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Using macromodels in evaluating impact of agricultural interventions

Zagreb, May 23rd

1.Introduction

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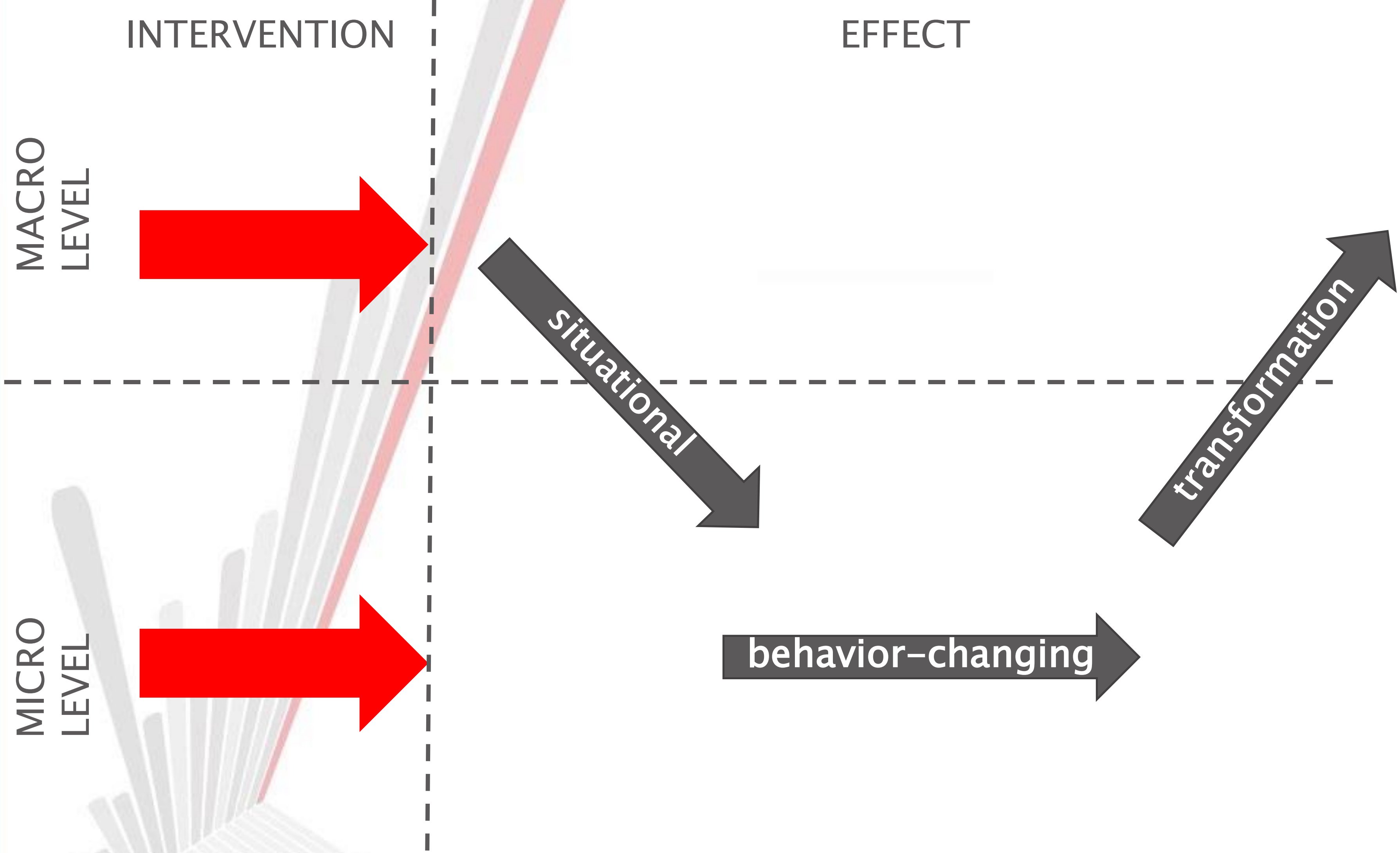
Types of effects



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Classes of macroeconomic models

	one-sectoral models	multisectoral models
theory models • understanding	DSGE	
policy models • analyzing and experimenting		CGE

- DSGE modelers should capture what we believe are the macro-essential characteristics of the behavior of firms and people, and not try to capture all relevant dynamics.
- Policy modelers should accept the fact that equations that truly fit the data can have only a loose theoretical justification.

Both classes should clearly interact and benefit from each other. But the goal of full integration has proven counterproductive.

(Olivier Blanchard, 2017, PIIE)

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2.Upscaling microeconomic evidences

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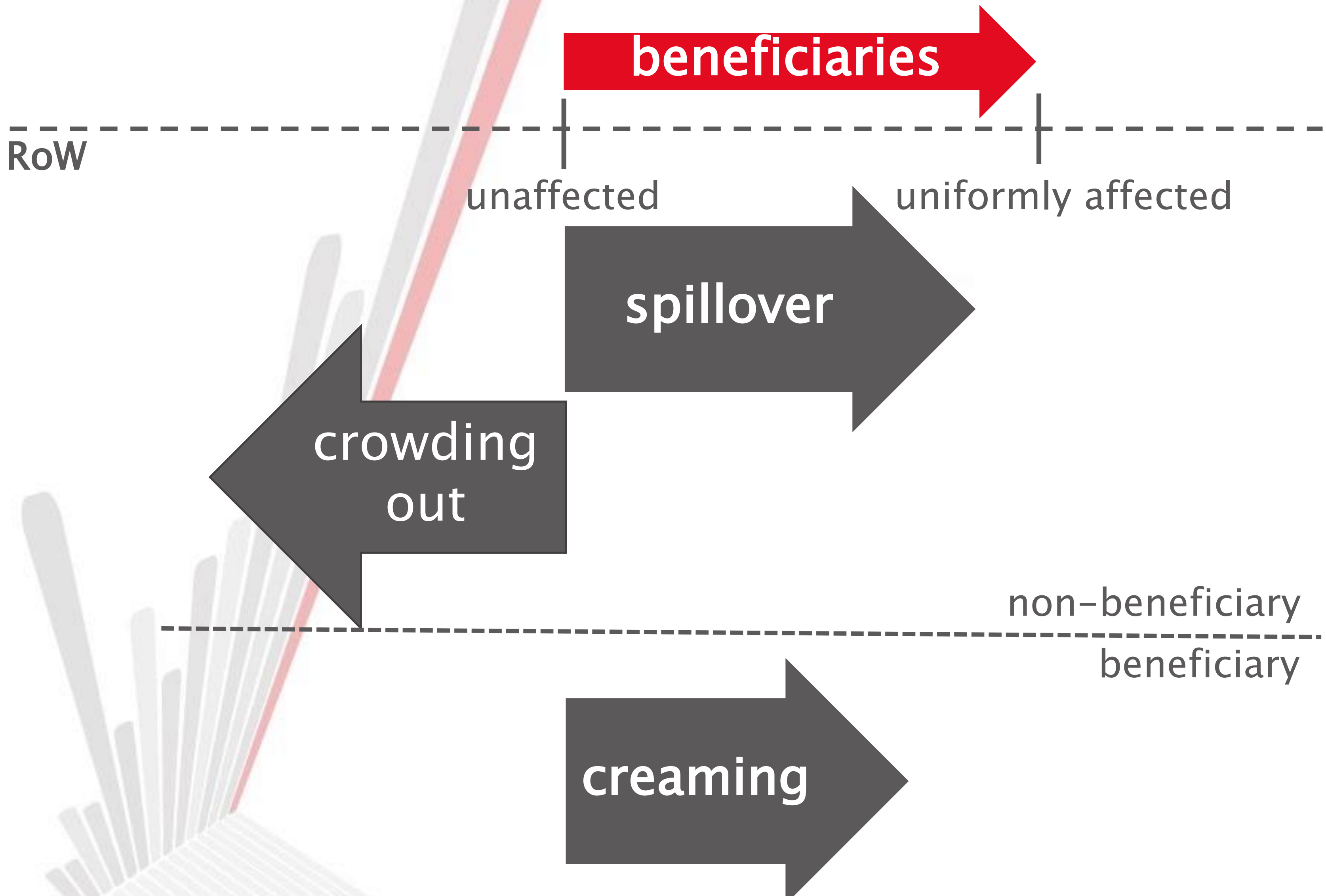
Threats to validity of upscaling



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Upscaling strategy

- Define beneficiary and non-beneficiary population relative to the interventions and the statistical observations and create adjustment functions
- Define direct effects on the beneficiaries
  - microeconomic exercise on behavior changing effects
  - macroeconomic exercise based on microeconomic foundations or pure sampling on situational effects
- List relevant spillover, crowding-out and creaming effects
  - if any is relevant and sizable, abandon upscaling and use a macro-economic model
  - if none is relevant, use triangulation (sampling or surveying RoW)

3.General equilibrium models

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The (static) Walras model

Households own all stocks and resources, their choices are represented by the (homogeneous by degree zero)

- demand functions for the produced goods $v_i(\mathbf{p},\mathbf{r})$
- supply functions of the factors of production $s_k(\mathbf{p},\mathbf{r})$

The household's demand and supply functions always fulfil the budget constraint (Walras's law):

$$\sum_i p_i v_i(\mathbf{p},\mathbf{r}) = \sum_k r_k s_k(\mathbf{p},\mathbf{r})$$

Firms demand factors from households and supply produced goods, they apply technology represented by d_{kj} coefficients. Prices of goods cover their costs:

$$p_j = \sum_k r_k d_{kj}$$

and markets of manufactured (final) goods and factors of production clear:

$$v_i(\mathbf{p},\mathbf{r}) = y_i, \qquad s_k(\mathbf{p},\mathbf{r}) = \sum_i d_{ki} y_i$$

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Walras and the General Equilibrium Theory

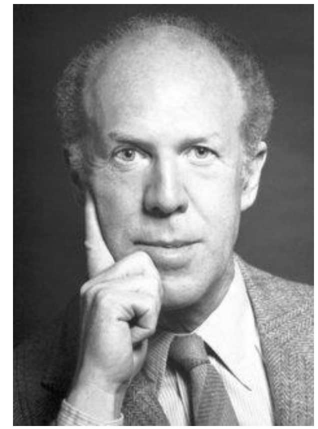
The distinguishing features of general equilibrium modelling derive from the Walrasian general economic equilibrium theory.

The economy is considered a set of agents, interacting in several markets for an equal number of commodities under a given set of initial endowments and income distribution. Each agent defines individually his supply or demand behaviour by optimizing his own utility. His decision yields a set of excess supply functions that fulfil the Walras law, i.e. the global identity of incomes and expenditures.

Arrow and Debreu have proved that under some general conditions, there exists a set of prices that bring supply and demand into equilibrium.

Walras and the General Equilibrium Theory

Kenneth Joseph Arrow
Nobel laureate in 1972
for his pioneering contributions
to general economic
equilibrium theory
and welfare theory



Gerard Debreu
Nobel laureate in 1983
for having incorporated
new analytical methods
into economic theory
and for his rigorous reformulation
of the theory of general equilibrium

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Macromodels: use and setup

A compromise between available information, modelling purpose and manageability

- homogeneity vs. heterogeneity (actors, products, prices etc.)
- mechanisms and sectors explicitly accounted for
- complexity and mathematical formulation

Even the most theoretical models need data, and even the most practical and data-driven models need economic theories

Modeling: mathematical abstraction and solving, data handling and identification, calibration and test runs, results and presentation

Baseline and counterfactual

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The time horizon

- one-period or static (usually a year), short-term
- medium-term (business cycle, 3-5 years)
- longer term

Interventions clearly have different

- short-term (mostly demand-side macro-macro) and
- long-term (supply-side micro and macro)

effects. A clear decision is to be made which one governs modeling.

Baseline and/or counterfactuals are to be defined consequently, especially in an equilibrium setup.

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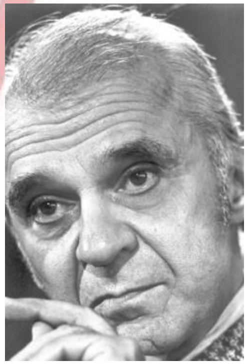
4.Linear input-output models

Pattern of the input–output table at basic prices for domestic output

Use Supply	Input by homogenous branches J= (1,…,n)	Final uses by categories	Total uses
Domestic output by products i = (1,2,…,n)	**Intermediate consumption (X)**	Final consump-tion expenditure (y_c) Gross capital formation(y_I) **Exports (y_e)**	**Total uses (p)**
Imported products	**For intermediate consumption (v_1')**	For final uses	Total uses
Net taxes on products	For intermediate consumption (v_2')	For final uses	Total uses
Value added by components (primary inputs)	Compensation of employees (v_3') Other taxes on products (v_4') Consumption of fixed capital (v_5') Net operating surplus (v_6')		
Total domestic supply	**Domestic output (p')**		

The Leontief input-output model



Wassily Leontief
Nobel laureate in 1973
for the development
of the input-output method
and for its application
to important economic problems

The Leontief input-output model

n sector producing a representative product in a period

$1 \times n$ product, $n \times n$ structural matrix

$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{y}$

If Leontief inverse $(\mathbf{I}-\mathbf{A})^{-1}$ is invertible, the unique production level for a given final consumption is

$\mathbf{x} = (\mathbf{I}-\mathbf{A})^{-1}\mathbf{y}$

and duality of prices $\mathbf{p} = \mathbf{p}A + \mathbf{c}$ can be established and also shown to be unique.

Variants

- product or value
- by branches or by activity

Developed to also contain

- external trade/current account $x = (A+F)x + d + t$
- investments $\mathbf{x} = (\mathbf{A} + \rho\mathbf{B})\mathbf{x} + \mathbf{d}$

thus allowing for calculating import and value-added content of domestic output and of final uses

Other linear models

- Linear activity models and further developments
- von Neumann’s model (Brouwer’s fixpoint theorem)
- the Arrow-Debreu model
- further developments
  - spatial Leontief model
  - stationary development Leontief model
  - models with additional modules (pollution etc.)

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5.Computable General Equilibrium models

The Johansen model

Production is represented by Johansen-type production functions

$$X_j = min\left(\frac{X_{1j}}{a_{1j}}, \frac{X_{2j}}{a_{2j}}, \ldots, \frac{X_{nj}}{a_{nj}}, f_j(L_j, K_j)\right)$$

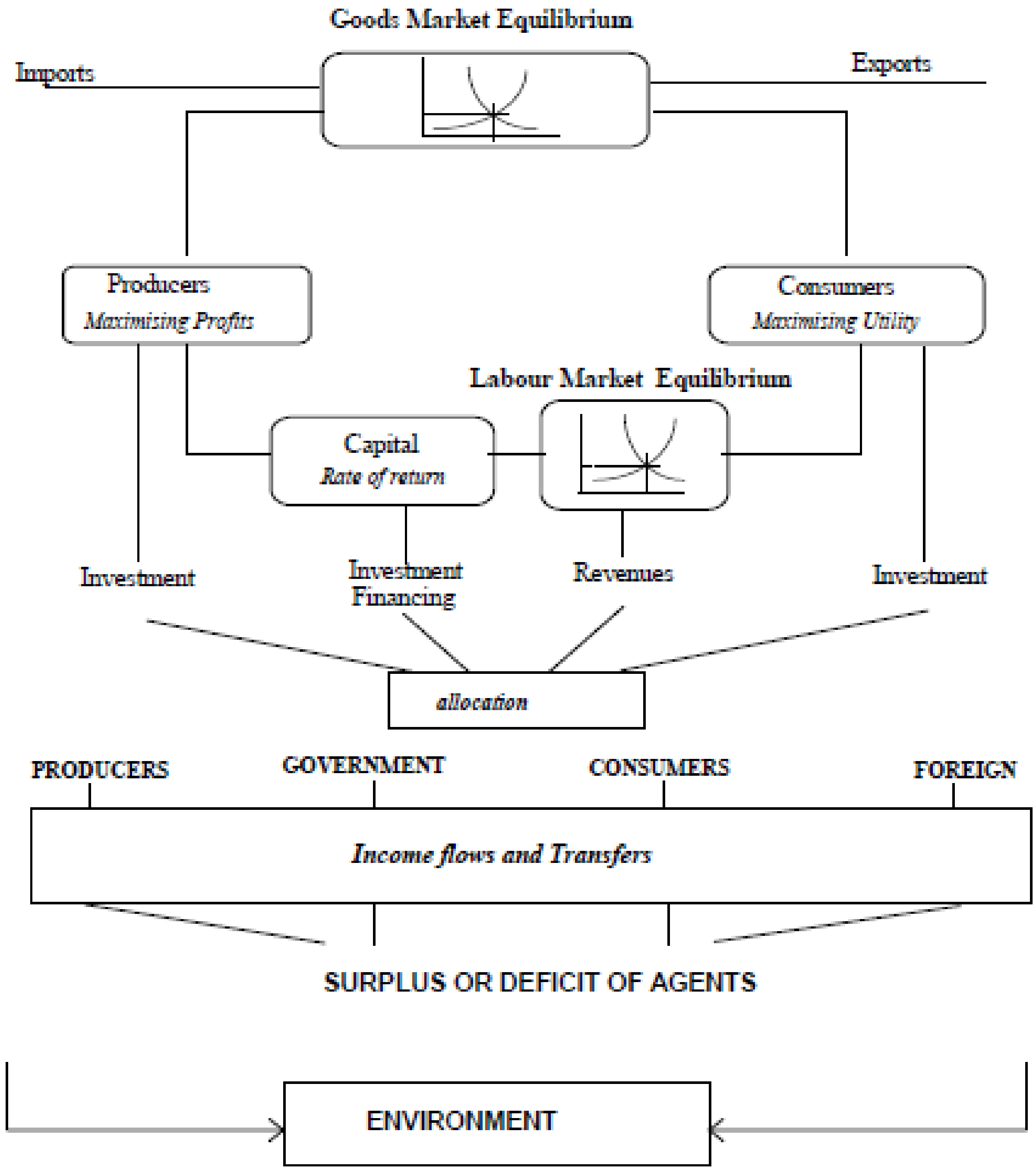
Consumption is represented by Stone-Geary-type utility function and Walras's law. The system is subject to market-clearing of sectoral outputs and primary inputs. Thus, we arrive at an eight-equation system that can be solved for equilibrium. Welfare maximization can be verified to correspond to the equilibrium conditions of the model.

Main building blocks of a CGE model

- primary goods, domestically produced and imported commodities
- representation of production and exports
- representation of final demand
- market clearing conditions and the current account

- endogenous variables (of the core model)
- rates of taxes and subsidies

Calibration of substitution functions (elasticities in the sectoral production functions, parameters of the demand system, substitution possibilities via foreign trade etc.)



The basic scheme of the GEM-E3 model (General Equilibrium Model for Energy-Economy-Environment interactions)

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Dynamics in a model

Comparative statics

- time path of successive equilibria, given time paths of exogenous variables and parameters
  - speed
  - sustainability etc.
- correspondence between
  - the exogenous variable time path and
  - the time path of the parameters

  and the equilibrium time path

Thus, when evaluating impact, one considers the difference the intervention made to the time path vis-a-vis a baseline.

(Comparative) dynamics

- existence and uniqueness of a steady-state (or other appropriately defined equilibrium state or path)
- stability (or instability) of the steady-state(s) locally and globally, speed of convergence
- correspondence between parameters and the steady-state.

Thus, when evaluating impact, one considers the difference the intervention made to the steady-state and thus the path (convergence etc.).

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6.Dynamic General Equilibrium models

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The forerunner: the Solow-Swan model

Robert Merton Solow
Nobel laureate in 1987
for his contributions to the theory of economic growth

The forerunner: the Solow-Swan model

Constant returns to scale production function (CES) and labor-augmenting technological progress $A(t)=A(0)e^{gt}$,

$Y(t)=K(t)^{\alpha}(A(t)\,L(t))^{(1-\alpha)}$

Population grows by e^{nt}, owns all means of production and consumes $cY(t)$, leaving $(1-c)Y(t)$ for investment (also offsetting depreciation of capital $\delta K(t)$).

Dividing the model by the effective unit of labor $A(t)L(t)$ ($y(t)$, $k(t)$) and taking the time derivative, capital intensity

$$\dot{k}(t) = sk(t)^{\alpha} - (n+g+\delta)k(t)$$

converges to its steady state value

$$\dot{k}^{*} = \left(\frac{s}{n+g+\delta}\right)^{\frac{1}{1-\alpha}}$$

without respect to the original value where both $K(t)$ and $A(t)L(t)$ grow by $(n+g)$ and the golden rule saving rate applies

$$\frac{K(t)}{Y(t)} = \frac{s}{n+g+\delta}$$

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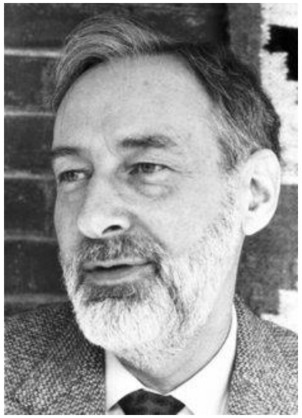
The Ramsey-Cass-Koopmans model



Tjalling Charles Koopmans
Nobel laureate in 1975
for his contributions to the
theory of optimum allocation
of resources

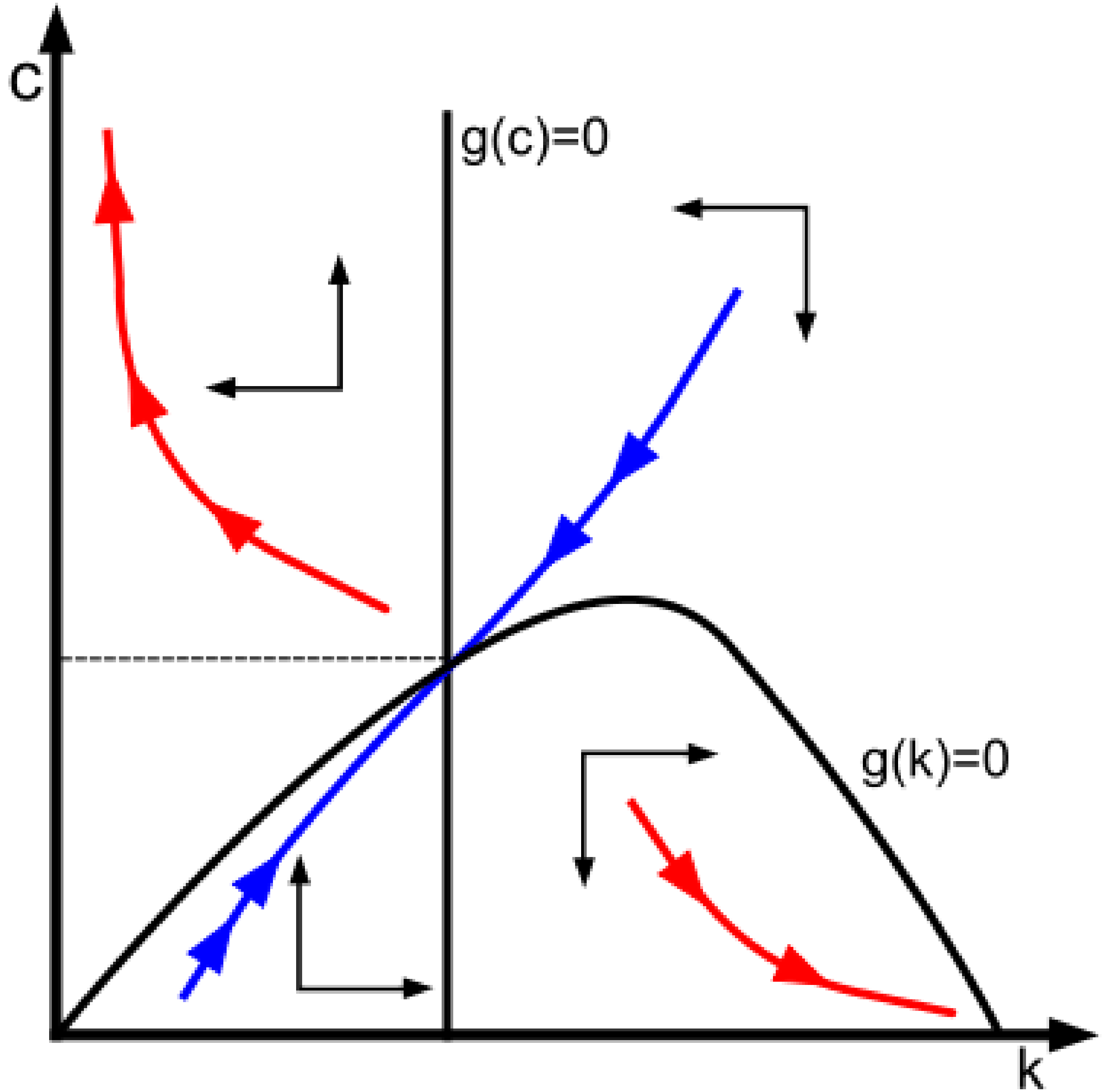
The Ramsey-Cass-Koopmans model

- an aggregate production function (satisfying Inada conditions, homogenous of degree 1, often specified as Cobb–Douglas type)
- the state equation for capital accumulation
- the social planner's problem of maximizing a social welfare function (discounted utility from consumption), converted into a second state equation.

The two differential equations constitute a system that has a unique steady–state, where

$f_k(k^*)=\delta+\rho$, $c^*=f(k^*)-(n+\delta)k^*$

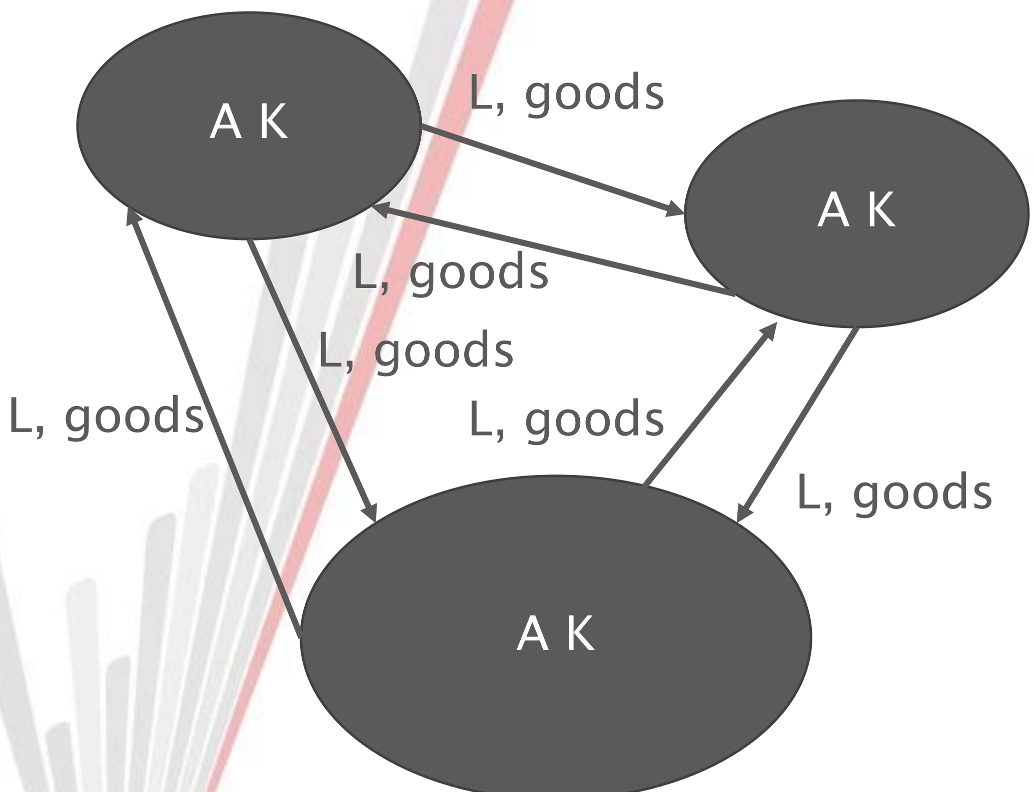
The equilibrium has saddle point property, and there exists a unique stable manifold that converges on the equilibrium. All unstable trajectories are ruled out by the no–Ponzi condition.


c
g(c)=0
g(k)=0
k

Trade models

Goal to understand patterns of trade:

Who exports/imports what and why?



Trade models

Goal to understand patterns of trade:

Who exports/imports what and why?

- Eaton Kortum(2002):
  - explains why trade does not lead wage equalization
  - multiple countries GE model
  - finds closing trade is not costly
  - technology diffusion as other countries also benefit from improvements in one country
- Melitz(2003):
  - allocative efficiency increases when opening up to trade
  - heterogenous effect, productive firms benefit more
  - wages increase because labor is scarcer
- Nagy Dávid (2018):
  - macro impacts of environmental changes

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Heterogenous Agents Macro

- Heterogeneity affects macro aggregates?
  - Firm heterogeneity affects growth?
- Aggregates affect heterogeneity?
  - Fiscal policy affects income and wealth inequality
- Ex ante or ex post heterogeneity
  - Ex post: Aiyagari (1994), Bewley (1986), Huggett (1993)

$$c_t + a_{t+1} = (1+r_t)a_t + w_t \epsilon_t$$

- Agent wants to insure labor productivity risk
  - Perfect (too much) insurance: Permanent income hypothesis
  - No (too little) insurance: Hand to mouth
  - Intermediate insurance: Stationary distribution
    Interpretation: Can the observed income process generate wealth inequality we see?
- Macro: effect of an increase in unemployment risk on interest rates (–) and consumption (?)

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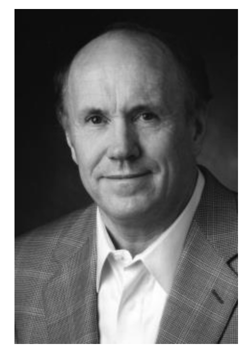
Dynamic Stochastic General Equilibrium models

- What drives business cycles?
  - Technology shocks – Kydland and Prescott (1982)



Finn E. Kydland and Edward C. Prescott
Nobel laureate in 2004
for their contributions to dynamic macroeconomics:
the time consistency of economic policy and
the driving forces behind business cycles

Dynamic Stochastic General Equilibrium models

- What drives business cycles?
  - Technology shocks – Kydland and Prescott (1982)
- Micro founded models for policy analysis
- RCK modified with a stochastic aggregated productivity in production function

  $Y(t)=K(t)^{\alpha}(A(t)\ L(t))^{(1-\alpha)}$

  $\log A(t+1)=\rho \log A(t) + \epsilon(t) \qquad \epsilon(t)\sim N(0,\sigma)$
- Environmental policy model

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7.Partial equilibrium models

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CAPRI (Common Agricultural Policy Regionalised Impact) model

A "multi-purpose" modeling system for EU's agriculture, allows to analyze

- market policies (administrative prices/tariffs/preferential agreements)
- premium systems/quotas/set-aside at regional level
- environmental policies (standards/market solutions)
- changes in exogenous drivers (population/inflation/exchange rates/consumption behavior/technical progress)

regarding

- supply/demand/trade flows
- hectares/herd size/yields/input use
- producer & consumer prices, income indicators
- environmental indicators
- welfare effects including the EU budget for the Common Agricultural Policy (CAP)

comprising

- the underlying "data base"
- the "economic model"
- the software tools/code

CAPRI (Common Agricultural Policy Regionalised Impact) model

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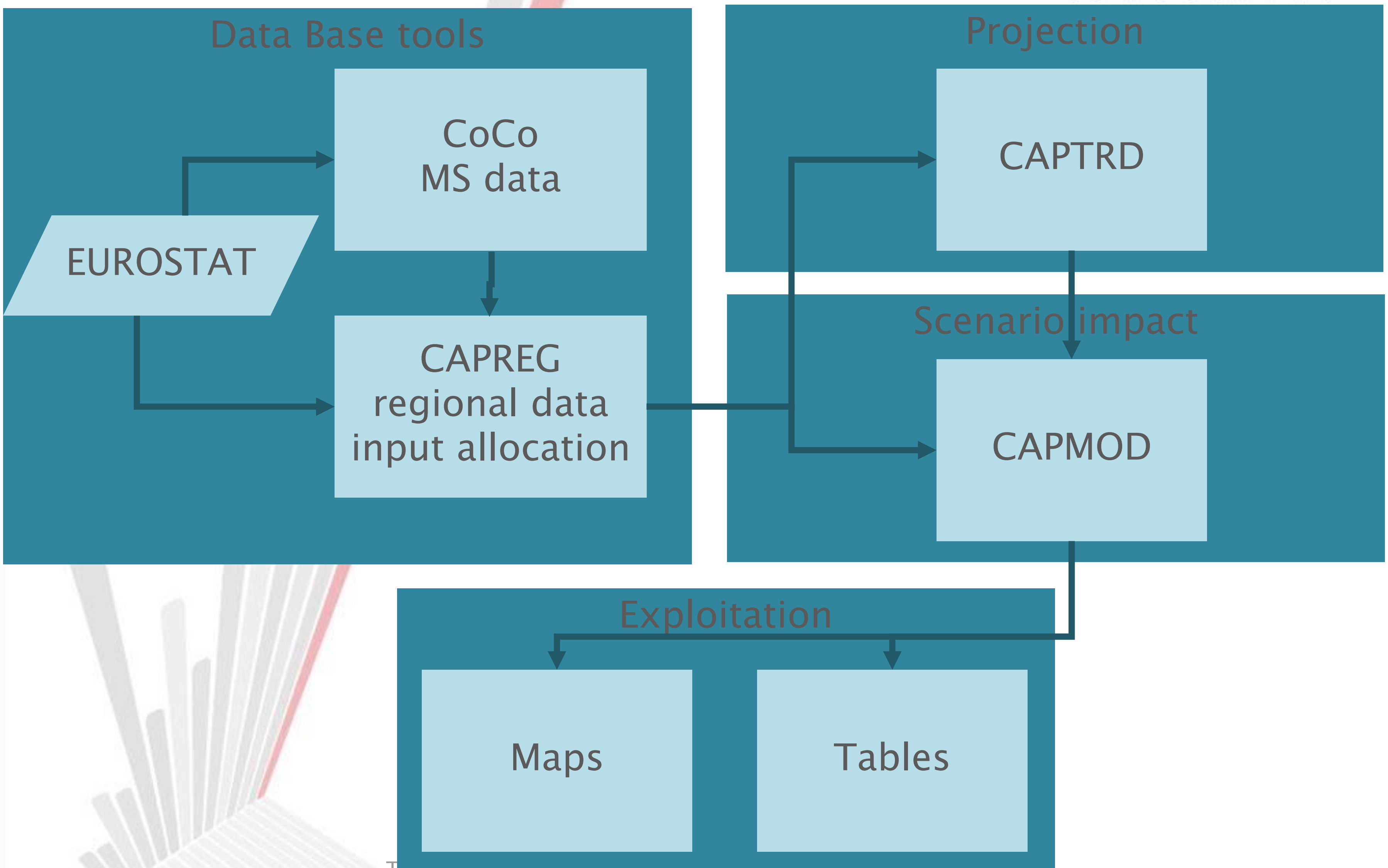
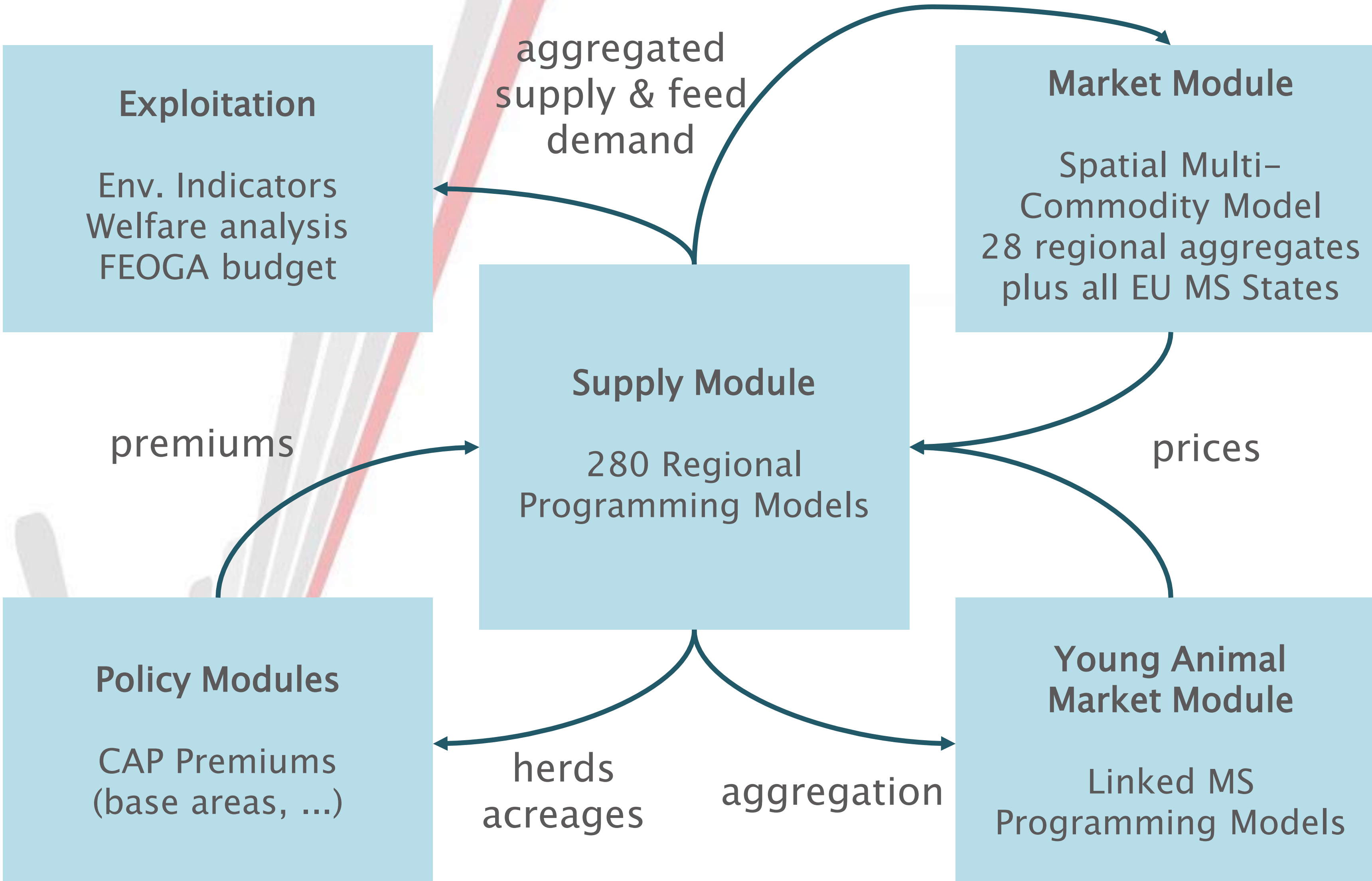
Wolfgang Britz, University Bonn
https://www.slideserve.com/jacie/an-overview-on-the-capri-model-common-agricultural-policy-regionalized-impact-model-powerpoint-ppt-presentation



Data Base tools
CoCo
MS data
EUROSTAT
CAPREG
regional data
input allocation
Projection
CAPTRD
Scenario impact
CAPMOD
Exploitation
Maps
Tables

Link of modules in CAPRI



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8.Consistency

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Items to check

Macro impacts minus direct and indirect micro impacts equals indirect micro on RoW

- Calculate indirect micro impacts
- Check plausibility with TBIE (esp. when offseting)
  - Demand and supply side impacts may differ
  - Time scales may differ
  - Persistence may vary
  - Sustainability may vary
- Options to feed back to macromodel
  - parameter and/or exogenous/policy variables
  - calibration

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