Macroeconomic Modelling of the Global Economy-Energy-Environment Nexus

An Overview of Recent Advancements of the Dynamic Simulation Model GINFORS

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1. The overall goal of modelling

- What are the likely development paths of the global economy up to 2050 in deep sectoral and country differentiation, taking into consideration the expected population growth and the multitude inter- and intranational interdependencies?
- Which pressure on the environment with a full picture of resource use and emissions of pollutants does this mean up to 2050?
- What are the likely impacts of different policy options on environmental pressures as well as on the socio economic development considering the global interdependencies?

Consistent projections

Scenario analysis

Genesis of GINFORS

- GINFORS evolved from the COMPASS model (Meyer and Uno 1999)
- 2003 to 2006: GINFORS$_1$ developed and applied within the FP5 MOSUS project (Modelling opportunities and limits for restructuring Europe towards sustainability)
- 2007 to 2011: GINFORS$_2$ developed and applied, i.e. MACMOD project (Macroeconomic modelling of sustainable development and the links between the economy and the environment)
- Since 2012: GINFORS$_3$ developed and applied within 3 FP7 projects
  - POLFREE: Policy options for a resource-efficient economy
  - CECILIA2050: Optimal EU climate policy
  - ToPDAd: Tool supported policy development for regional adaptation

Philosophy of the model

General assumption: Agents decide under conditions of bounded rationality on imperfect markets

Consequences:

- The model does **not** describe a long run equilibrium of competitive markets and a macroeconomic closure due to Say's Law
- Nevertheless market clearing: Suppliers set their prices in relation to unit costs and demanders take the prices as one determinant of their decision. Suppliers produce the demanded volumes.
- Balanced influence of supply and demand on the solution of the model
- Technical progress: Cost push hypothesis
- Specification of structural equations is not derived **explicitly** from an optimization approach: selection of competing hypothesis necessary
- Econometric estimation of competing hypothesis basis for selection: empirically evaluated model structure

Evaluation of the model:

- Econometric estimation of the behavioural equations:
  - Selection of competing hypothesis,
  - Statistical significance test for parameters.
- Ex post test: Does the iterative solution of the highly interdependent nonlinear dynamic model year by year meet the development at the actual margin outside the estimation period?
- Plausibility check of long run ex ante simulations.

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Endogenity of the system:

- Exogenous variables:
  - population,
  - world market producer prices for fossil fuels and ores
  - tax and subsidy rates on production, products and income
- All other variables are endogenous
- Global coverage
  - endogenous development of the global economy,
  - endogenous global pressures on the environment.
- Every variable (including the endogenous) can be influenced by additional assumptions

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Database of the model

Database:

- Central data base:
  - World Input Output Database (WIOD):
    - national supply and use tables (i.e intermediate and final demand, net taxes, margins, value added)
    - socio-economic accounts (i.e. labour market, capital stocks, price levels)
    - world Input-Output tables (i.e. international trade)
    - environmental accounts (i.e. energy use, emissions, land use, material use)
- Additional:
  - United Nations Statictics Division:
    - SNA sector accounts
    - population prospects
  - International Monetary Fund: Public debt and interest rates

consistency checks

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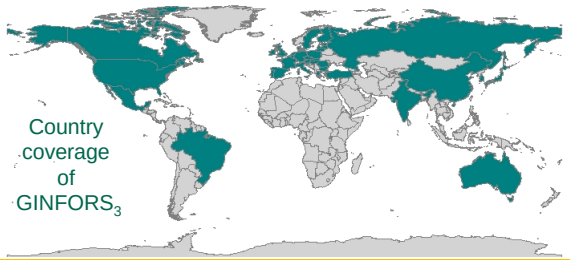
- Main progress of WIOD database:
  - All data available as time series (coverage 1995 to 2009)
  - All data available in the same classification (35 industries, 59 product groups)
  - Consistent integration of international trade data for 59 product groups
  - Consistent integration of environmental accounts (i.e. energy use, emissions)
  - Global coverage (38 countries and Rest of World)



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The modules of GINFORS$_3$

Economy:

- Input-Output structures (intermediate inputs, final demand, production, gross value added, prices)
- Labour (employment / labour compensation for 3 different skills) and capital inputs
- Bilateral trade for 59 product groups
- Sequence of accounts and balancing items

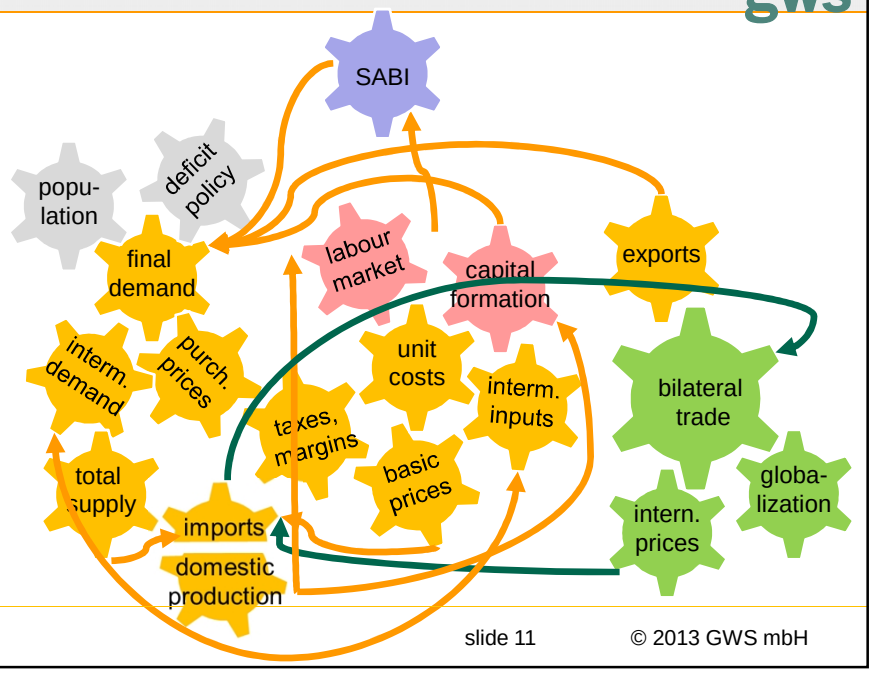
Energy:

- Energy use and electricity and heat production

Environment:

- Material use
- Water abstraction
- Agricultural land use
- Emissions

Figure 1: **The complexity of the economic system**



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3. Integration of the sequence of accounts and balancing items

- Sequence of functional accounts for the institutional sectors
- Data set published by UN Statistics Division
- Institutional sectors:
  - Total economy
    - non-financial corporations (S.11) and financial corporations (S.12)
    - General government (S.13)
    - Households (S.14) and non-profit institutions serving households [NPISH] (S.15)
  - Rest of the world (S.2)
- Sequence of functional non-financial accounts and balancing items:
  - I Production Account => value added
  - II.1.1 Generation of income account => operating surplus / mixed income
  - II1.2 Allocation of primary income => balance of primary incomes
  - II.2 Secondary distribution of income accounts => disposable income
  - II.4.1 Use of disposable income account => gross saving
  - III.1 Capital account => net lending / net borrowing

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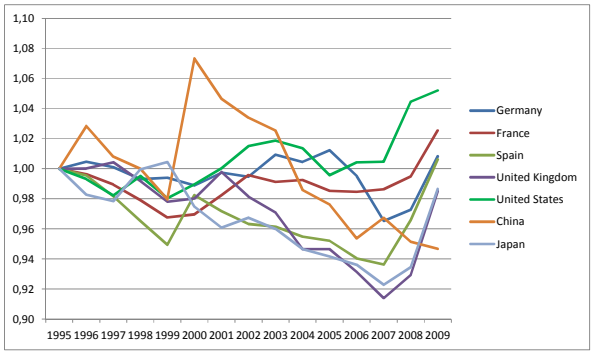
Key Arguments for a fully endogenization

- Requests by policy makers: valuable increase in policy-relevant variables
  Example: Measuring the impact of several forms of an environmental policy instrument on public debt, disposable income of households, etc.
- The desire of the model builder to develop a “perfect model” :
  explanation quality -> strength of model results
- **SNA consistent complementary linkage of the Input-Output data set** (IO module) **with the sector accounts data set** (SABI module) **within GINFORS$_3$**

Figure 2: **Differences between GDP and disposable income development of private households for selected countries in the years 1995 to 2009**



Source: Author' calculations

Figure 3: Linkage of the IO module to the SABI module within GINFORS

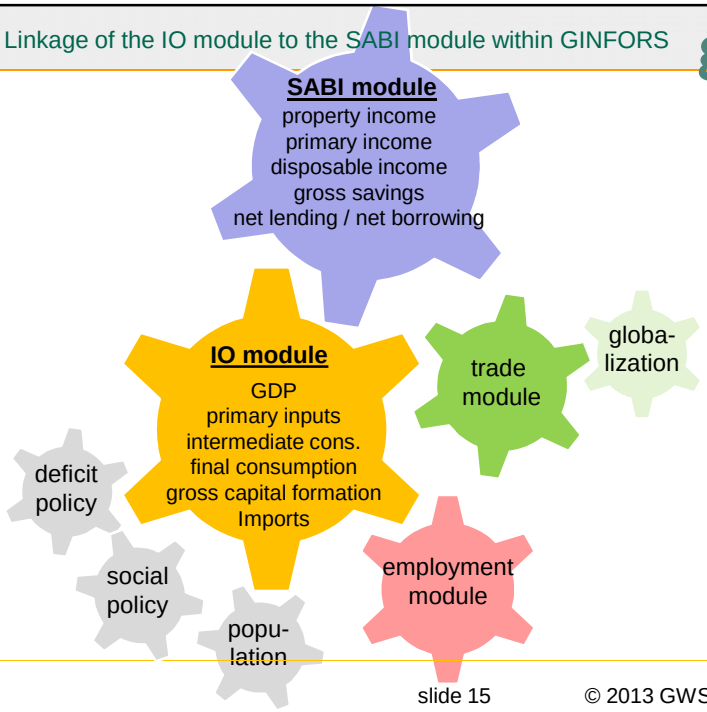


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Figure 4: Linkages of the IO module to the SABI module in detail

			Corporations S.11+S.12	Government S.13	Private households & NPISH S.14+S.15	Rest of World S.2
V.1		External account of goods and services				
B.11		External balance of goods and services				
II.1.1		Generation of income account				
B.1g		Gross value added at basic prices				
D.1	-	Compensation of employees - uses				
D.29	-	Other taxes on production				
D.39	+	Other subsidies on production				
B.2g	=	Gross operating surplus				
B.3g	+	Gross mixed income				
II1.2 / V.II		Allocation of primary income account				
D.1	+	Compensation of employees - resources				
D.2	+	Taxes on production and imports				
D.3	-	Subsidies on production and imports				
D.4	+	Property income - resources				const.
D.4	-	Property income - uses				
B.5g	=	Balance of primary incomes				
II.2 / V.II		Secondary distribution of income account				
D.4	+	Current taxes on income, wealth, etc. (resources)				const.
D.5	-	Current taxes on income, wealth, etc. (uses)				const.
D.61+D.62	-	Social benefits other than social transfers in kind (uses)		const.		
D.61+D.62	+	Social contributions and benefits (resources)				
D.7	-	Other current transfers (uses)				
D.7	+	Other current transfers (resources)		const.		
B.6g	=	Gross disposable income				
B.12	=	Current external balance				
II.4.1		Use of disposable income account				
D.8	-	Adjustment for the change in net equity of households on pension funds		const.	const.	
P.3	-	Final consumption expenditure				
B.8g	=	Gross saving				
III.1 / V.III		Capital account				
P.51	-	Gross fixed capital formation				
P.52	-	Changes in inventories				
P.53	-	Acquisitions less disposals of valuables	const.			
D.9	-	Capital transfers, payable	const.	const.		
D.9	+	Capital transfers, receivable		const.		const.
K.2	-	Acquisitions of non-produced non-financial assets	const.	const.	const.	const.
B.9	=	Net lending (+) / Net borrowing (-)				
		Government debt				

Source: Author' representation

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4. Conclusions and recommendations

- GINFORS exhibits a fully integrated sequence of accounts and balancing items which consistently combines the IO dynamics of primary and intermediate inputs with final demand developments

- GINFORS contains most of the essential components of an impact assessment model for analyzing sustainable economic, social and environmental development within a sustainable welfare model

4. Conclusions and recommendations

- GINFORS routinely provides insights into likely global development trends until 2050:
  - growth rate of real GDP per capita,
  - employment rates,
  - resource productivity,
  - emissions,
  - the share of renewable energy in gross final energy consumption,
  - primary energy consumption,
  - energy consumption of transport relative to GDP,
  - further sophisticated consumption or production based sustainability indicators.

4. Conclusions and recommendations

- Need for applying generalised IO models in scenario applications
  - linkages with established climate change models
  - scenario development within the IO context
- Need for consecutive updates of the global MRIO databases
- The extensive use of the WIOD database might also be regarded as an in-depth test of compilation procedures applied and developed by the WIOD team. The corresponding experience by the GWS team might be helpful for an improvement of some of these procedures.
  Task for future research!

Thanks for your attention!