Ruhr Graduate School in Economics
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TRADE AND CLIMATE POLICY ANALYSIS WITH GAMS AND MPSGE

Instructors:

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➢ *Objectives*

Over the last decades computable general equilibrium (CGE) models have become a wide-spread tool for the economic impact assessment of policy regulation. The bottom line 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 interference.

This workshop provides a practical guideline to CGE modeling of open economies using the Global Trade Analysis Project (GTAP) dataset 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 international trade in a general equilibrium framework: (i) the wide-spread 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) Melitz's new trade theory of monopolistic competition among heterogeneous firms. Numerical models for these complementary approaches to policy analysis of open economies will be developed and applied to the fields of economic integration and climate policy.

For model implementation and data management we use the Generalized 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 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 price rigidities (e.g., in the context of involuntary unemployment) and quantity constraints (e.g. in the context of equal-yield tax reforms). 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 matrixes, etc.) including the structural estimation of key elasticities such as Armington trade elasticities.

The thematic focus of the workshop is on trade and climate policy analysis. To provide the basis for subsequent large-scale applications we discuss and implement three alternative theoretical approaches to study international trade (Armington, Heckscher-Ohlin, Melitz) as well as standard extensions to represent greenhouse gas emissions, emission abatement possibilities and alternative climate policy regimes (emission taxes, standards, tradable permits). Pedagogic analysis based on small-dimensional models with stylized data will be complemented with large-scale applications based on the GTAP data set. We will explain in detail the structure of the GTAP data set and show how the data can be easily made amenable for trade and climate policy analysis in multi-sector, multi-region CGE models based on Rutherford's GTAPinGAMS packages.

To facilitate the formulation and calibration of large-scale CGE models we introduce Rutherford's Mathematical Programming System for General Equilibrium analysis (MPSGE) – a wide-spread meta-language for CGE modeling. We discuss in detail the implementation of a generic multi-sector, multi-region CGE model based on GTAP data. The standard GTAPinGAMS trade model adopts the Armington assumption of product heterogeneity but we present alternative representations of trade in homogenous goods and monopolistic competition among heterogeneous firms. To investigate the economic implications of greenhouse gas control strategies the trade models will be extended with satellite energy flow and CO_2 emission data. Applied policy analysis based on large-scale CGE trade models will compromise the impact assessment of trade reforms and the study of unilateral emission reduction policies complemented with border adjustment measures such as tariffs on embodied carbon to counteract emission leakage to non-abating trading partners.

Material and teaching is in English. Teaching will combine lectures on theoretical underpinnings with worked examples on model implementation as well as hands-on sessions with exercises for participants.

Christoph Böhringer

University of Oldenburg

Prof. Dr. Christoph Böhringer is Professor of Economic Policy at the University of Oldenburg. His research for the last years has focused on the quantitative analysis of environmental and energy policies based on numerical optimization 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, 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 Regulatory Economics, Kyklos, Oxford Review of Economic Policy, The World Economy*.

Ed Balistreri

Colorado School of Mines

Prof. Dr. Ed Balistreri is an Associate Professor at the Colorado School of Mines, Division of Economics and Business. His research focuses on the formulation of numeric simulation models of economic policy and outcomes. Balistreri's models have been used to analyze a diverse set of topics including global climate policy and international trade. He has also contributed to the literature on structural estimation and the empirical calibration of advanced models of trade and industrial organization. He has published in international journals like *Journal of International Economic, Economic Letters, Economic Modeling, Economic Inquiry, Energy Journal, The Canadian Journal of Economics, Energy Economics, Review of International Economics, and Environmental and Resource Economics*.

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, *Journal of International Money and Finance, Journal of Economic Integration, Review of World Economics and Economic Modelling*.

Course Coordinator: Zoryana Olekseyuk, University of Duisburg-Essen

➢ *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)

Part 3: MPSGE – a Meta-Language for CGE Modeling

- Introduction to MPSGE – a meta-language for CGE modeling based on mixed complementarity and the calibrated share form for CES functions
- *Hands-on session:* MPSGE implementation of template CGE models

Part 4: International Trade and GTAPinGAMS

- Simple open economy models (Heckscher-Ohlin and Armington trade formulations)
- The GTAP8 database – a global economic dataset with 57 sectors and 129 regions
- The GTAP8inGAMS package – data aggregation and standard global economy model
- *Hands-on session:* Illustrative economic impact analysis of trade liberalization with the GTAPinGAMS model

Part 5: Introduction to monopolistic competition and trade

- Introduction to monopolistic competition and the extensive margin of trade
- Partial Equilibrium Krugman Model (PEKM)
- Dixit-Stiglitz Preferences and Firm Behavior
- Krugman (1980) General Equilibrium in GAMS
- *Hands-on session:* Iceberg trade cost impacts in Krugman GE
- *Hands-on session:* Adding tariffs (tariff versus iceberg cost impacts) in Krugman GE.

Part 6: Applying monopolistic competition and heterogeneous firms

- New and (New New) Trade theory Part I: Armington vs. Krugman vs. Melitz
- Partial Equilibrium Models and Computation
- FDI and the new trade theory
- *Hands-on session:* Iceberg trade cost changes
- *Hands-on session*: Trade structures and model calibration for climate policy

➢ **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.

➢ *Payment*

The fee for participating in the training workshop is 2,500 Euro and includes lectures, course material and lunches. **Participants are required to bring a laptop with a DVD drive and adapters to 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.

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 **May 31, 2013**. 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 Zoryana Olekseyuk. A decision on the allocation of scholarships will be made until **June 7, 2013,** in order to allow for an early arrangement of flights, visa etc.

➢ *Registration*

To register you need to complete an online registration form. Please contact the course coordinator if you have any questions:

> *Zoryana Olekseyuk*
> *University of Duisburg-Essen*
> *Department of Economics*
> *45117 Essen, Germany*
> *Telephone: +49 (0)201-183-4507*
> *Fax: +49 (0)201-183-3974*
> *email: rgss(at)vwl.uni-due.de*

The registration deadline is **July 8, 2013**. 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 **July 8, 2013**. 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.

➢ *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 **July 15, 2013** under the catchword *"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*

➢ *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.
- J. Südekum teaching materials for a course "International Trade", especially part 1 and 3.

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).