



International Institute for  
Applied Systems Analysis  
www.iiasa.ac.at

science for global insight



# International Institute for Applied Systems Analysis: short overview

Elena Rovenskaya

IIASA Advanced Systems Analysis Program



IIASA, International Institute for Applied Systems Analysis

# What is IIASA?



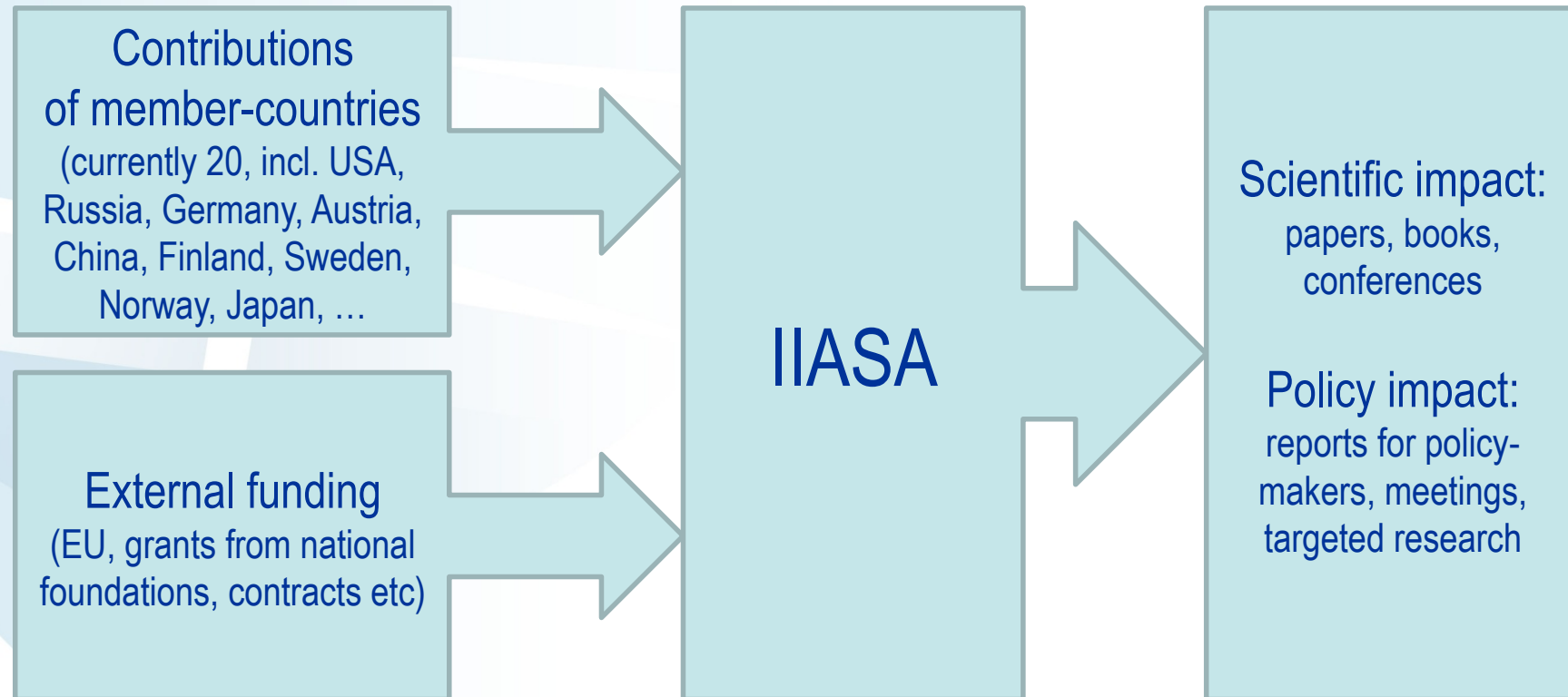
- IIASA is an **international** scientific institute that conducts **policy-oriented research** into problems that are too large or too complex to be solved by a single country: independent, non-governmental organization
- Topics: climate change, energy security, population aging, economic growth, etc: **interdisciplinary character** => integrated assessment
- Important issues: **stakeholder involvement**, bridge **science-policy** divide
- Nearly 200 natural and social scientists, mathematicians, and engineers from over 35 countries research at IIASA

# IIASA's history

- After the Second World War: a growing number of **complex scientific and technological problems** could no longer be examined on a purely national basis: a **global approach** through **international cooperation** was required
- The idea of an “**East–West Institute**” began to take shape in the 1960s through discussions between the USA and the USSR
- Through the Ambassador to the USSR, Austria suggested the 18th century Habsburg palace **Schloss Laxenburg** as a site.
- On **4 October 1972**, the Institute was officially constituted in London under the auspices of the Royal Society as the International Institute for Applied Systems Analysis (IIASA).
- 12 National Member Organizations (NMOs) from Canada, Czechoslovakia, Bulgaria, East Germany, France, Italy, Japan, Poland, the Soviet Union, the United Kingdom, the United States, and West Germany signed the Charter.
- Now: **North-South orientation** in addition to East-West, **large networks**



# Current IIASA's structure

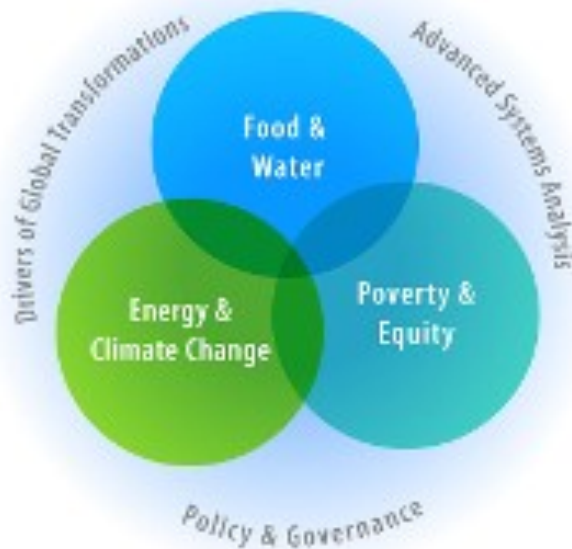


# Research at IIASA

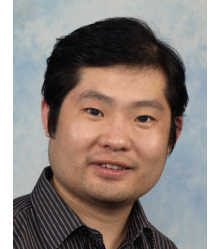
ASA's goal:  
to **advance systems analysis**,  
which uses mathematical  
models and analytical  
techniques to investigate  
**complex systems** with a focus  
on an **integrated,**  
**interdisciplinary approach.**

8 research programs:

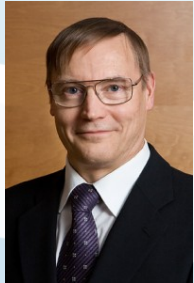
- **Advanced Systems Analysis (ASA)**
- Ecosystems Services and Management (ESM)
- Energy (ENE)
- Evolution and Ecology (EEP)
- Mitigation of Air Pollution (MAG)
- Risk, Policy, and Vulnerability (RPV)
- Transitions to New Technologies (TNT)
- World Population (POP)



# ASA: Some figures and facts



- 15 research scholars/senior research scholars and 3 research assistants
- **Network:** Most of the staff have their main affiliations elsewhere (Russia, Ukraine, Finland, Japan, Austria, USA)
- Disciplinary backgrounds: applied mathematics, ecology, social sciences, economics
- ASA's research strategy includes: (i) development of **new systems-analytic methods** rooted in IIASA's applied research, (ii) development of **feedback between systems methods and applied research** on global change, and (iii) **demonstration** to a broad scientific audience of **new knowledge** obtained through the use of the new methods



# Main research themes

	Assessment of Dynamical Systems	Systemic Risks and Robust Solutions	Integrated Modeling and Decision Support
<b>Dynamic systems</b>	Management of heterogeneous dynamical systems	Systemic risk and network dynamics (in collaboration with EEP)	Model integration (COMPLEX)
<b>Networks</b>		Network analysis in ecology  Systemic risk, security and robust solutions	
<b>Optimization</b>	Global economic growth and optimization (in collaboration with POP)  Assessment of resource productivity		Multi-criteria analysis  Operating energy efficient buildings (EnRiMa)  Food, water and energy security management
<b>Game theory</b>	Sustainable forest management (in collaboration with ESM & EEP)		
<b>Agent-based modeling</b>			Artificial world for forecasting (Dream Valley)
<b>Qualitative analysis</b>		Drivers of extreme events	



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Thanks for your attention and  
welcome to IIASA!



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# Approaches to science-based support of decision-making in regional economic development

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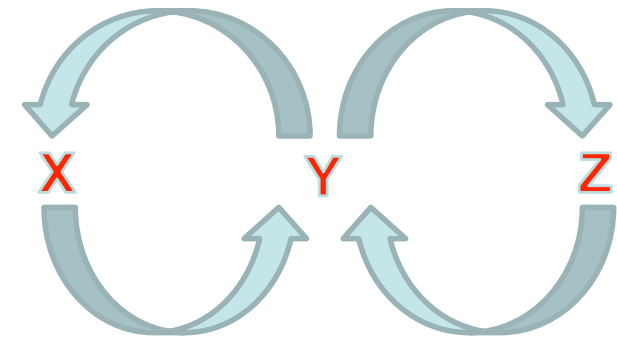


IIASA, International Institute for Applied Systems Analysis

# Two approaches

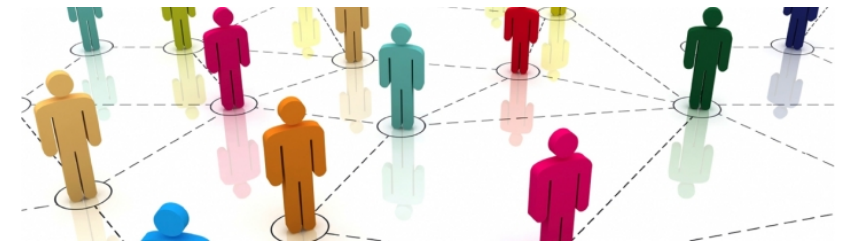
- **Systems dynamics**

..an approach relying on **causal loop** diagrams and accumulating **flows** into **stocks**



- **Agent-based modeling**

..an approach relying on simple **behavioral rules** of multiple interacting agents which emerge into a **complex systems behavior**



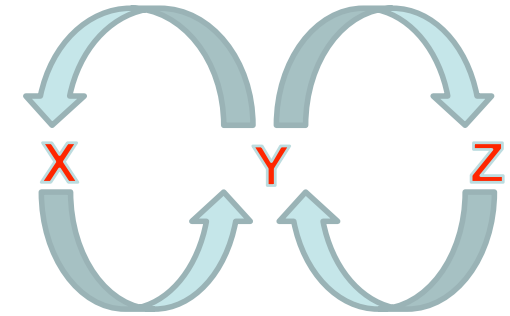
**SCOPUS database, 2012:**

SD: about 27,000 papers

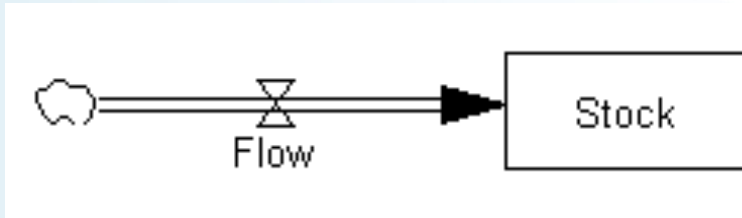
ABM: about 20,000 papers

Both approaches have been proven to be effective tools for the science-based support of the decision-making in various fields including economy, social sphere, environment etc.

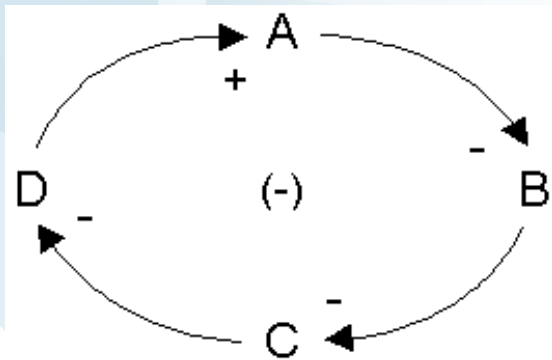
# Systems dynamics



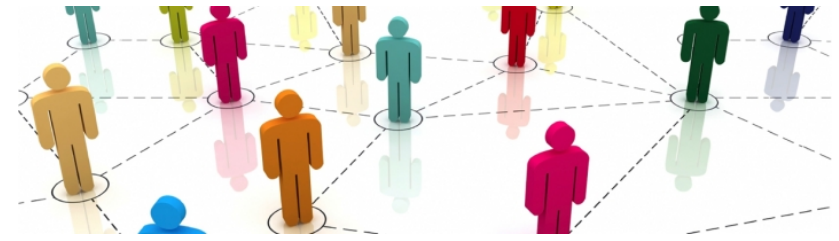
A **flow** contributes to a **stocks**:



Where does a **flow** come from? Via feedback loops from another **stock** (as its **share!**) and from outside the system (**external scenarios**)



# Agent-based modeling

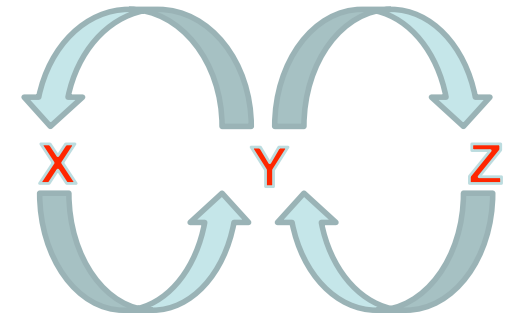


An agent-based model should consist of

- numerous agents specified at various scales
- agents' decision-making rules
- learning rules or adaptive processes
- interaction topology
- non-agent environment

# Comparison of the two approaches

	Power	Limitations
Systems dynamics (SD)	Tractable feedback loops  Requires little computer resources, easy to program	Aggregated representation, simple decision rules
Agent-based modeling (ABM)	More realistic representation of actors and their interactions  Decentralized decisions	Many parameters, difficult to calibrate  Requires more computer resources, difficult to program



# Model I: Systems dynamics of regional economic development

# Model I: Systems dynamics of regional economic development

## Main actors in the model:

Municipalities, Companies, Distributors, Public sector, Employed, Unemployed, Retired

## Main stocks:

- Actors' cash stocks
- Companies' accumulated debts
- Companies' accumulated profit

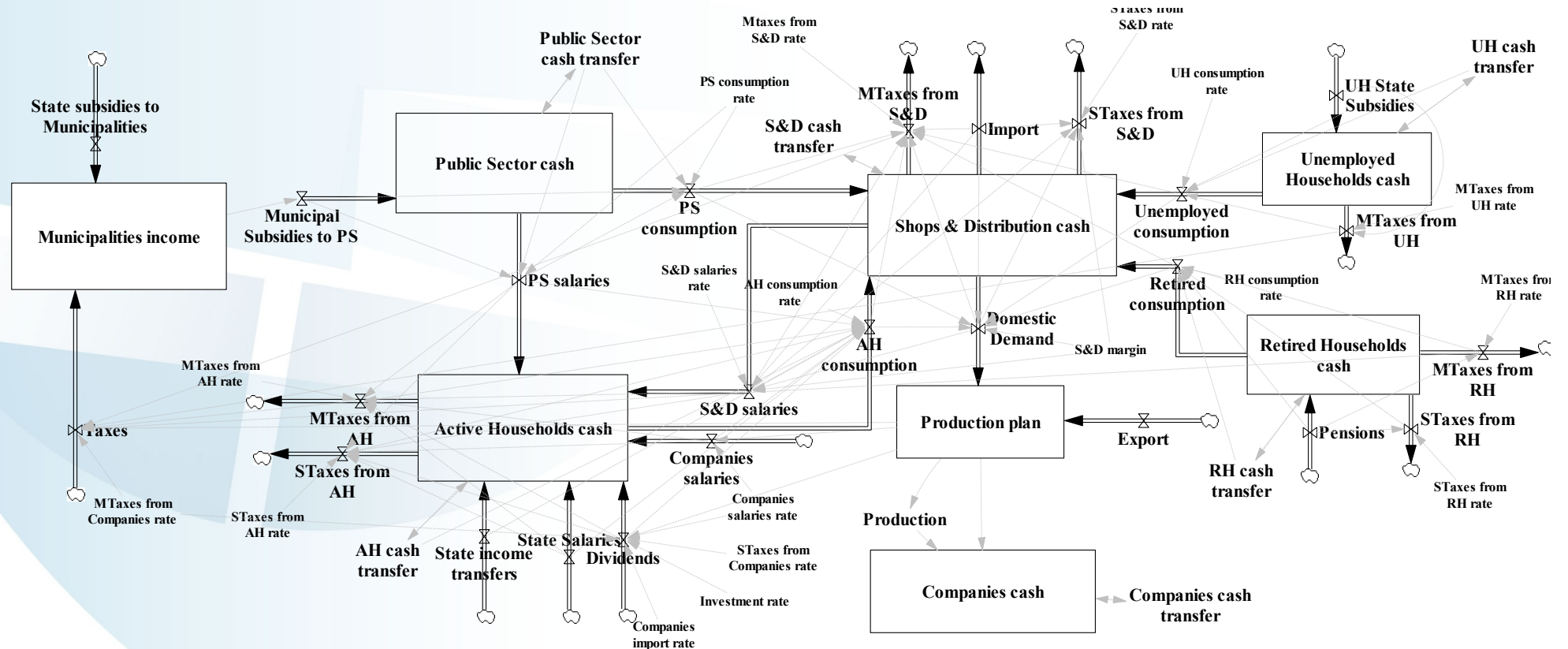
## Main flows:

- Companies' production
- Local demand
- Total consumption
- Taxes paid by actors to the local and state governments
- Salaries paid by companies, distributors and social services

## Main external variables:

- Export
- Import
- State subsidies to municipalities and employed
- Pensions, unemployment benefits
- State salaries

# Model I: Systems dynamics of regional economic development





# Model I: Systems dynamics of regional economic development

Parameters that need to be defined (about 20):

## Companies:

- Profit share allocated for investment
- Cost structure: shares of labor cost, materials and energy cost
- State tax rate

## Distributors:

- Profit margin
- Share of labor cost
- State tax rate

## Municipalities + Public sector:

- Share of labor cost
- Tax rates for other actors

## Employed:

- Consumption share
- State tax rate

## Unemployed:

- Consumption share

## Retired:

- Consumption share
- State tax rate

# Model I: Systems dynamics of regional economic development

## General concept of the analysis:

Two modes of operation: constant and non-constant exogenous inputs

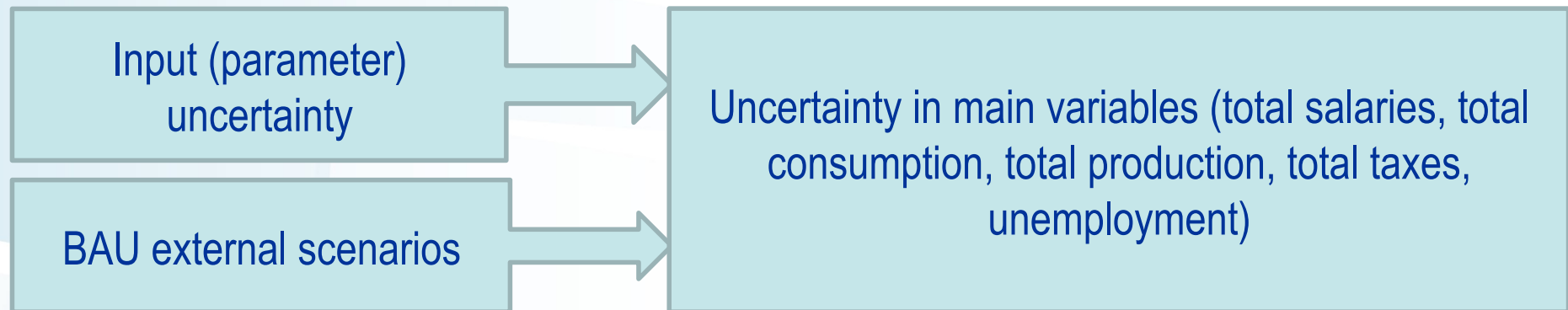
Property of SD models: with constant outputs the dynamics stabilizes very quickly => **stationary process independent on the initial state**

Stationary process: dynamics with constant over time variables dependent only on the external inputs

Allows for simpler and more comprehensive analysis of the **impact of changes in some external scenario onto the main state variables**

# Model I: Systems dynamics of regional economic development

## Task 1: sensitivity analysis of the main state variables



**Input  
uncertainty:  
20%**

	Min	Max	Uncertainty	Uncertainty per 1%
Municipalities income	1726	7858	355%	18%
Total salaries	8378	49479	589%	25%
Total consumption	7247	32615	350%	18%
Total production	6027	23711	293%	15%
Total taxes	1590	7722	385%	19%
Savings of employed	2888	19901	589%	29%
Savings of unemployed	16	49	200%	29%
Savings of retired	67	210	213%	11%

# Model I: Systems dynamics of regional economic development

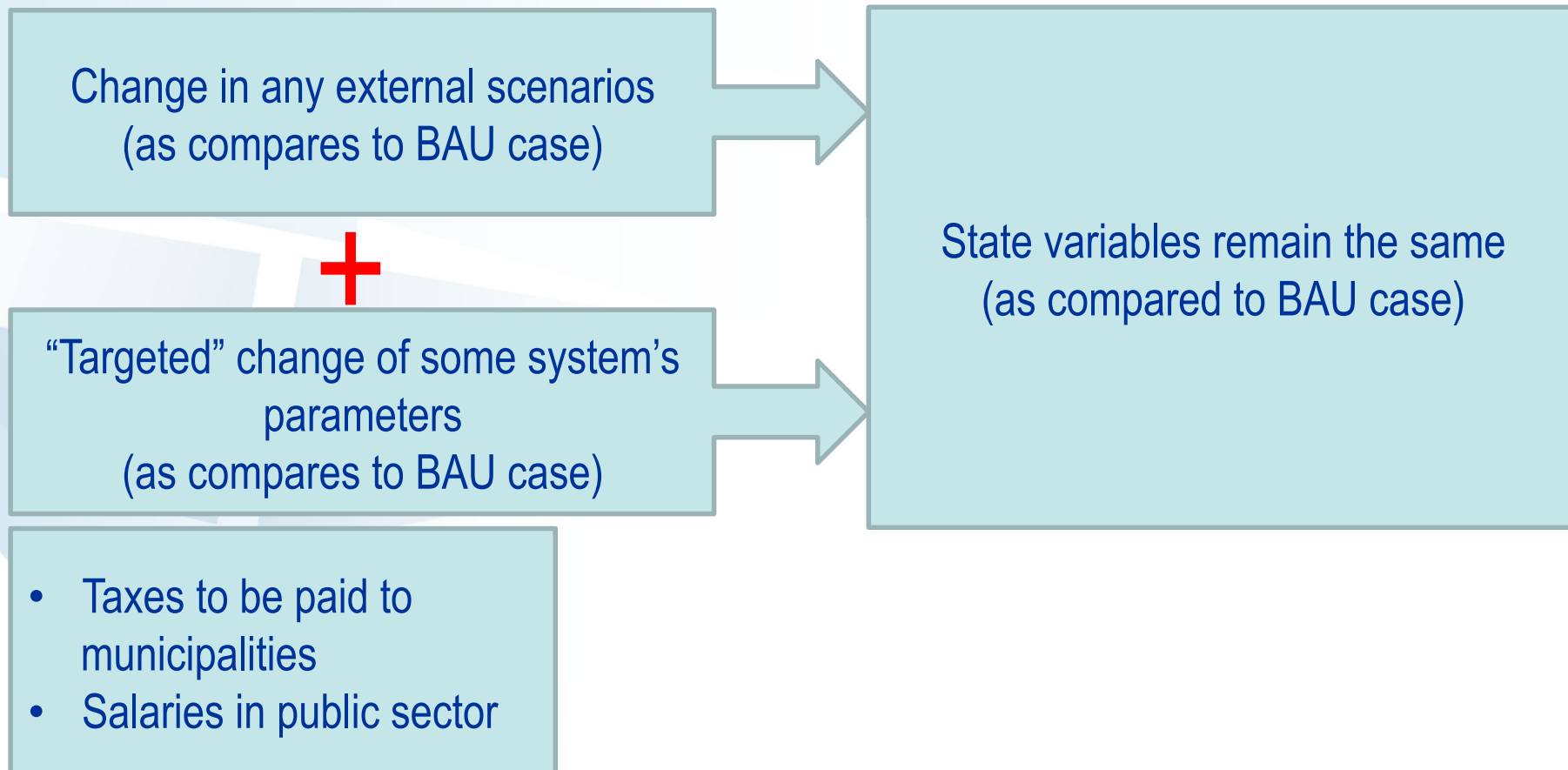
## Task 2: sensitivity results of the elasticity

**Elasticity of Y with respect to X:** the percentage change of Y corresponding to 1% change of X

	Export	Import	State subsidies to municipalities	State subsidies to employed	Pensions	Unemployment benefits	State salaries
Municipalities income	137...173%	-156...-124%	8...15%	8...10%	43...46%	10...10%	9...10%
Total salaries	152...182%	-164...-137%	8...9%	10...10%	43...45%	10...10%	10...12%
Total demand	156...422%	-571...-134%	8...26%	9...30%	41...133%	9...31%	9...29%
Total production	162...203%	-183...-146%	8...9%	10...10%	43...45%	10...10%	9...10%
Total taxes	146...176%	-159...-132%	8...9%	8...10%	41...133%	10...10%	10...12%
Savings of employed	150...180%	-162...-135%	8...9%	10...12%	42...45%	10...10%	10...11%
Savings of unemployed	-	-	-	-	-	100%	-
Savings of retired	-	-	-	-	100%	-	-

# Model I: Systems dynamics of regional economic development

## Task 3: re-adjustment of policies in case of shock scenarios

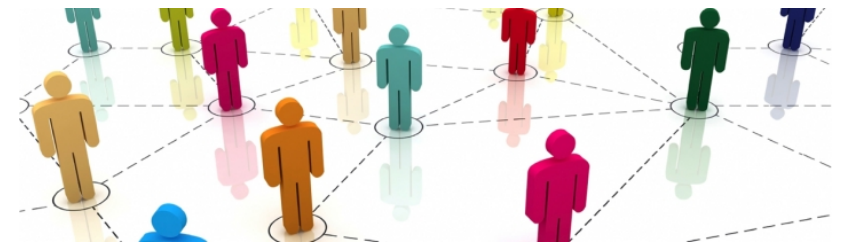


# Model I: Systems dynamics of regional economic development

## Task 3: re-adjustment of domestic policies in case of shock scenarios

**Drop in export by 30%**

	BAU value	Adjusted value	Percentage change
Taxes from companies			
Taxes from distributors			
Taxes from employed			
Taxes from unemployed and retired			
Salaries in public sector			



# Model II: Agent-based modeling of regional economic development

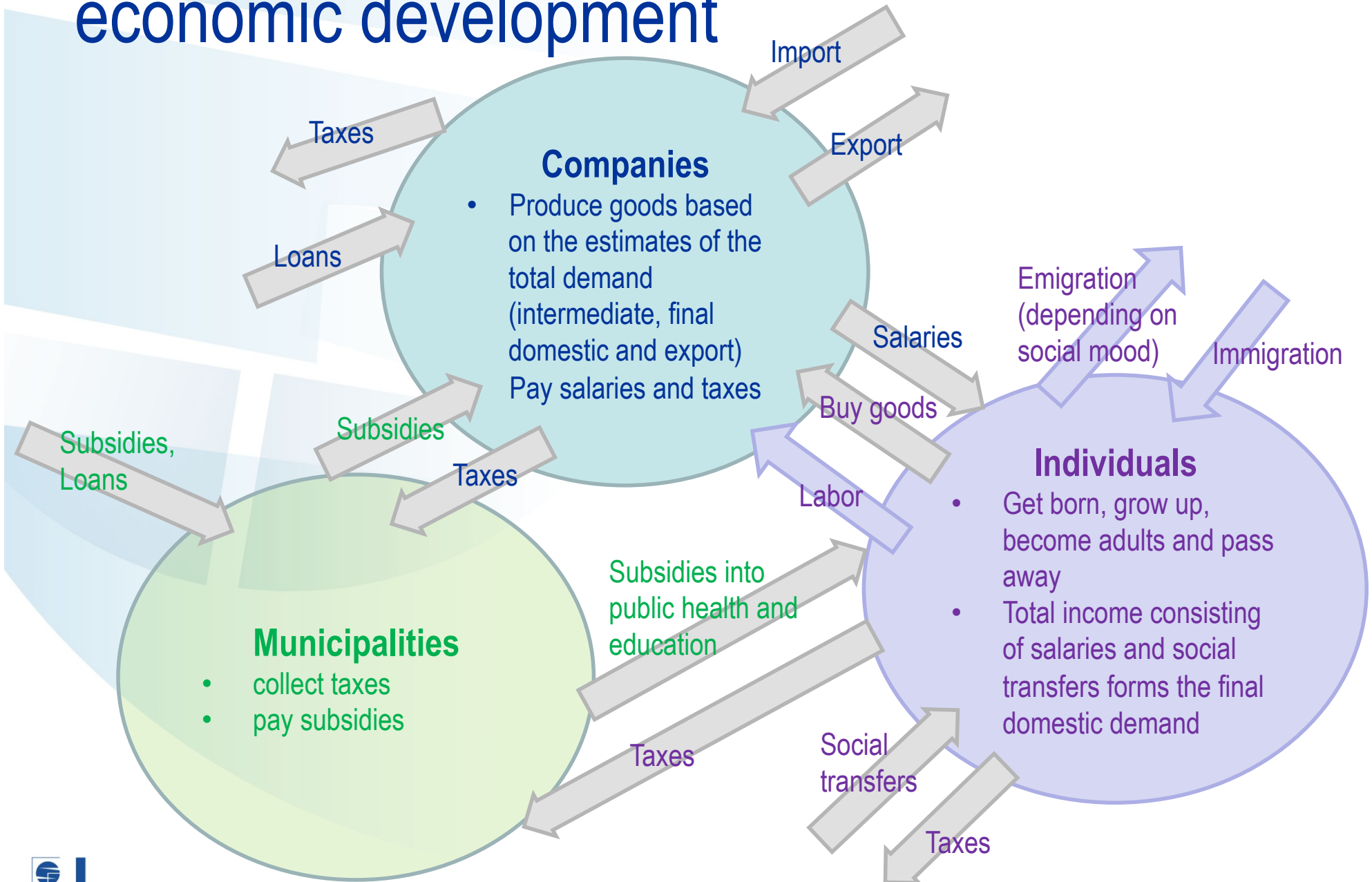
# Model II: Agent-based modeling of regional economic development

## Main agents in the model:

- Municipalities
- Companies (11 sectors: industry, agriculture, construction, trade, hotels and restaurants, information and communication, administration, public sector, education, health and social services, other)
- Individuals (can be employed, unemployed, students, children, retired; can have high education or not, have different social mood)

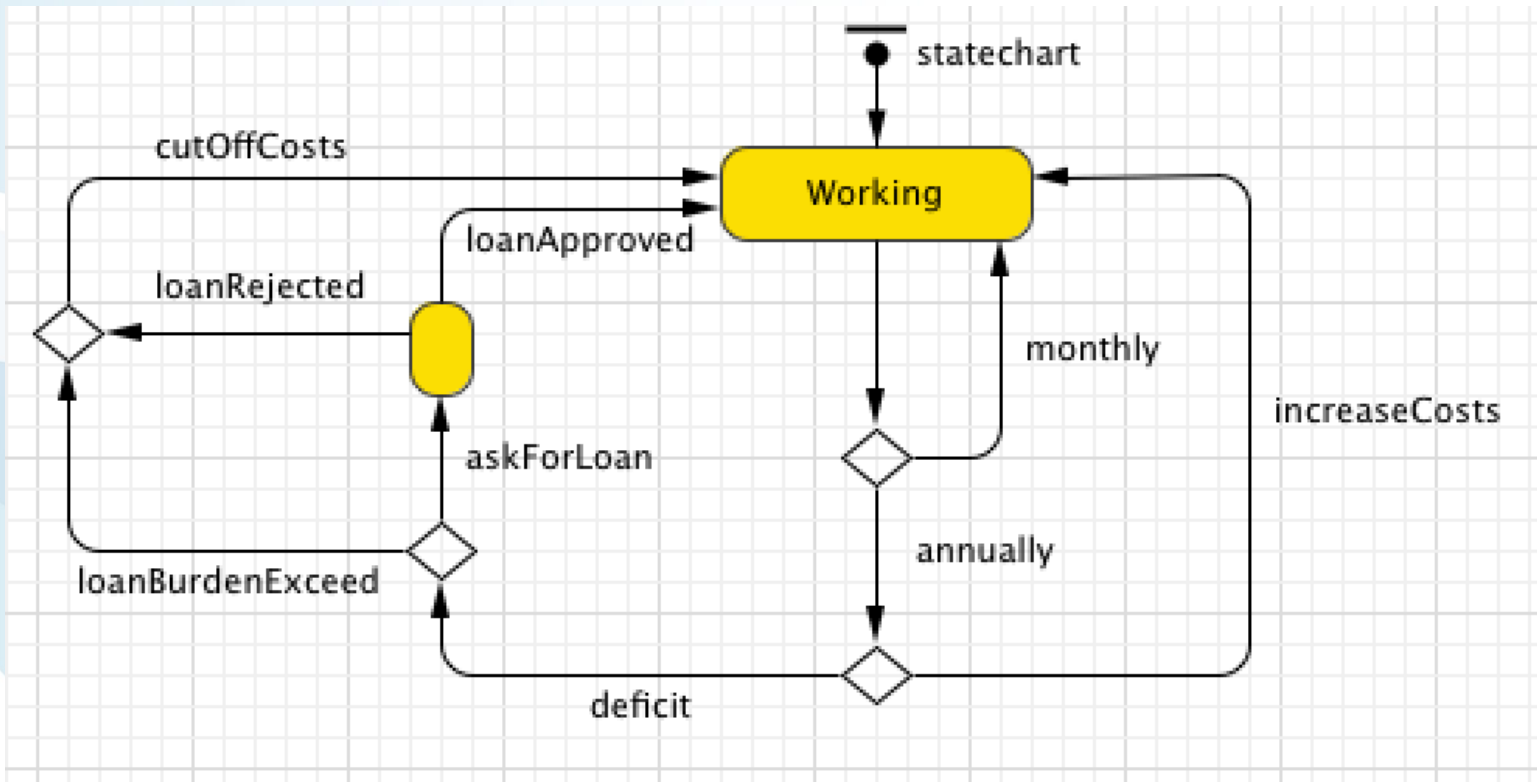


# Model II: Agent-based modeling of regional economic development



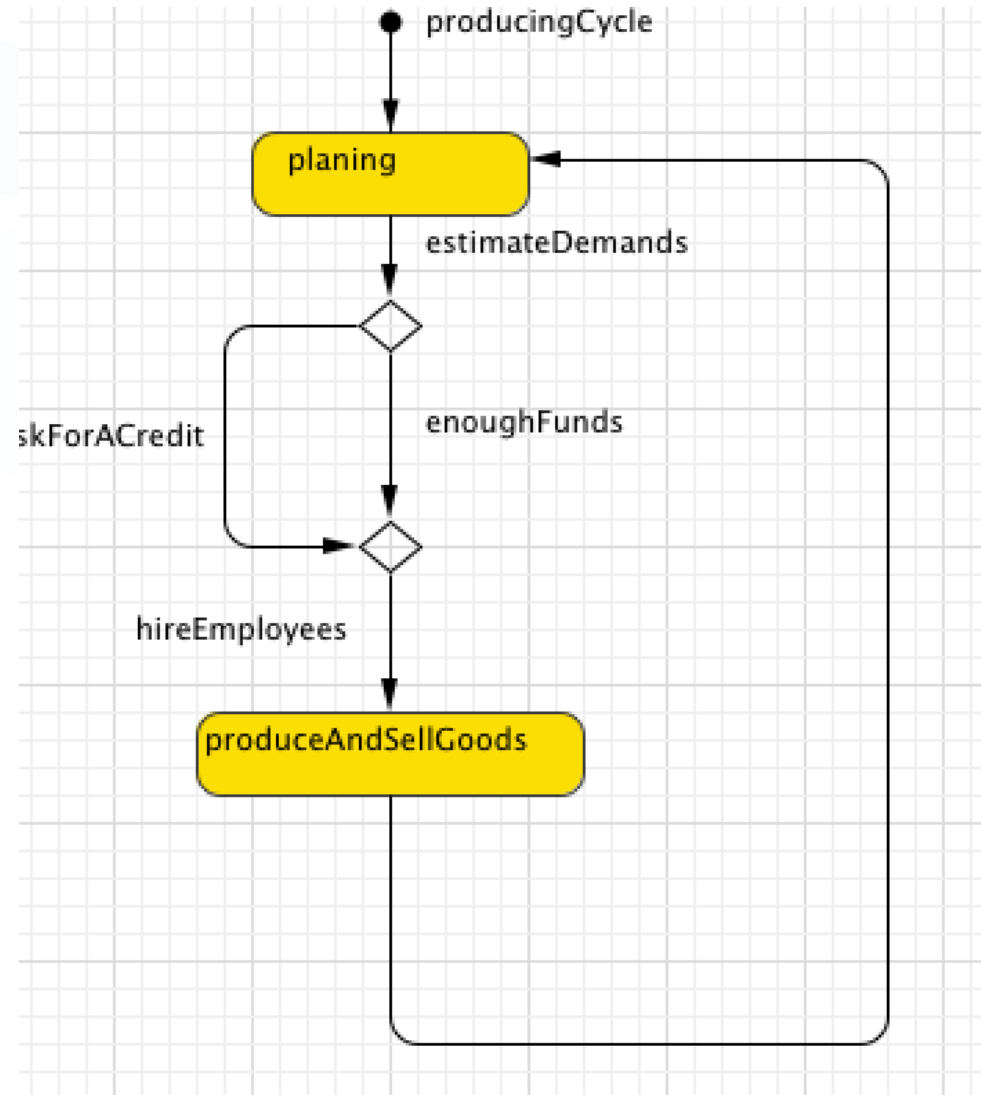
# Model II: Agent-based modeling of regional economic development

## State chart of municipalities



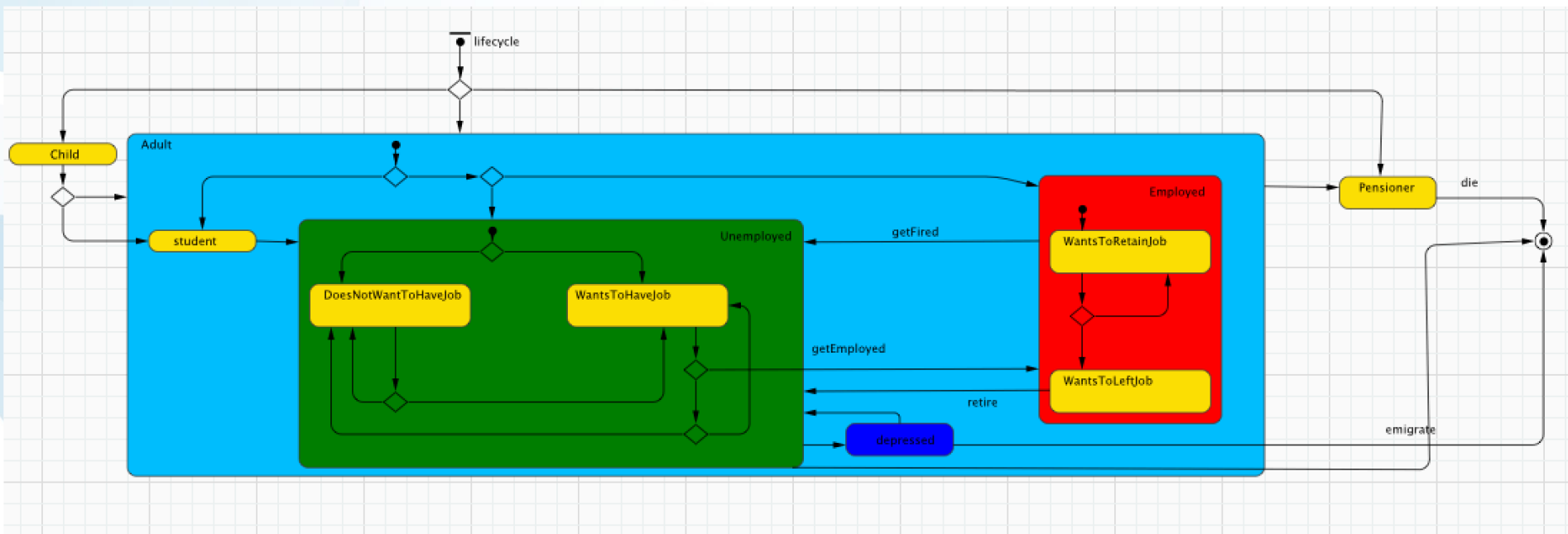
# Model II: Agent-based modeling of regional economic development

## State chart of a company



# Model II: Agent-based modeling of regional economic development

## State chart of an individual



# Model II: Agent-based modeling of regional economic development

**Main parameters that need to be defined (more than 120 in total)**

- Birth and mortality rates, immigration rate
- Shares of intermediate consumption (input-output tables)
- Tax rates
- Individuals' consumption rates depending on their age and job status
- Cost structure of companies, incl. labor cost, cost of materials and energy, profit rate etc.
- Ratio of employees with high education needed in each sector
- Interest rates and loan's time
- Impact of social mood on emigration
- Impact of social transfers on health and number of people going to universities
- ...

# Model II: Agent-based modeling of regional economic development

## Input scenarios

- Export
- Social transfers to households
- State subsidies to municipalities
- State subsidies to companies
- Social mood

# Model II: Agent-based modeling of regional economic development

Demonstration in AnyLogic