade (Armington, Heckscher-Ohlin, Krugman, and Melitz). Applied policy analyses will include the impact assessment of Brexit and potential tariff wars between the US, Mexico and China.

**Christoph Böhringer**

University of Oldenburg

Prof. Dr. Christoph Böhringer is Professor of Economic Policy at the University of Oldenburg and expert advisor to the German government on research and innovation policies. His research focuses on the economic impact assessment of policy regulations using partial and general equilibrium models. Since 1994, he has been regularly conducting workshops on applied analysis in the fields of environmental, energy, fiscal and trade policies. He has widely published in international journals, including *Applied Economics*, *Canadian Journal of Economics*, *Computational Economics*, *Ecological Economics*, *Energy Economics*, *Energy Journal*, *Energy Policy*, *Environmental and Resource Economics*, *European Economic Review*, *European Journal of Political Economy*, *Journal of Economic Dynamics and Control*, *Journal of Environmental Economics and Management*, *Journal of Policy Modeling*, *Journal of Public Economics*, *Journal of Regulatory Economics*, *Kyklos*, *Oxford Review of Economic Policy*, *Scandinavian Journal of Economics*, or *The World Economy*.

**Volker Clausen**

University of Duisburg-Essen

Prof. Dr. Volker Clausen has been Professor of International Economics, University of Duisburg-Essen, Campus Essen since 2001. Previously he worked at the Universities of Kiel and Bonn in Germany and at Indiana University, in Bloomington, Indiana (USA). He holds a Ph.D. in Economics from the University of Kiel, Germany, and a Master of Science in Economics from the London School of Economics and Political Science. His current research interests include general equilibrium modelling with a focus on open economies. His publications have a focus on international topics and appeared in, among others, *Economic Modelling*, *Journal of Economics and Statistics*, *Journal of Economic Integration*, *Journal of International Money and Finance* and *Review of World Economics*.

## ➤ *Workshop contents*

### **Part 1: GAMS, Economic Equilibrium and Mixed Complementarity**

- A short primer in GAMS
- Mixed Complementarity Problems (MCP)
- Economic equilibrium and complementarity
- Partial equilibrium models of international trade
- *Hands-on session:* Alternative implementation of market equilibrium conditions as a mathematical program, system of equations or a mixed complementarity problem (MCP)
- *Hands-on session:* Economic impacts of free trade agreements on commodity markets

### **Part 2: CGE Models – Structure, Functional Forms and Calibration**

- Numerical implementation of a basic (Arrow-Debreu) general equilibrium model
- Micro-consistent dataset and model calibration to empirical datasets
- Incorporation of price and quantity constraints with applications to technology choice (activity analysis), involuntary unemployment and equal-yield tax reforms.
- Nested functional (CES) forms
- *Hands-on session:* Algebraic implementation of template CGE models with benchmark taxes (replication check and techniques for debugging)
- *Hands-on session:* MPSGE implementation of template CGE models

### **Part 3: International Trade and GTAPinGAMS**

- Simple open economy models (Heckscher-Ohlin and Armington trade formulations)
- The GTAP9 database – a global economic dataset with 57 sectors and 140 regions
- The GTAPinGAMS package – data aggregation and standard global economy model
- *Hands-on session:* Illustrative economic impact analysis of trade liberalization with the GTAPinGAMS model
- *Hands-on session:* The Economic Cost of EU Membership for the UK

### **Part 4: International Climate Policy Analysis and GTAPinGAMS**

- GTAP-E: Extension for energy flows and carbon emissions
- Implementation of emission taxes and (tradable) quotas
- Sub-global climate policies and emission leakage
- *Hands-on session:* Economic impact analysis of the Paris Agreement
- *Hands-on session:* Economic effects of border measures in sub-global climate agreements

### **Part 5: Advanced Trade Theories and Applications**

- Heckscher-Ohlin vs. Armington vs. Melitz
- *Hands-on session:* Non-tariff measures and economic integration/disintegration
- *Hands-on session:* Bilateral tariff wars and the Nash equilibrium

**Note:** An exact schedule as well as coverage of aforementioned topics depend on the previous experience of participants with GAMS, MPSGE and CGE modeling and their research interests. Some parts might be covered more quickly at the beginning of the workshop which allows for more discussion and implementation of recent research toward the end of the workshop. This will be decided on the basis of the actual list of participants who will be asked about their previous experience in the field before the workshop starts.

➤ **Target group**

The workshop is targeted to scientific researchers and policy analysts at universities, research centers, consulting companies and ministries who are interested in the economic impact assessment of policy interventions using computable general equilibrium (CGE) models. While the field of application for CGE models is broad, the workshop will pay special attention to the applied analysis of international trade policy.

➤ **Your benefit**

The workshop provides you with state-of-the-art CGE modeling techniques. Application of these techniques will allow you to gain insights into economic theory with numbers and to undertake comprehensive economic impact assessment of policy reforms based on real data.

➤ **Prerequisites**

Material and teaching is in English. Registered participants will receive teaching material prior to the start of the workshop such that they can prepare in advance. Teaching will combine lectures on theoretical underpinnings with worked examples on model implementation as well as hands-on sessions with exercises for participants.

Participants should be familiar with intermediate microeconomics (Master's level). In the run-up to the workshop, participants should get to know the basics of the programming language GAMS which is used for the numerical implementation of equilibrium models as well as data management. A compact do-it-yourself GAMS tutorial will be sent out to participants in advance.

**Participants are required to bring a laptop and adapters for German power supply if necessary.** The GAMS workshop license (valid for 2 months) as well as extensive course material will be provided on USB flash drives.

➤ **Payment**

The fee for participating in the training workshop is 2,500 Euro and includes lectures, course material and lunches. Academic participants from accredited universities or research institutions will be admitted on a space-available basis for a discount of 20%. Graduate students from accredited academic institutions are likewise admitted on a space-available basis for a discount of 50%. Please fax or email a copy of your student ID to get the discount. There will be a limited number of scholarships (*excluding travel and subsistence expenses*) that have been set aside for qualified participants from developing countries. Deadline for the application for a scholarship is **July 13, 2018**. Preference will be given to applicants who have documented previous experience in general equilibrium modelling with GAMS. To apply for a scholarship in the form of a tuition waiver, send your CV and a research paper via email to the

course coordinator Elias Sobotka. A decision on the allocation of scholarships will be made until **July 20, 2018**, in order to allow for an early arrangement of flights, visa etc.

### ➤ **Registration**

Please contact the course coordinator if you have any questions:

*M. Sc. Elias Sobotka  
University of Duisburg-Essen  
Department of Economics  
45117 Essen, Germany  
Telephone: +49 (0)201-183-2845  
Fax: +49 (0)201-183-3974  
email: [rgss\(at\)vwl.uni-due.de](mailto:rgss(at)vwl.uni-due.de)*

The registration deadline is **August 20, 2018**. The maximum number of participants is restricted to 16! **Slots are guaranteed only upon full payment of fees through the course coordinator.** Cancellations will be fully refunded if made prior to **August 20, 2018**. No refunds will be made after the registration deadline. **Note the following disclaimer and limited liability:** The program and the list of instructors are confirmed and correct at the time of publication. In case of any serious circumstances or acts of nature beyond control of the organizers, such as for example illness, death, cancellation of flights etc., the organizers aim for an adequate substitution. In the very unlikely, but still possible case, the maximum liability of the organizers is limited to the tuition. The organizers do not cover any other costs of the participants, such as travel bookings, visa fees etc. The organizer also reserves the right, in the unlikely case of very limited enrolment, to run the workshop with one instead of two external instructors.

### ➤ **Times and location**

Morning sessions will begin at 9am. Lunch is provided for workshop participants at noon. The afternoon sessions will run from about 1-4pm. Between 4 and 5 pm there will be time for further individual programming and consultation. All sessions take place in the **Casino Gästehaus** located in the east of the University of Duisburg-Essen, Campus Essen:

*University of Duisburg-Essen, Campus Essen  
Universitätsstraße 12  
45117 Essen, Germany*

### ➤ **Venue and accommodation**

**Workshop participants must make their own arrangements for accommodation.** The workshop will be held at the Department of Economics at the University of Duisburg-Essen, Campus Essen. Detailed venue information will be provided after reservation.

Some rooms of category C have been earmarked until **early September** under the keyword “*Ruhr Graduate Summer School*” at:

*Bildungshotel im Bfz-Essen e.V.  
Karolingerstraße 93  
45145 Essen, Germany  
T: 0201/3204-243;F: 0201/3204-277  
[bildungshotel@bfz-essen.de](mailto:bildungshotel@bfz-essen.de)*

### ➤ *How to prepare*

No previous knowledge of GE modeling is assumed. However, participants should be familiar with intermediate microeconomics and get somewhat acquainted **beforehand** with GAMS which is the (rather intuitive) programming language used for computer-based model implementation. To be able to follow during the workshop, we suggest for the purpose of preparation the following introductory readings and a short do-it-yourself GAMS tutorial:

- Böhringer, C., Rutherford, T.F., Wiegard, W. (2003): Computable General Equilibrium Analysis: Opening a Black Box, ZEW discussion paper 03-56.
- Rutherford, T.F. (1999): Applied General Equilibrium Modelling with MPSGE as a GAMS Subsystem, Computational Economics 14, 1-46.
- Rosenthal R. E.: A GAMS Tutorial.
- J. R. Markusen teaching materials for a course “Simulation Modeling in Microeconomics”, especially chapters 1-4.

Get familiar with GAMS:

- Download the GAMS User's Guide.
- Download the Demonstration Version of GAMS. The GAMS workshop license will be provided on the first day of the workshop.
- Study background material provided over the web, including the MPSGE home page at GAMS and an introduction to GAMS from Jensen (2006).

Further readings regarding recent academic publications around climate policy analyses:

- Böhringer, C.; Balistreri, E.J.; Rutherford, T.F. (2018): Carbon policy and the structure of global trade, The World Economy, 41(1), 194-221.
- Böhringer, C.; Carbone, J.C.; Rutherford, T.F. (2018): Embodied Carbon Tariffs, Scandinavian Journal of Economics, 120(1), 183-210.
- Böhringer, C.; Rosendahl, K.E.; Storrøsten, H.B. (2017): Robust policies to mitigate carbon leakage, Journal of Public Economics, 149, 35-46.