universitätbonn

CGEBox
Modular Extendable Flexible

A flexible, modular and extendable framework for CGE analysis in GAMS

Wolfgang Britz
and
Dominique van der Mensbrugghe

Presentation at the 20th Annual Conference
on Global Economic Analysis
“"Global Economic Analysis in the 21st Century:
Challenges and Opportunities"”
West Lafayette, Indiana, USA, June 7-9 2017

universitätbonn

Content

CGEBox
Modular Extendable Flexible

- Why a modular CGE in GAMS
- Status of the project
- Some results from structural sensitivity analysis
- Next steps
- Summary

Why a modular CGE?

CGEBox
Modular Extendable Flexible

- Vision: complement "one data base – many models", by "one modeling platform - many model variants"

- In order to
  - easily change model set-up
  - specifically, allow for combinations of (GTAP)-extensions, for instance GTAP-E + GTAP-AEZ + GTAP-HET + MRIO + myGTAP
  - avoid duplicate coding efforts by teams, share modules

universitätbonn

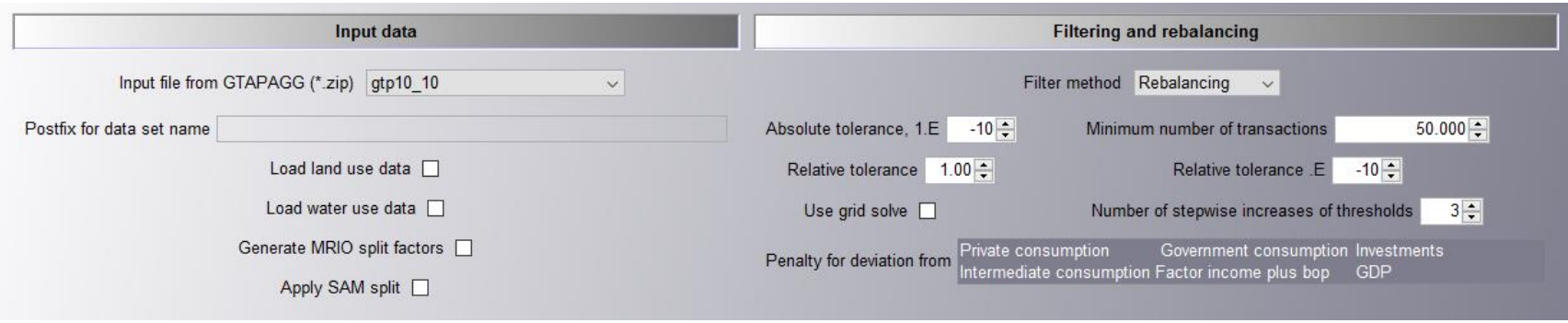
Why GAMS

CGEBox
Modular Extendable Flexible

- GLOBE, STAGE, ENVISAGE, MIRAGE, IFPRI-S, OECD Metro, GTAPinGAMS (only examples) in GAMS, potential collaborators
- Ease link up to PE or supply side models
- Built-in conditional includes and macros, eases modularity
- Support for NLP (constraint optimization) and MCP: simplifies data balancing problem(s) and KKT-conditions

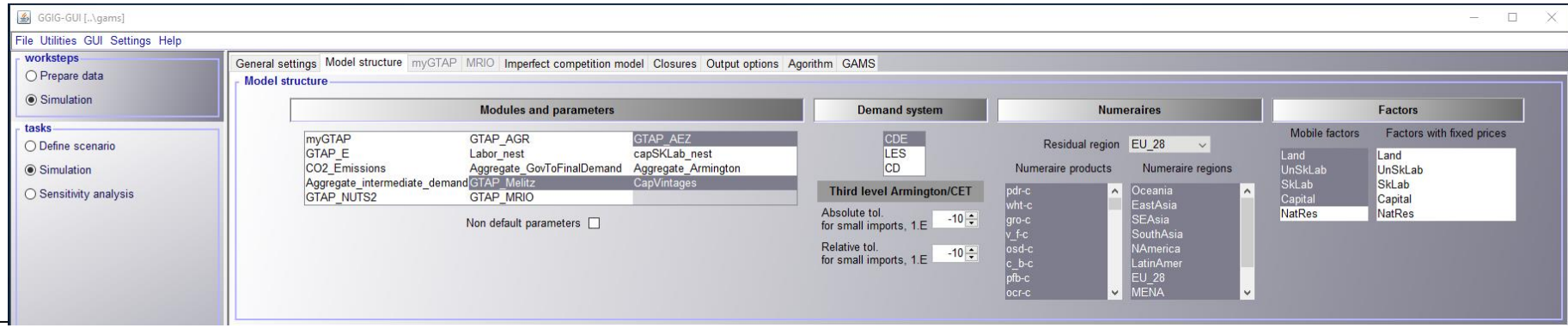
Status of the project

- 2016 conference: standard GTAP plus GUI
- Now: GTAP extensions plus features from ENVISAGE, comparative-static or recursive-dynamic, global or single country
- Data driver, handles
  - GTAPAGG output (GTAP6-9) + Land use data (GTAP-AEZ)
  - MRIO split factors from METRO + SAM split + non-diag make
  - Regional SAMs for Europe (280 regions)
  - filter for small entries and re-calibration of global SAM



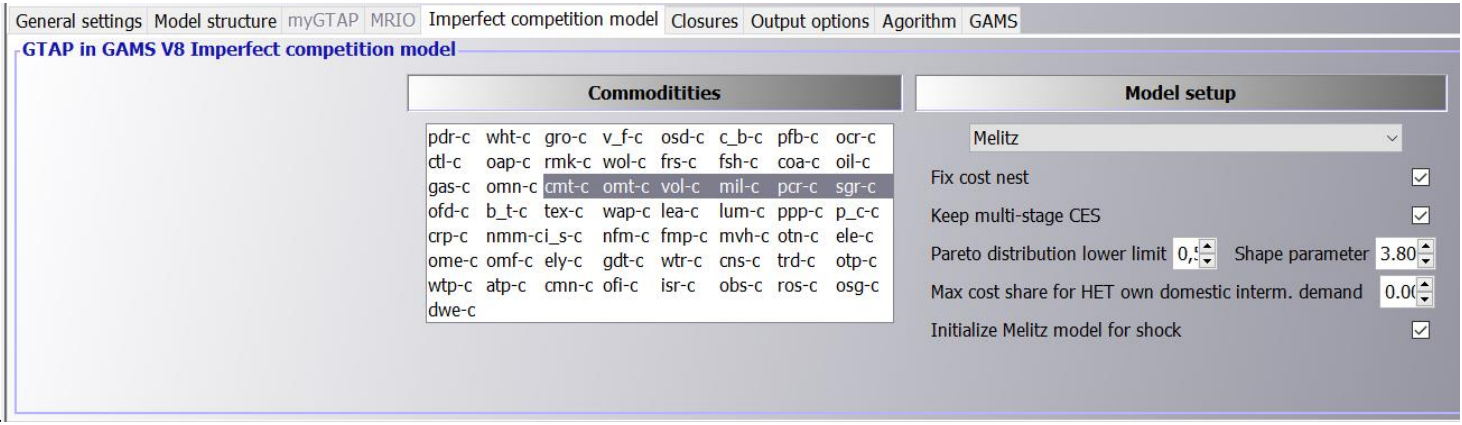
GUI

- Graphical User Interface:
  - Model and shock setup: choice of modules, data base, numeraires, closures, edit and select shock file, design and run sensitivity analysis based on LHS ..
  - Result exploration by maps, graphics and structured tables, compare several runs (shocks, model variants ..)



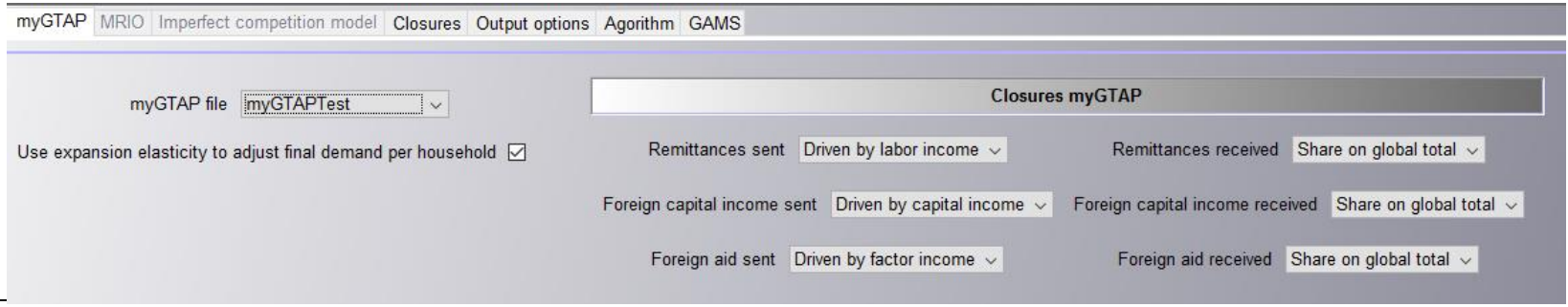
Options for trade

- 2-stage Armington as in GTAP Standard
- Optional:
  - 2-Stage CET on the supply side
  - 3-Stage CES/CET (Leontief for small shares)
  - Aggregated Armington: over intermediate demand or all
- Melitz / Krugmann, either AKME or 2-stage CES
- MRIO based on split-factors from OECD-Metro model



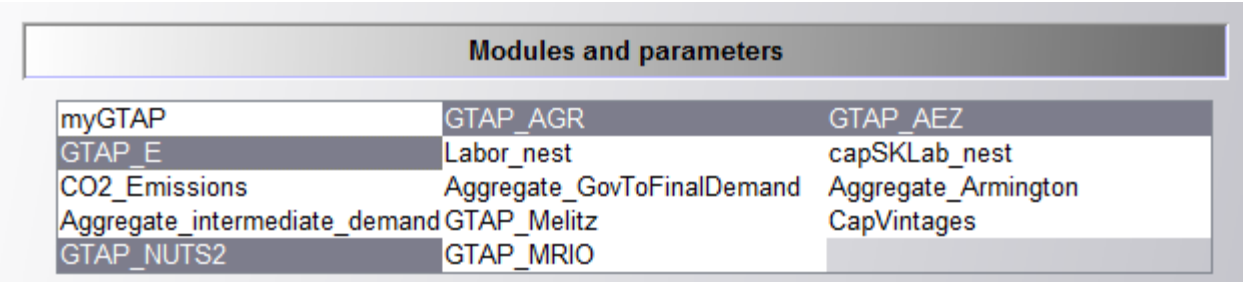
Accounts and final demand

- Replication of GTAP Standard:
  Regional household and CDE
- LES or CD as alternatives
- Plus optionally:
  - CDE/LES/CD with product aggregates via CES-nests
  - myGTAP clone: Separate accounts for government and (multiple) households, with remittances, transfers …, plus features from STAGE



Production

- Completely flexible nesting
  over multiple CES nests:
  - using dynamic sets, i.e. no additional programing
  - same input can be split into several nests,
    example: fixed costs in GTAP-HET
  - pre-programmed nestings, e.g. GTAP-E, GTAP-AGR
- Non-diagonal make with CET/CES
- GTAP-AEZ and GTAP-WATER available
- Sub-national disaggregation (Europe with 280 regions)



Factor supply

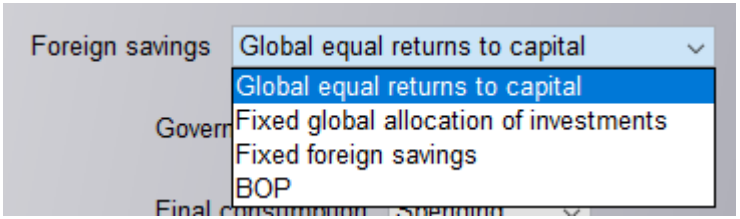
- Completely flexible nesting over multiple CET factor supply nests, based on dynamic sets
- Support for fixed factor prices and price floors
- CET for factor supply from nation to sub-regions (Europe)
- Factor supply functions
- Vintage module: capital split-up in new (fully or partially mobile) driven by investments and non-depreciated (sector specific) stock in comparative static mode

GTAP_AGR

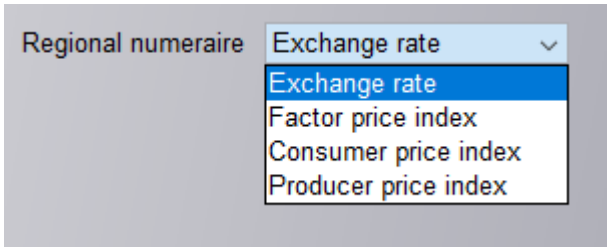
```
fNest("agr")                          = YES;
fNest_a_f("agr",agr,ffNest)           = YES;
fNest_n_f("xft","agr",ffNest)         = YES;
omegafNest(r,"agr",ffNest)            = omegaf(r,ffNest);

fNest("nonAgr")                       = YES;
fNest_a_f("nonAgr",nonAgr,ffNest)     = YES;
fNest_n_f("xft","nonAgr",ffNest)      = YES;
omegafNest(r,"nonAgr",ffNest)         = omegaf(r,ffNest);
```

Foreign savings

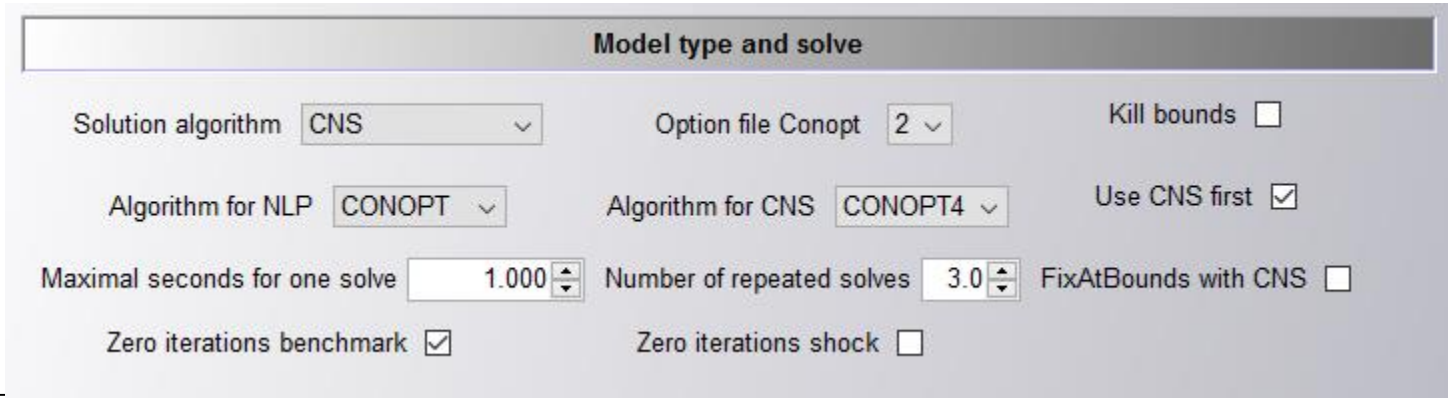


- Options:
  - Global bank
  - Fixed foreign savings
  - Fixed regional allocation shares
  - Driven by regional capital account balance under fixed exchange rate
- Note: regional numéraire can be freely chosen



Model solution

- Standard:
  - One go CNS with CONOPT
    (square equation system in levels)
- Options/Alternatives:
  - (Multiple) pre-solves for single region models
  - One go MCP (PATH) to capture KKTs, e.g. emission quotas
  - MCP after CNS if CNS fails
  - CONOPT4 (parallel) instead of CONOPT3

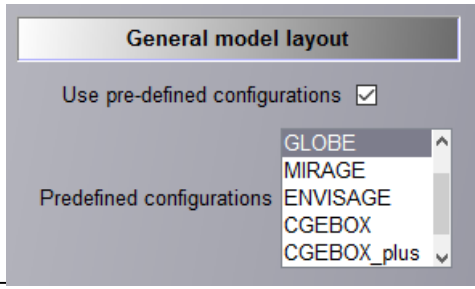


Example application

- Set-up of model variants which replicate core features of ENVISAGE, GLOBE, MIRAGE, compared to GTAP standard and a variant with GTAP-AEZ and Melitz …
- Explore boxed approach – combine different features and extensions to yield different model set-ups
- 57x10 data base (including AEZ land use)
- 50% multi-lateral trade liberalization experiment and a 20% TFP shock in North-America

Model configs in example

- GTAP Standard: true replica
- GTAPinGAMS (replica): CD for private demand, total real gov demand fixed, gov and inv demand CD
- "GLOBE": Armington aggregated, 2-stage CET, LES for final demand, separate accounts for private household and gov, CPI as regional numéraire, foreign savings fixed in international currency, flexible exchange rates close regional capital accounts
- "MIRAGE": Krugman (a la AKME), global bank, sluggish factor mobility between agr and non-agr, total real gov demand fixed, LES for final demand, Armington aggregated



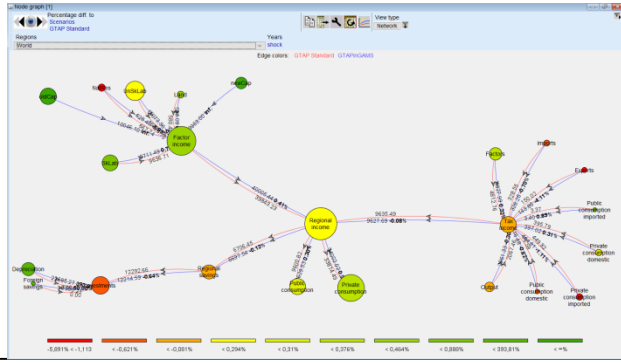
Example applications

- "ENVISAGE": 2-stage CET, sluggish factor mobility between agr and non-agr, GTAP-E nesting, LES + CES sub-nests for energy in final demand, gov and inv demand CD, real gov saving and consumption fixed, gov account closed by direct tax rates, fixed foreign savings, vintage capital module
- "CGEBOX": GTAP-AEZ + land supply, GTAP-E, GTAP-AGR, vintage capital module, 2-stage CET
- "CGEBOX+": as before, but CET replaced by Melitz model for all manufacturing sectors (~20)

Main results

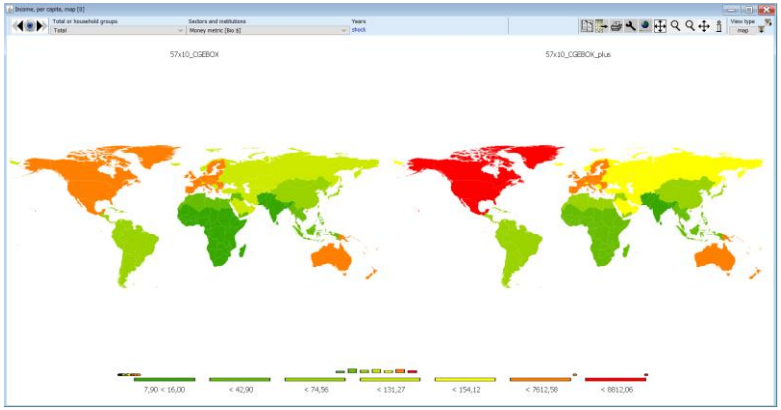
- EV US$ per capita under a 20% TFP shock in the North America

	GTAP Standard	GTAPinGAMS	GLOBE	ENVISAGE	CGEBOX	MIRAGE	CGEBOX_plus
World	498	494	576	566	562	700	653
Australia, New Zealand	-55	7	67	73	220	101	238
East Asia	-8	-2	18	4	53	-2	66
Southeast Asia	1	1	12	2	26	14	33
South Asia	-3	0	2	3	8	-2	9
North America	7503	7342	8374	8271	7613	10468	8812
Latin America	0	12	35	29	69	9	75
European Union 25	-49	-3	49	53	271	-50	327
Middle East and North Africa	23	22	29	38	43	21	49
Sub-Saharan Africa	7	7	13	15	16	8	19
Rest of World	65	58	67	77	131	68	154



Main results

- Trade lib shock:
  - Especially new-trade theory models (Krugman in “MIRAGE”, Melitz in “CGEBOx+”) lead (as expected) to considerably higher welfare gains, might quadruple standard results
  - Other configurations not much different in core results
  - CET + removal of global bank (GLOBE, ENVISAGE) somewhat dampen welfare gains



For more results and details, read paper …

universitätbonn

Next steps

CGEBox
Modular Extendable Flexible

- Explore collaborations
- Discuss:
  - Cost savings? … code is naturally more complex compared to a less flexible model layout
  - Common coding and documentation style
  - Quality management and testing
  - Incentives to contribute
  - IPR / trademarking

GTAP

universitätbonn

Summary

CGEBox
Modular Extendable Flexible

- CGEBOX: freely distributed code base for CGE modeling, modular, flexible, in GAMS
- Implements already various GTAP extensions and features found in well-known CGEs, sensitivity analysis
- Data filtering and pre-solves permit solving models with highly dis-aggregated SAMs
- Graphical User Interface for model configuration
- Exploration tools to analyze results with pre-defined views
- Survival and further development depends on take-up by users and active contribution