Economic modelling with natural resources

Experiences with Applied General Equilibrium models and the inclusion of natural resources

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Outline

- Introduction
- I: Examples: Economic models with environment
- II: AGE models: why?
  - Pros and cons
- Before you start...

- Part I: examples

AGE modelling and other systems

Study	Type	Region	Subject
SNI-model Gerlagh et al. (2004)	GE	NL	8 environm. themes
SNI-Water Brouwer et al. (2008)	GE	NL	Water quality
DEAN Dellink et al. (2011)	Dyn. GE	NL	Water quality
WAP model Van Beukering et al (2009)	GE	NL	Waste
EMELIE Lise et al. (2006)	PE	North-western Europe	Electricity
CAPRI Kulman et al. (2014)	PE (agri)	EU	4 environm. themes
MAGNET Van Meijl et al. (2016)	GE	World (trade)	Bio-energy

AGE modelling and other systems

Study	Type	Featuring
SNI-model Gerlagh et al. (2004)	GE	Emission permits, abatement costs, sustainability standards
SNI-Water Brouwer et al. (2008)	GE	Like SNI, with emissions to water with relative standards
DEAN Dellink et al. (2011)	Dyn. GE	Interactive with subsistence flow model (hydrology)
WAP model Van Beukering et al (2009)	GE	Waste sector focus within GE
EMELIE Lise et al. (2006)	PE	Electricity model with strategic behaviour
CAPRI Kulman et al. (2014)	PE (agri)	Economy of agricultural sector
MAGNET Van Meijl et al. (2016)	GE	GE model for the World with focus on agricultural sector (trade)

SNI model – Gerlagh et al. (2004)

- What is NNI when the Dutch economy complies to sustainability standards for 8 environmental themes (GHG, ozone, acidification, eutrophication etc.)
- Emissions linked to production levels (not Value Added)
- Trade-off between investing in abatement technologies and emission permits
- Based on SAM and NAMEA (Statistic Netherlands)

=>NNI 273.1, SNI1 204.6 (75%), SNI2 141.0 (52%)

Impact of foreign policies: to comply (SNI2) or not to comply (SNI1) to the sustainability standards

SNI-model for water quality – Brouwer et al. (2008)

- What are the direct and indirect economic impacts of water quality improvements in the Netherlands at national and river basin scale
- Similar to SNI model but only with emissions to water (NAMWARib, Statistical Netherlands)
- Eutrophication and toxic substances
- Relative sustainability standards

Table 4 – The impact of the different emission reduction scenarios on Net National Income and their total economic cost (in billion euros; price level 2000)

Variant	Variant 1			Variant 2		
Emission reduction scenario	10%	20%	50%	10%	20%	50%
Net National Income	339.3	338.4	329.6	339.4	338.1	308.0
Loss in NNI compared to baseline	0.7	1.6	10.5	0.7	1.9	32.1
Relative change in NNI (%)	−0.2%	−0.5%	−3.1%	−0.2%	−0.6%	−9.4%

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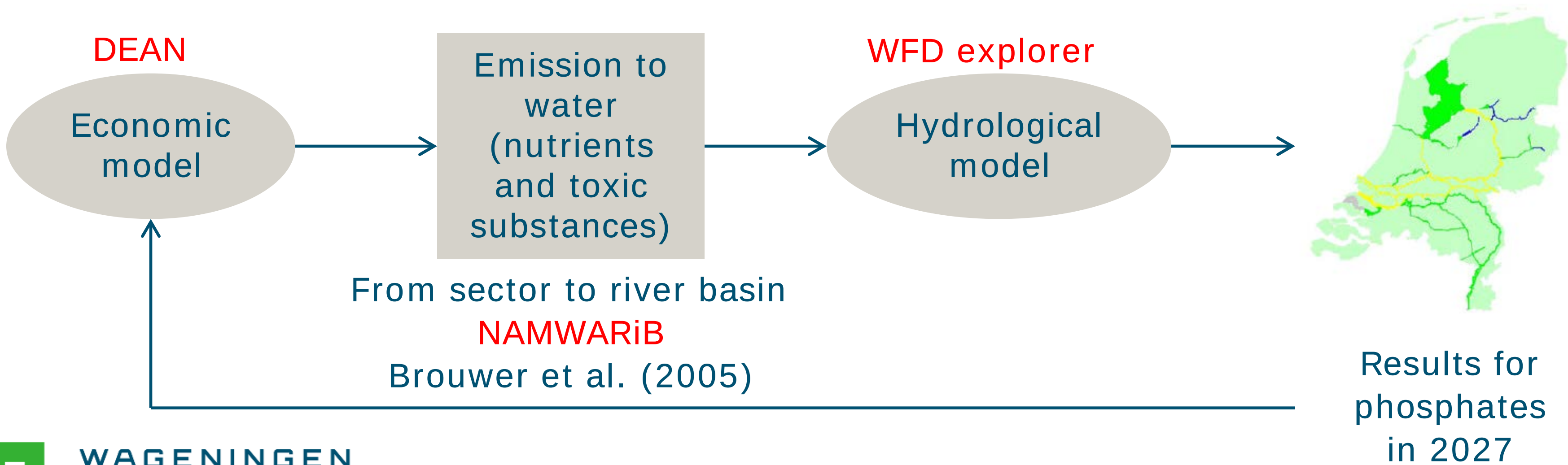
DEAN model for water quality (Dellink et al., 2011)

- How does national income develop if water quality targets have to be met in 2015 (or 2027)?
- The economic model is a forward-looking neo-classical growth model (based on DEAN)
- Interactive linked to hydrological model WFD explorer



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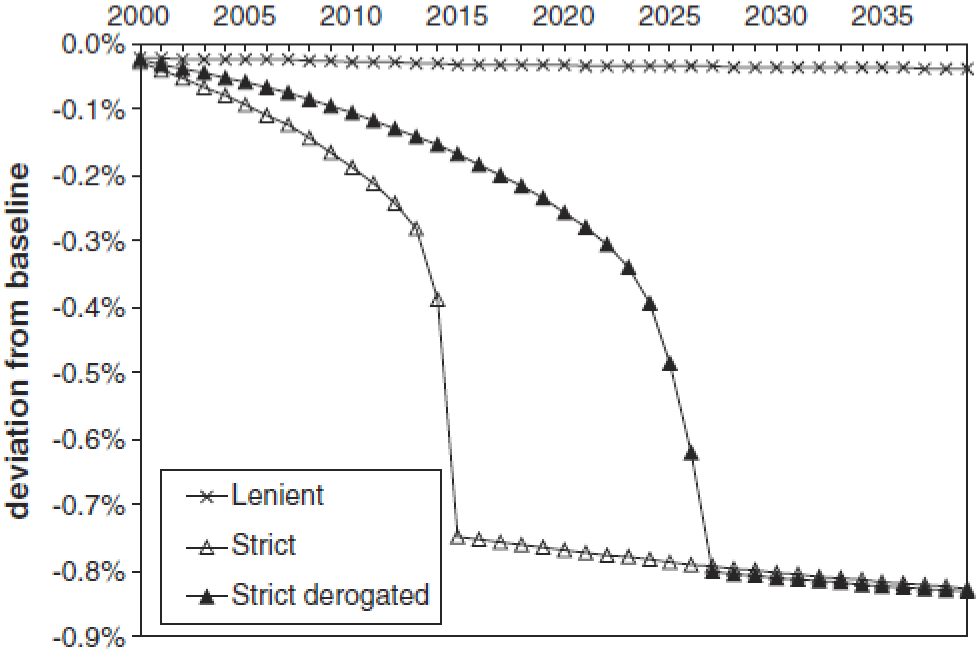
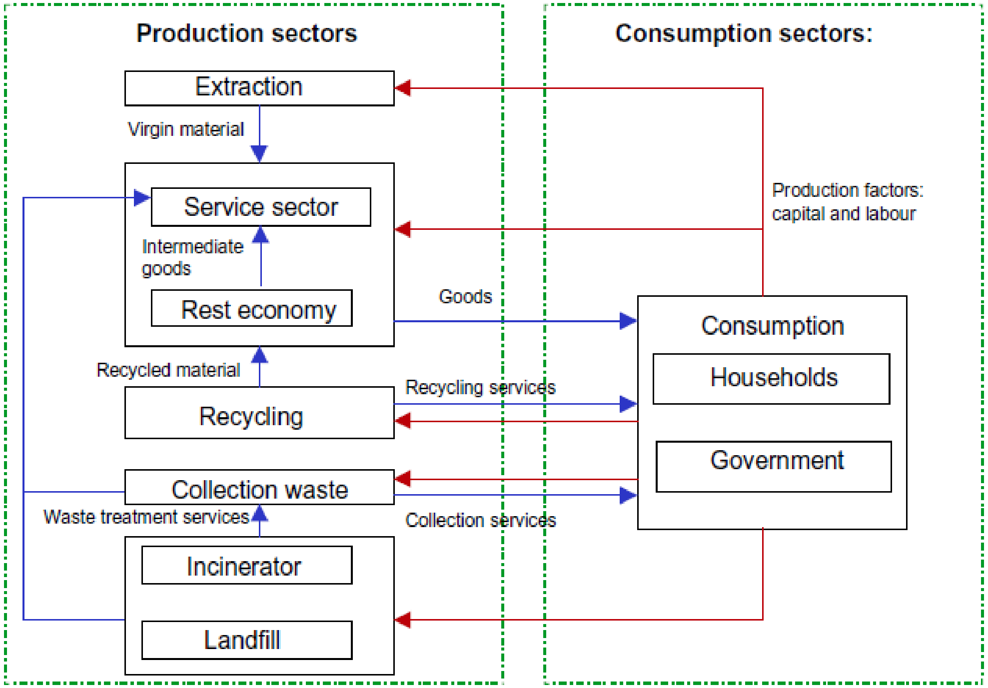
DEAN model for water quality (Dellink et al., 2011)



WAste Policy (WAP) model – Van Beukering et al. (2009)

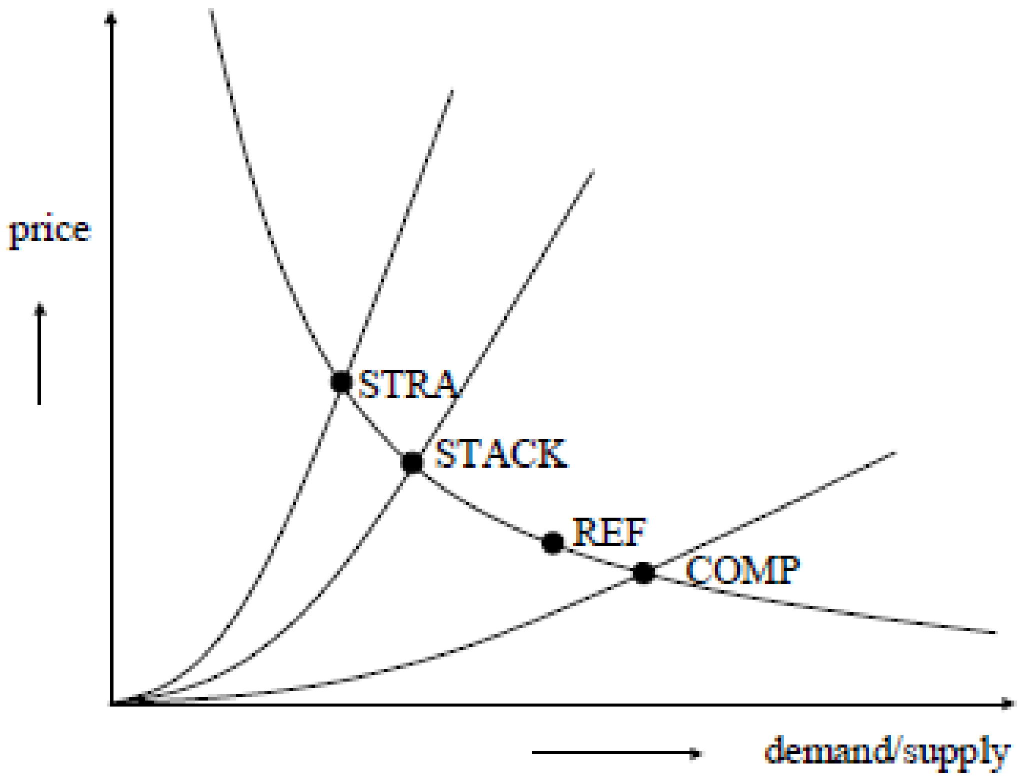
- How cost-effective is it to implement unit-based pricing in the Netherlands?
- 5 sectors
  13 commodities
- Static
- =>reduces waste (collection) and increases recycling
- Bartelings (2003)



EMELIE model – Lise et al. (2006)

- What is the environmental impact of the liberalisation of the electricity market in the EU?
- Partial equilibrium model: electricity in NW-Europe
- Strategic behaviour producers (price setting by one firm)
  - Mergers of firms
- Tradable permits for CO_2, NO_X, fine particles (PM10)
- Energy production mix with emission intensities: gas, coal, CHP, biomass, nuclear
- =>Strategic behaviour leads to higher prices, the impact on the environment depends on the circumstances

EMELIE model – Lise et al. (2006)



Source: Lise and Linderhof (2004)

- STRA=price setting (large firms)
- STACK=price setting (price fighter)
- COMP=full competition

- Lise and Kruseman (2008) *Energy Economics*

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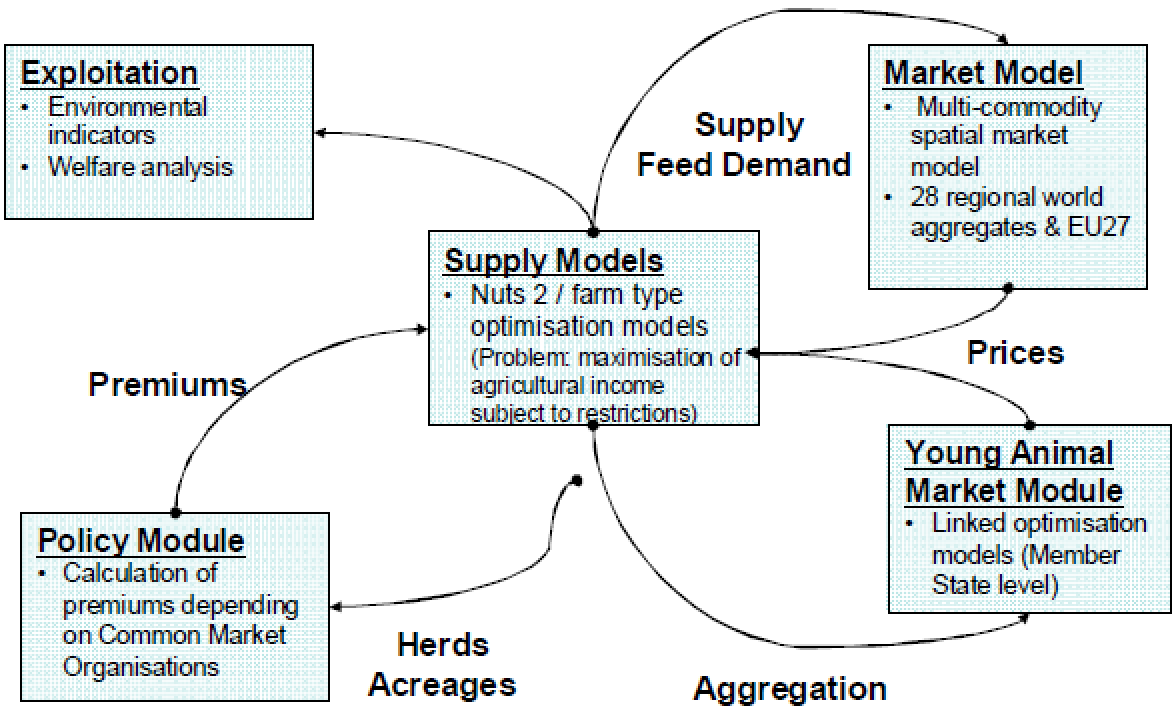
CAPRI – Kuhlman et al. (2014)

- What are the economic and environmental impact of supporting legumes in EU agriculture?
- Partial equilibrium model for agriculture
- EU wide
- Different research groups



Source: Kuhlman et al. (2014)

CAPRI – Kuhlman et al. (2014)

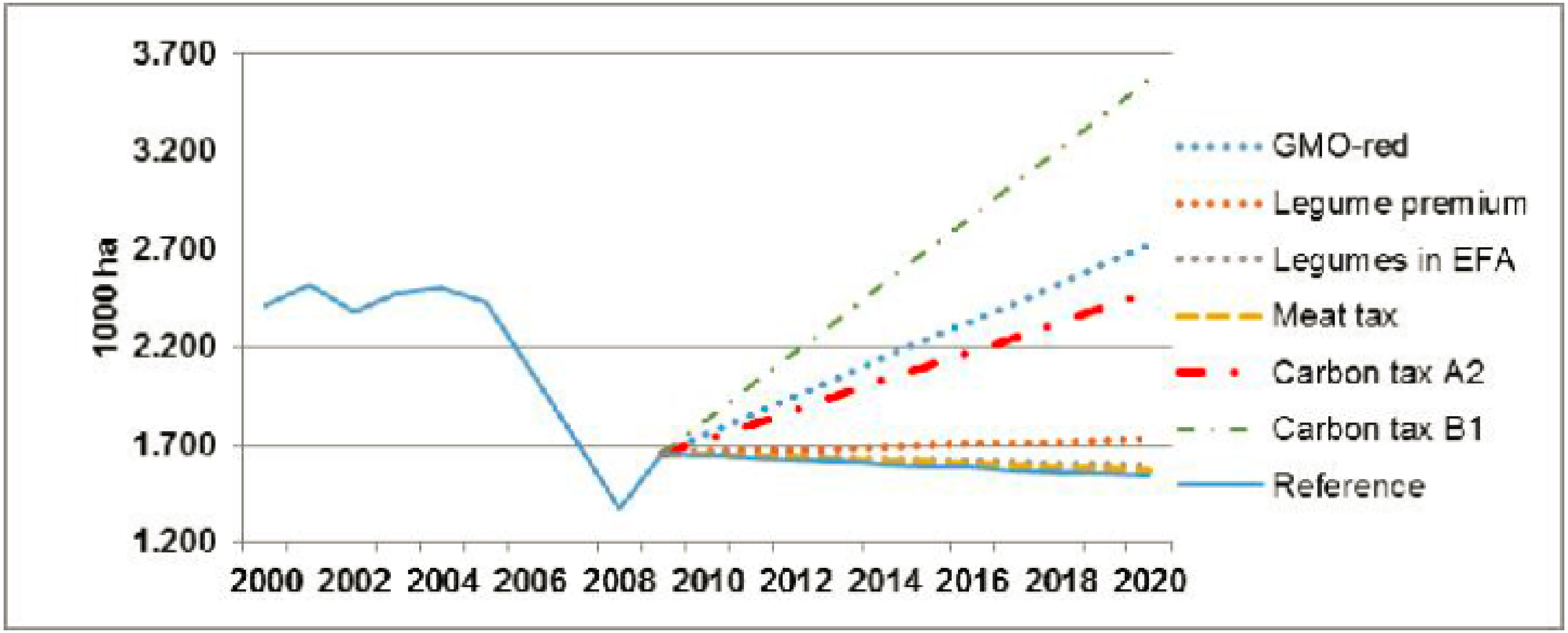


Figure 3. Area cultivated with grain legumes under different scenarios

Source: Kuhlman et al. (2014)

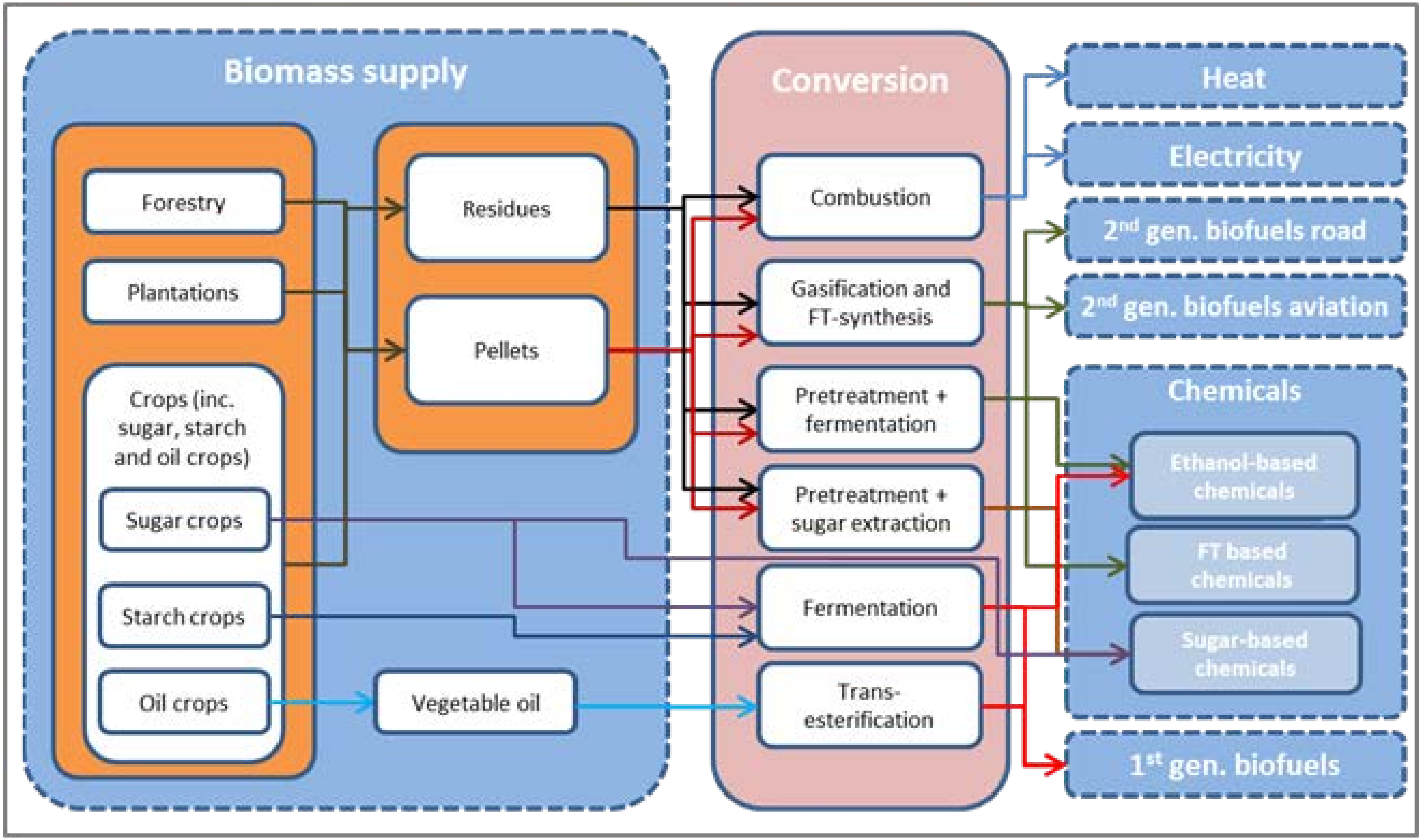
MAGNET – Van Meijl et al. (2016)

- Modular Applied GeNeral Equilibrium Tool
- Multi-regional, applied general equilibrium (CGE) model
- Owned by Wageningen Economic Research
- Global data base describing bilateral trade patterns, production, consumption and intermediate use of commodities and services, taxes, subsidies
- Key applications: agricultural, trade, land and bioenergy; with a particular focus on the impacts on land use, agricultural prices, nutrition and household food security
- Modular structure of MAGNET makes MAGNET flexible, quality control

MAGNET modules

- Modules, extensions (continued developments):
  - EU Common Agricultural Policy
  - Bilateral Tariff Rate Quota
  - Greenhouse gas emissions (CO_2, CH_4, N_2O)
  - EU Emission Trading System (CO_2 emission permits)
  - Land use (land supply function)
  - Segmented factor markets (labour, capital)
  - Flexible labour supply
  - Nutritional value of food consumption
  - Production and consumption of N, P and K fertilizers
  - Renewable energy (wind & solar, hydro, coal, gas, nuclear, etc.)
  - R&D in agriculture
  - Bioenergy & biobased economy

Bioenergy and biochemicals in MAGNET



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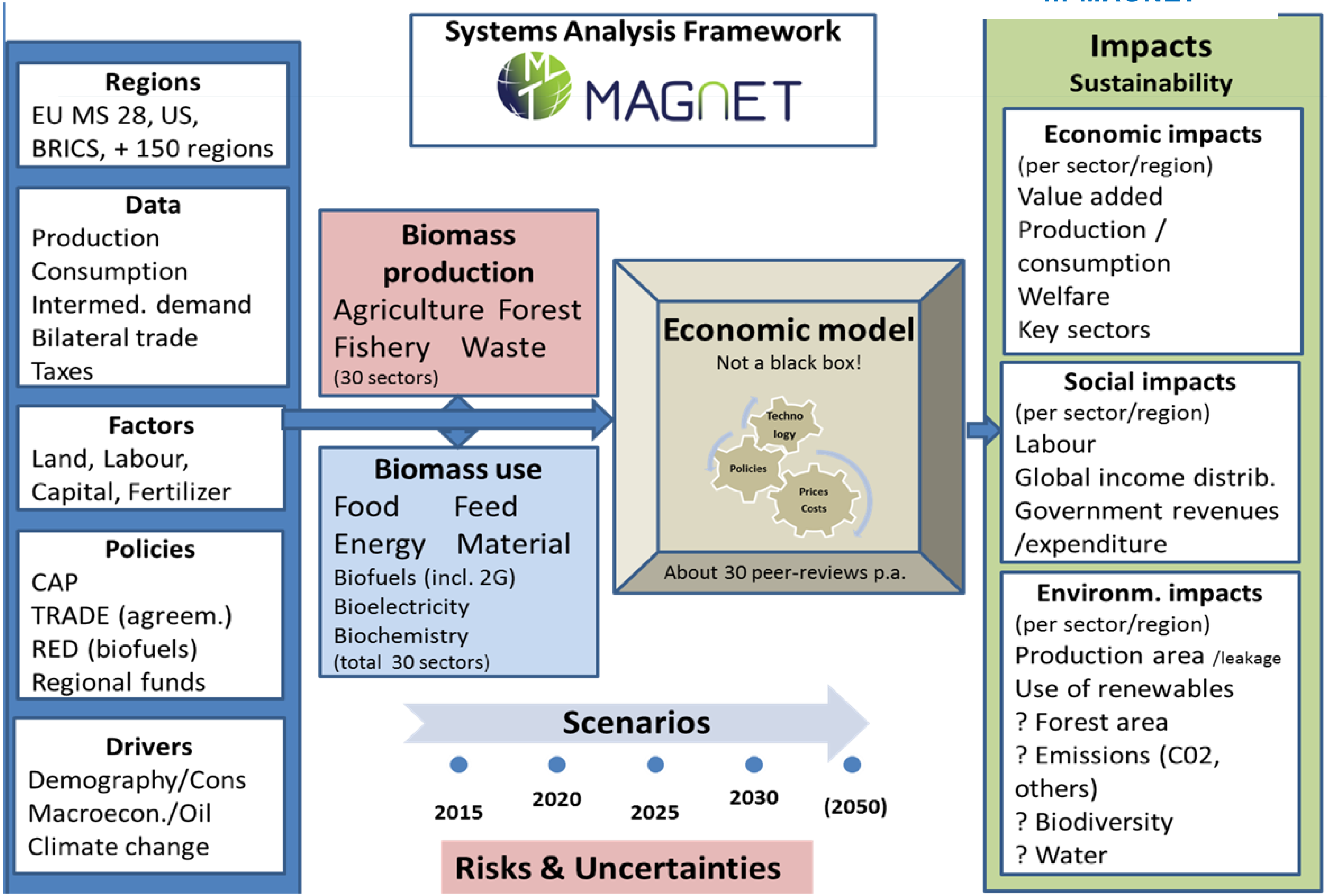
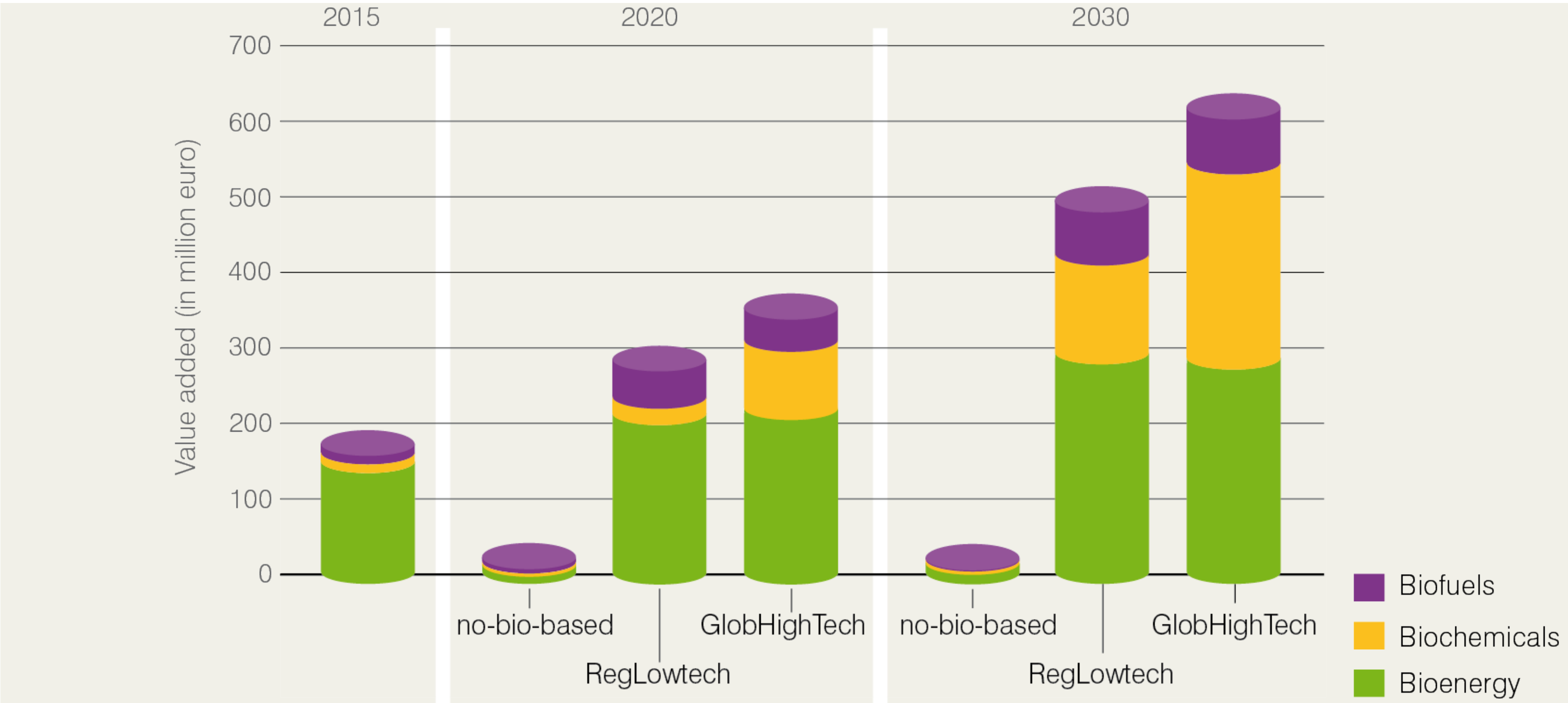
MAGNET

Impact parameters in MAGNET



Scenario parameters in MAGNET: Taxes & subsidies, crop yields and impact of climate change, crop yields and impact of R&D, technological change (GMO, improved agricultural productivity, etc.)!!, population growth, GDP growth, biofuel mandates (RED), trade barriers, oil price, CO2 price, land availability and forest protection (REDD), diet shifts, shift in consumer preference, etc.

Value added of biofuels, biochemicals, bioenergy



Current work – SIM4NEXUS

- H2020 project (2016-2020)
- Serious games based on system dynamics modelling
- NEXUS includes water, energy, food, land use and climate change
- How can we achieve a low-carbon economy and what will be the impact on water, food and land use?
- 12 case studies including NL, EU, global and transboundary
- Involvement of stakeholders in development and game
- AGE models provide inputs for scenarios (MAGNET, CAPRI)

- Part II: Why AGE models?

Purpose of AGE

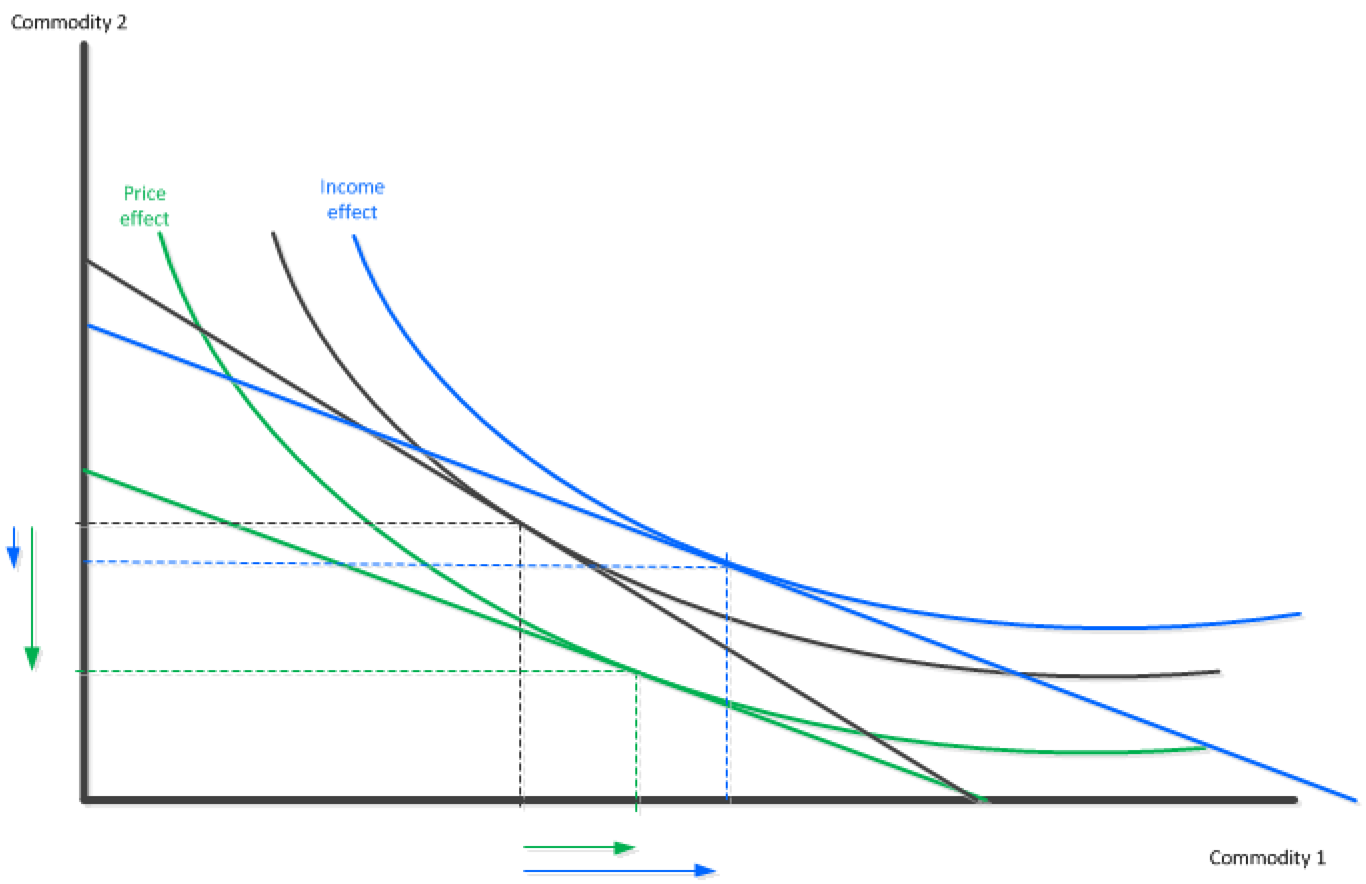
- “Computable general equilibrium (CGE) models are a class of economic models that use actual economic data to estimate how an economy might react to changes in policy, technology or other external factors”

Purpose of AGE

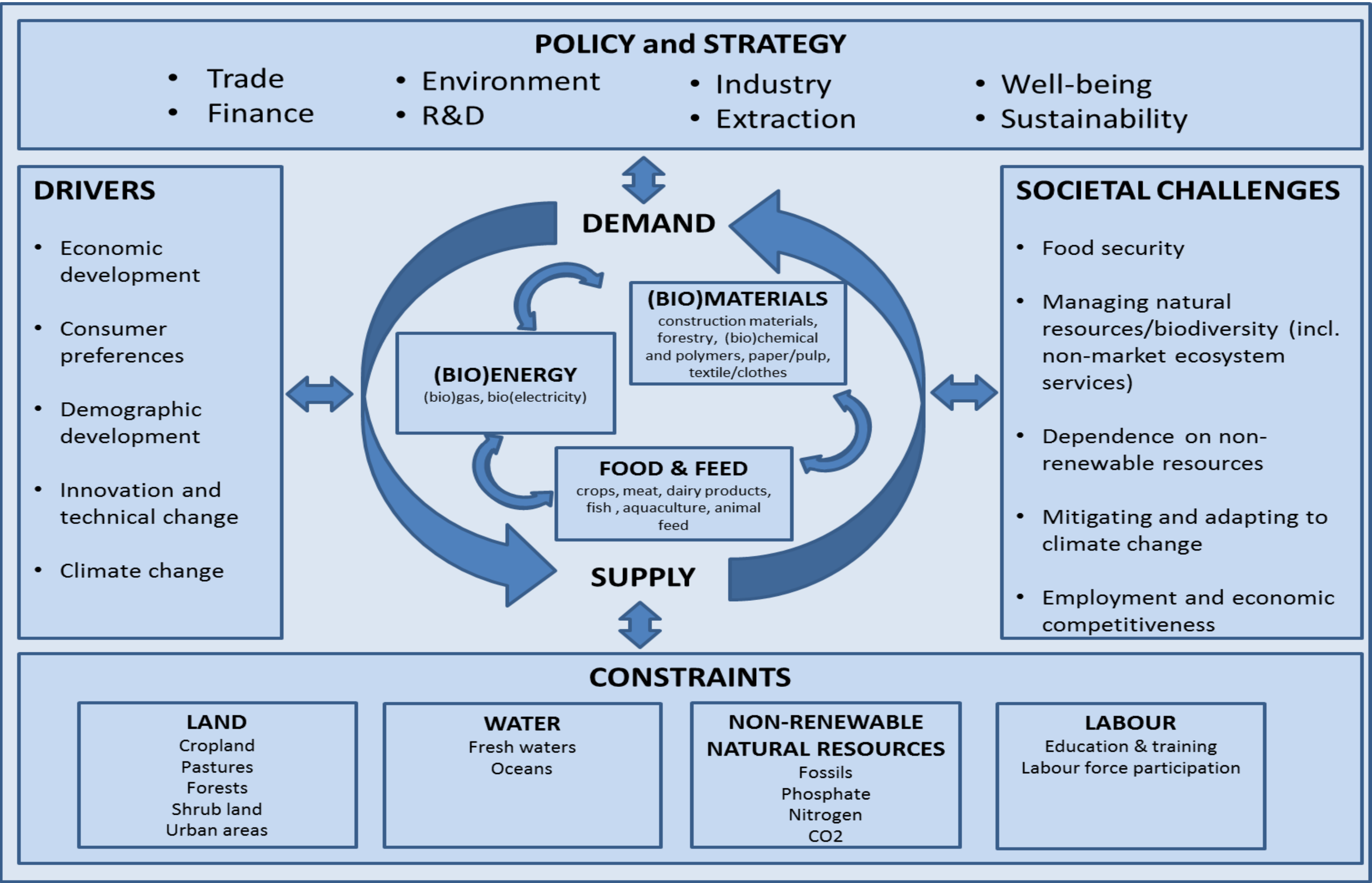
- Economic consequences of drivers of change:
  - Policies/future scenarios
  - Prices are endogenous
  - Economic-wide effects
  - Price and income effect (=direct effect)

- Static vs. dynamic models
  - Growth rates, stock accumulation
  - Path dependency (optimization over time)

Indifference curves: price increase (tax)

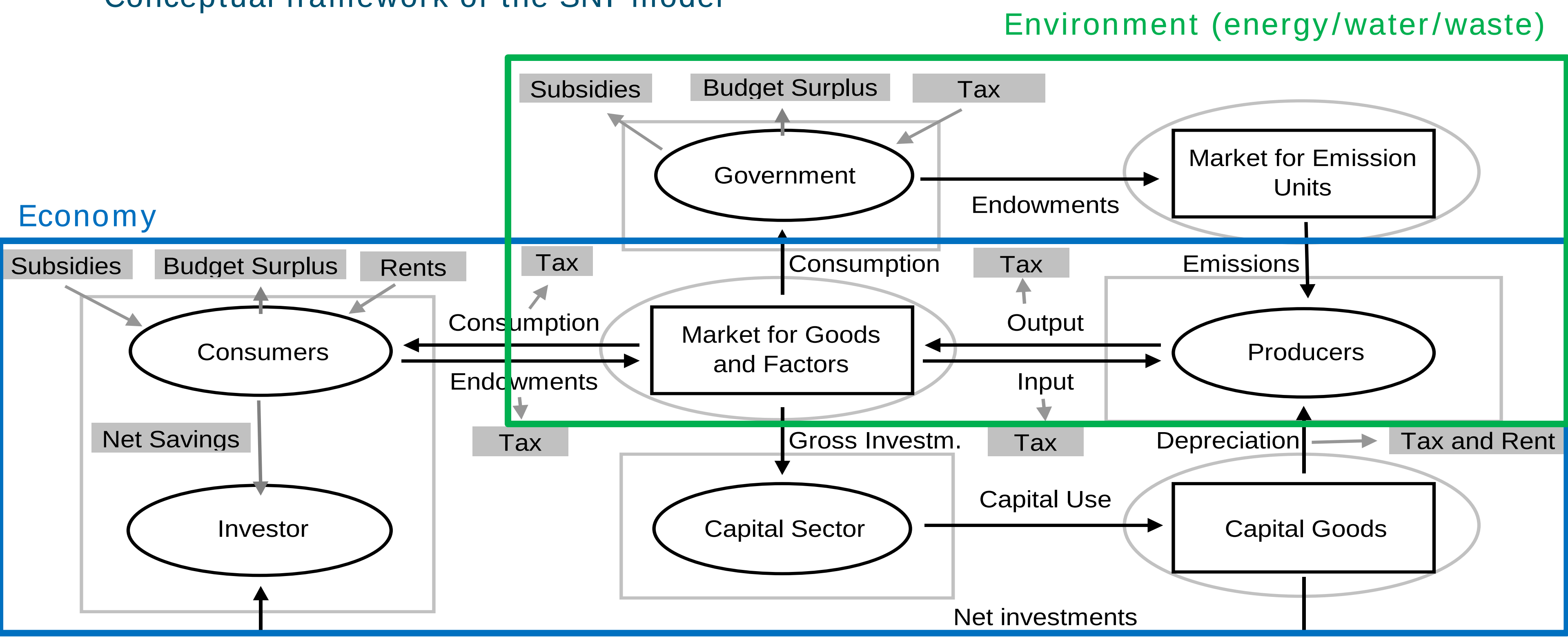


Conceptual Systems: Magnet with BBE



Environmental-economic model

Conceptual framework of the SNI-model



Source: Hofkes et al. (2004); Brouwer et al. (2008), Dellink et al. (2011)

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Environmental-economic model

- Trade-off between mitigation measures (abatement cost functions)
- Tradable permits
- Different prices for different types of electricity/waste/water
- Sustainability standards for emissions (annual numbers)
- Relate energy/water to land use (MAGNET)

Requirements for AGE modelling

- Data
  - Quantification of indicators for production, inputs, intermediate deliveries, outputs, use/consumption (values)
  - Elasticity of substitution for production (CES)
    - Literature
    - Econometric analyses
  - Growth rates of population, technology etc (dyn.)
  - Annual data (standard measurement period)
  - Time consuming!

Requirements for AGE modelling

- Calibration
  - Endogenous variables of the model (prices) => starting values
  - Parameters: Elasticity of substitution for production (CES functions) and consumption
  - Reproduce current status
- Sensitivity analysis on parameters
- Validation
  - Compare results with other models and methods

Issues to keep in mind with AGE

- Relative prices
- Inclusion of policy interventions
  - taxes/subsidies relative to price
  - a ban = high autonomous tax
  - an obligation = high autonomous subsidy
- All goods and services have to have a price (or value) such as carbon emission tradable permits
- Alternatives cannot enter or exit the model
  - If bioenergy is not included in the model, you cannot include it in scenarios
- Shocks and major transitions not included

Issues to keep in mind with AGE

- Base year
- Baseline/reference scenario
  - Current policy and autonomous developments
- Static vs. dynamic model (path dependency or not)
  - Path dependency cannot be simulated by a repetition of static models
  - Investments over time (dynamic model)
- Time efforts and high knowledge (on economics)

Before you start an AGE model

- Which policy or research question do you want to address?
    - Scale
    - Level
    - Subject
- Does it involve economic impacts?
- Does it involve economic (sectoral) or economic-wide (societal) impacts?
- Make a conceptual framework of actors and relationships keeping in mind possible interventions based on the research or policy question

Thank you for your attention

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Literature

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