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Modelling Structural Change in the Agricultural Sector – an Agent-Based Approach Using FADN Data from Individual Farms

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- Objectives
- Model design
  - Number of agents
  - Behaviour of the agents
- Modelling the land market
- Technical implementation
- Results of a prototype

SWISSland =

Structural change information system for Switzerland

Why SWISSland?

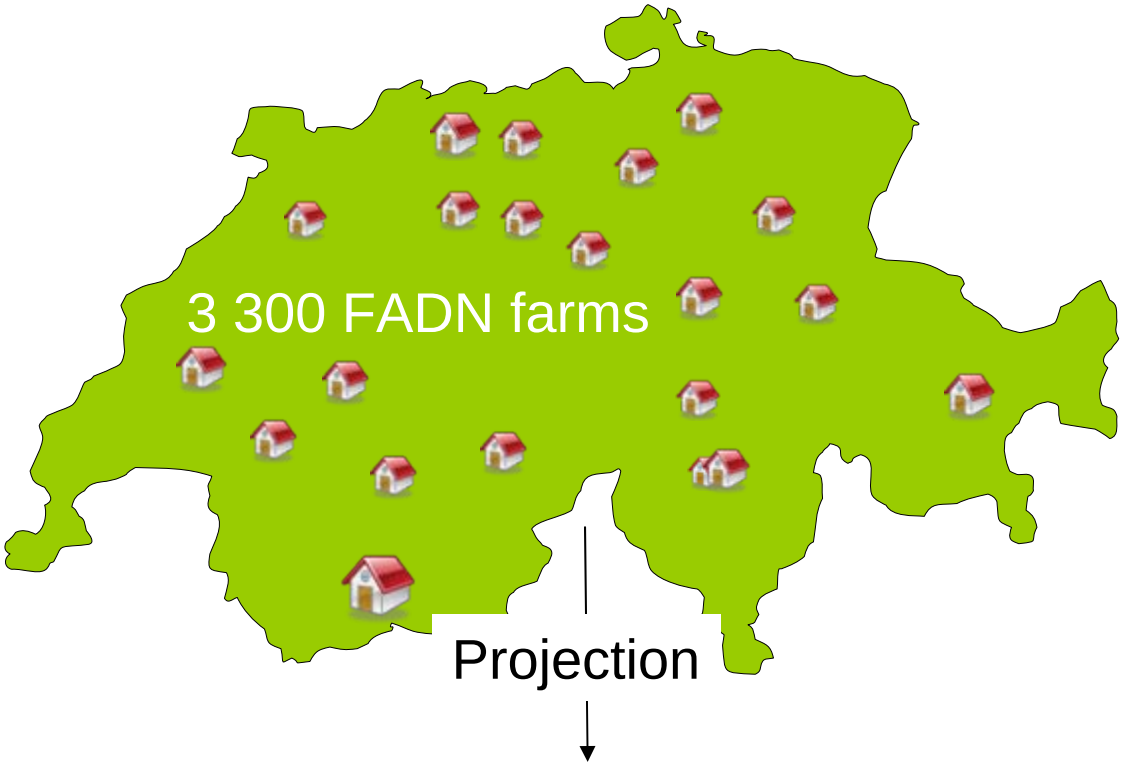
- To forecast the income of Swiss agriculture
- To forecast the supply of all agricultural products
- To forecast structural change
  - Number of farms, farm-size, farm abandonment, farm succession
- To cover the heterogeneity of agricultural production in Switzerland (regions, farm-types, farm-size).





Model design

- Number of agents
- Behaviour of the agents



Each FADN-farm is characterized by a projection factor

Total number of farms = 50 000
Total area = 1 000 000 ha

Solving projection problems

- Method:
  - Determining an identical projection factor for each FADN-farm type
  - Recalculating the number of FADN farms agents
    - Adding farm types, which are underrepresented
    - Deleting farm types, which are overrepresented.
  - Solving the problem by a minimization process, taking into account that several sectoral parameters (area, farm size, farm-type) have an adequate representation

Minimization:

$$\sum_m \left(\sum_b \frac{w_b * M_{mb}}{MSW_m} - 1\right)^2 * MF_m \rightarrow \min$$ Sum of square deviations

Constraints:

$$\sum_{w_b \in SW_g} w_b = NSW_g$$ Agents per group

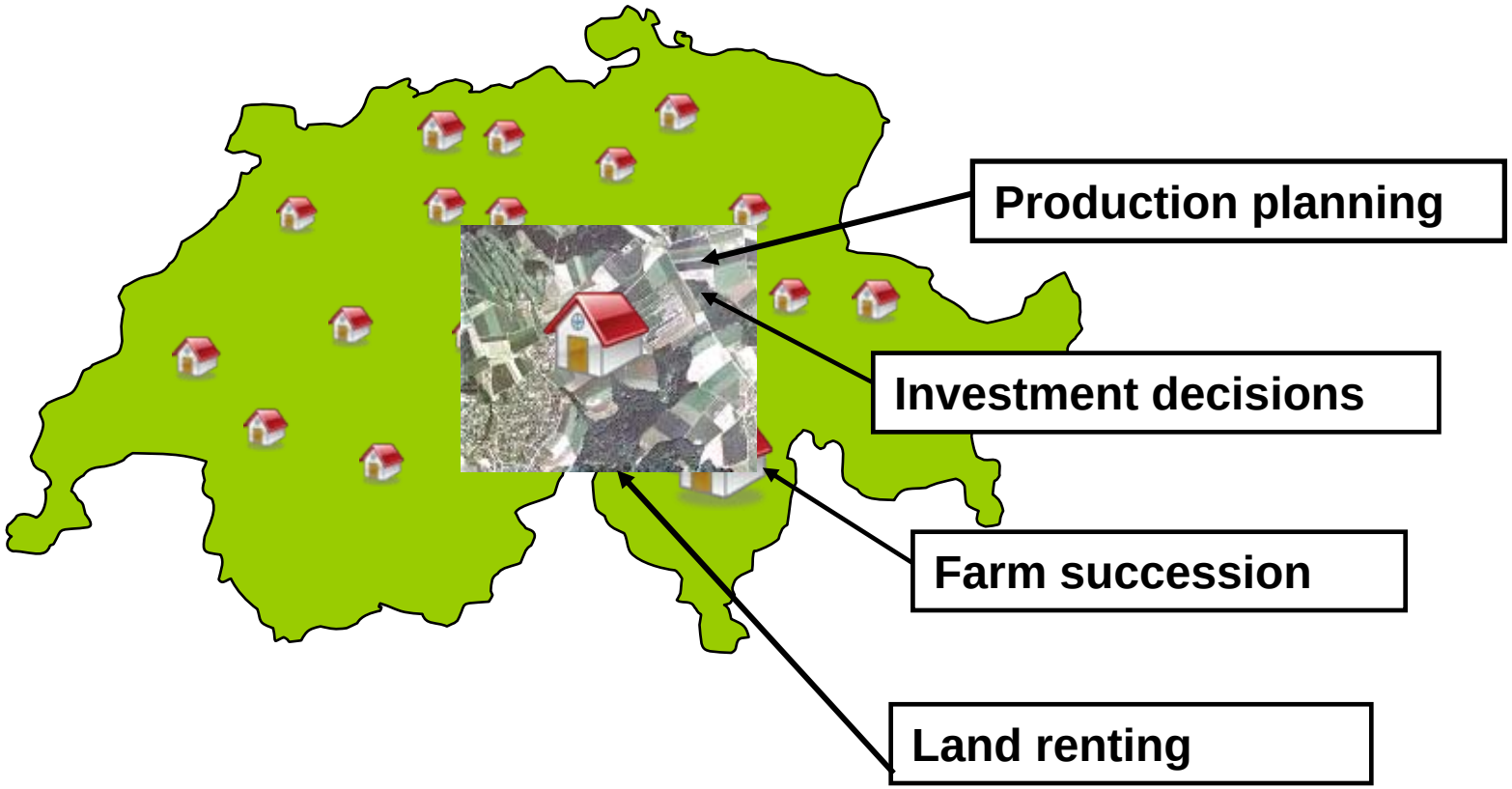
$$w_b \geq 0$$ Weighting factor w

$$NSW_g \geq NZA_g : w_b \geq 1$$ For underrepresented FADN-groups: $w_b > 0$

$$NSW_g < NZA_g : w_b \leq 1$$ For overrepresented FADN-gruops: $w_b < 1$

$$uMSW_m \leq \sum_b w_b * M_{mb} \leq oMSW_m$$ Constraints

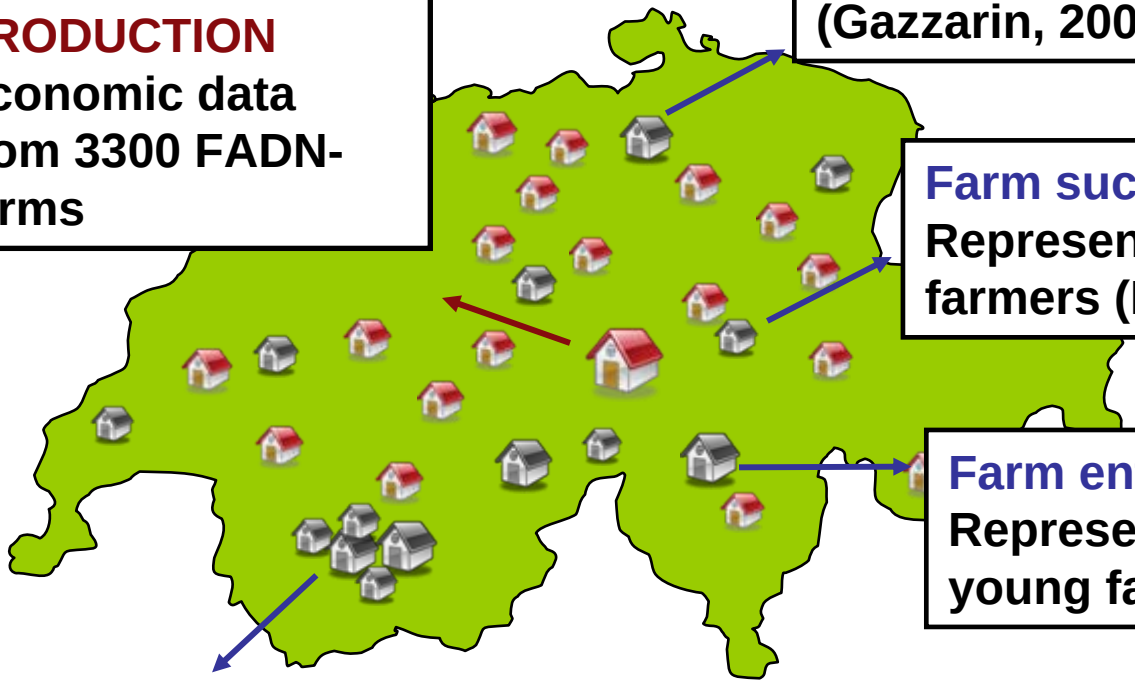
Modelling the agent‘s behaviour



Data base

Degree of capacity utilisation
Data from 1000 farm surveys (Gazzarin, 2008)

PRODUCTION
Economic data from 3300 FADN-farms



Farm succession
Representative survey of 776 old farmers (Rossier, 2006)

Farm entry
Representative survey of 1023 young farmers (Rossier, 2008)

Land market
Spatial data of 10 typical municipalities

Modelling production and investment decisions

PMP-based Optimization Model

$$Max \quad \sum_j c_j X_j$$

$$s.t. \quad \sum_j a_{ij} X_j \leq b_i \quad \text{for all } i$$

$$X_j \geq 0 \quad \text{for all } j$$

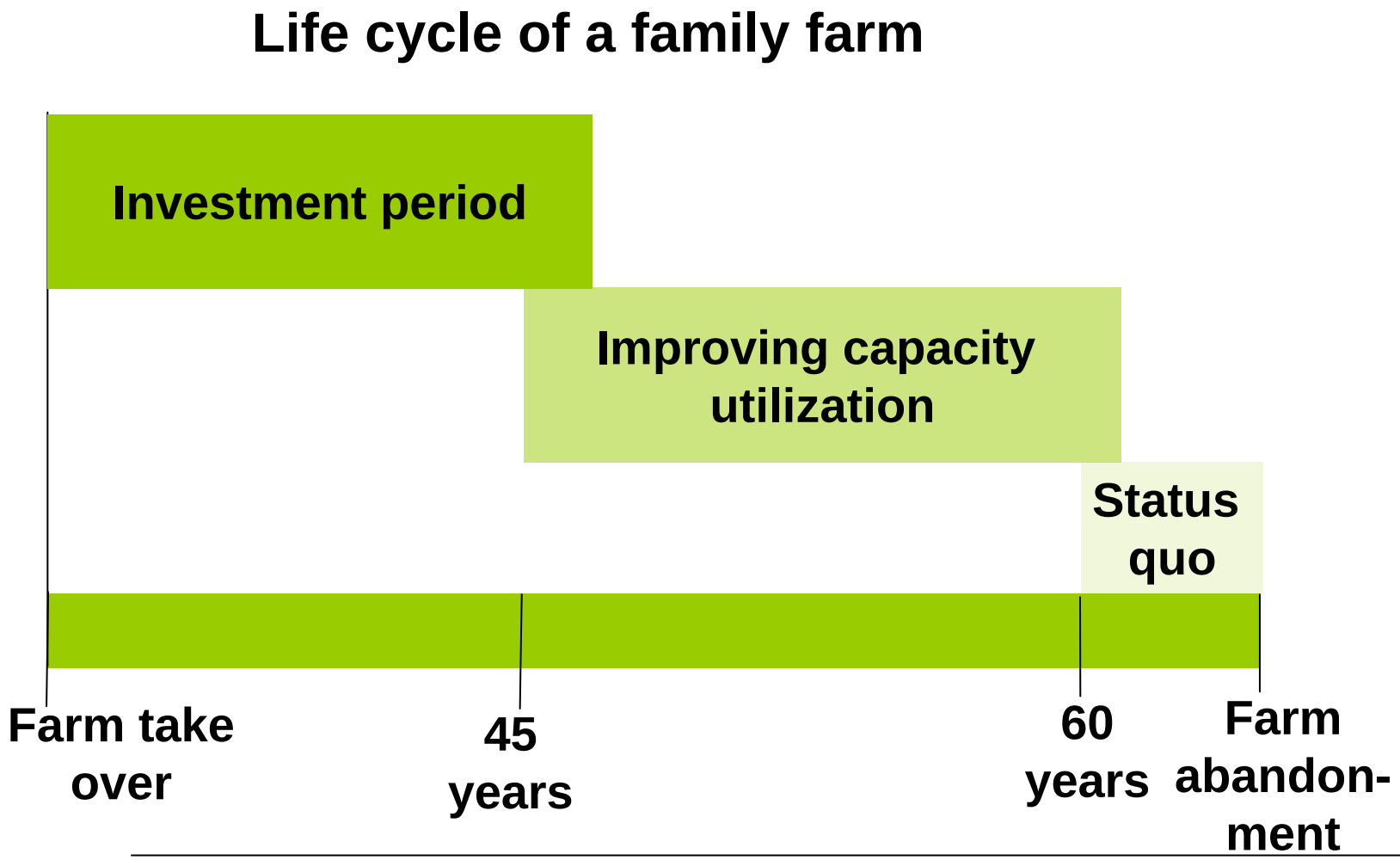
Recursive-dynamic approach

- Investment decisions are taken by annual investment costs
- Investment decisions lead to an increase in building capacities in the future

Information of FADN

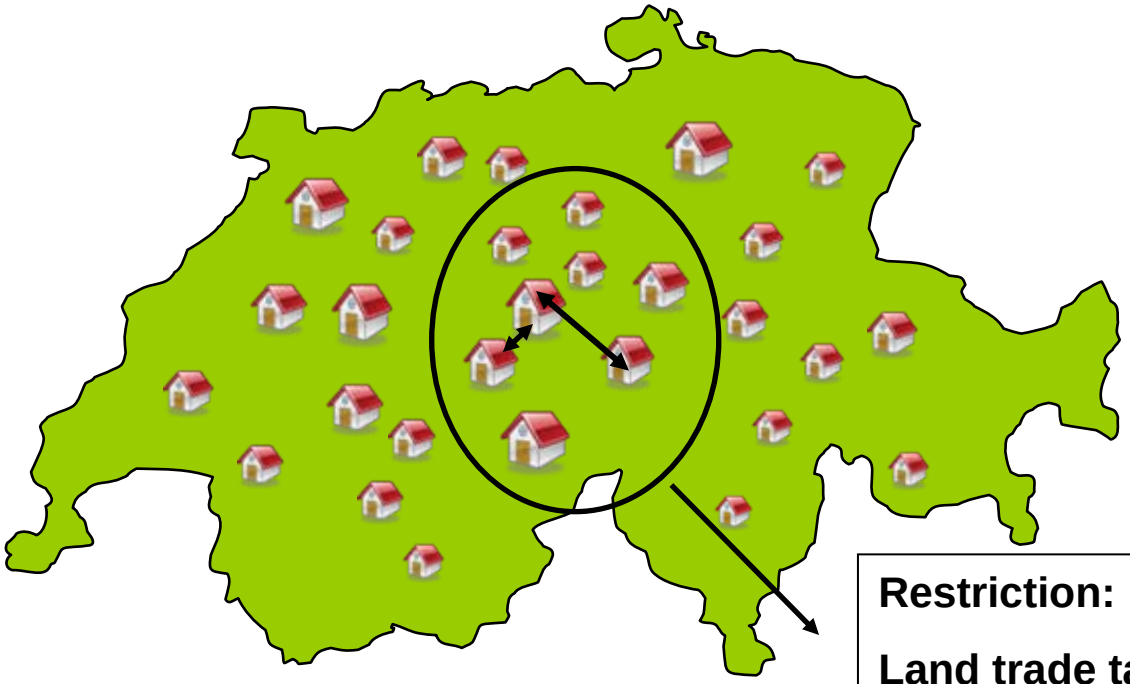
- Socio-economic data (age, education)
- Location (zone, canton, municipality)
- Organic, non-Organic, farm-type.
- Land-capacity, labour-capacity
- Farm specific variable costs, yields and prices for every single production line
- Production coefficients

Modelling investment decisions



Modelling the land market

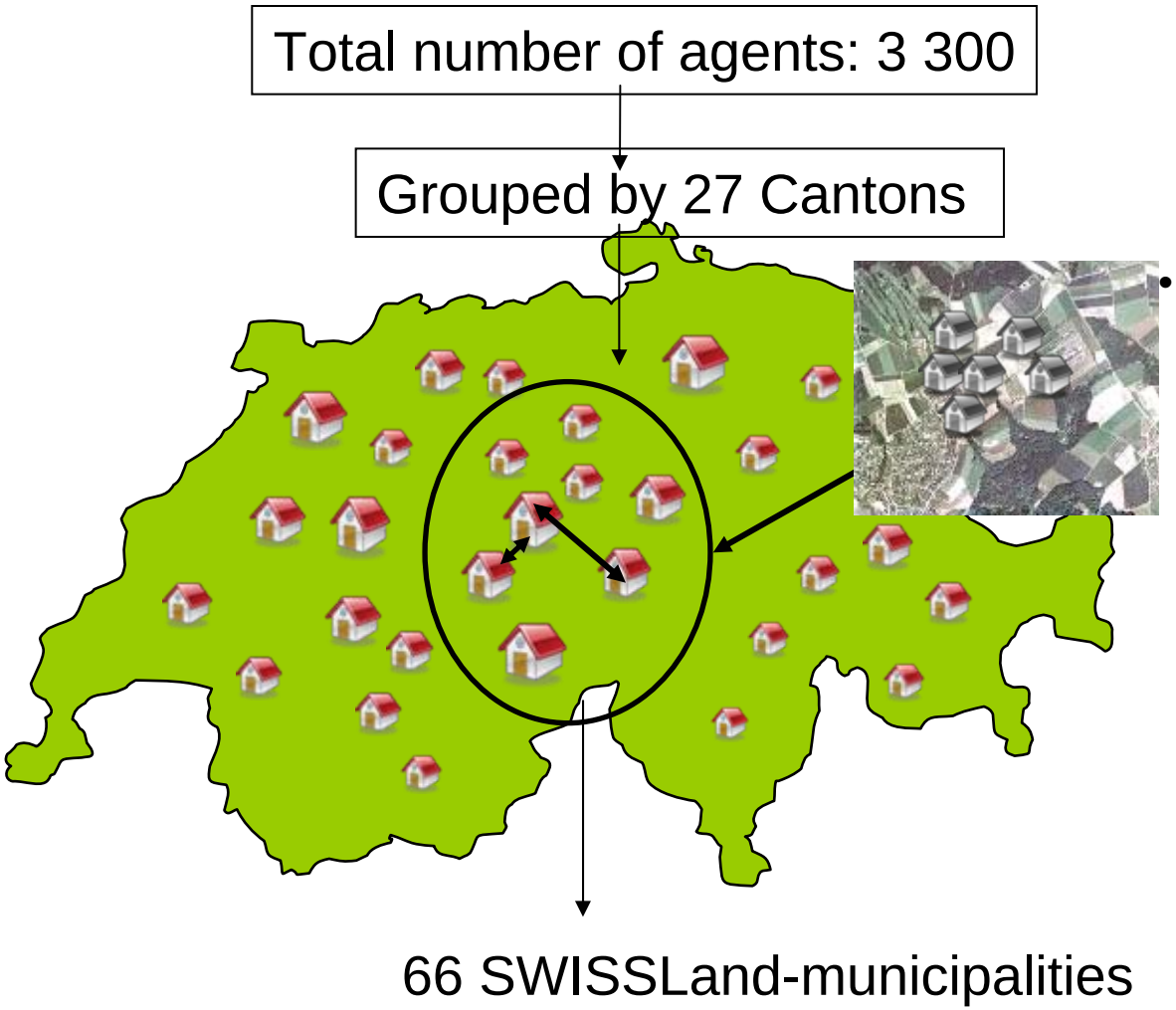
Spatial criteria determine land renting decisions



Restriction:

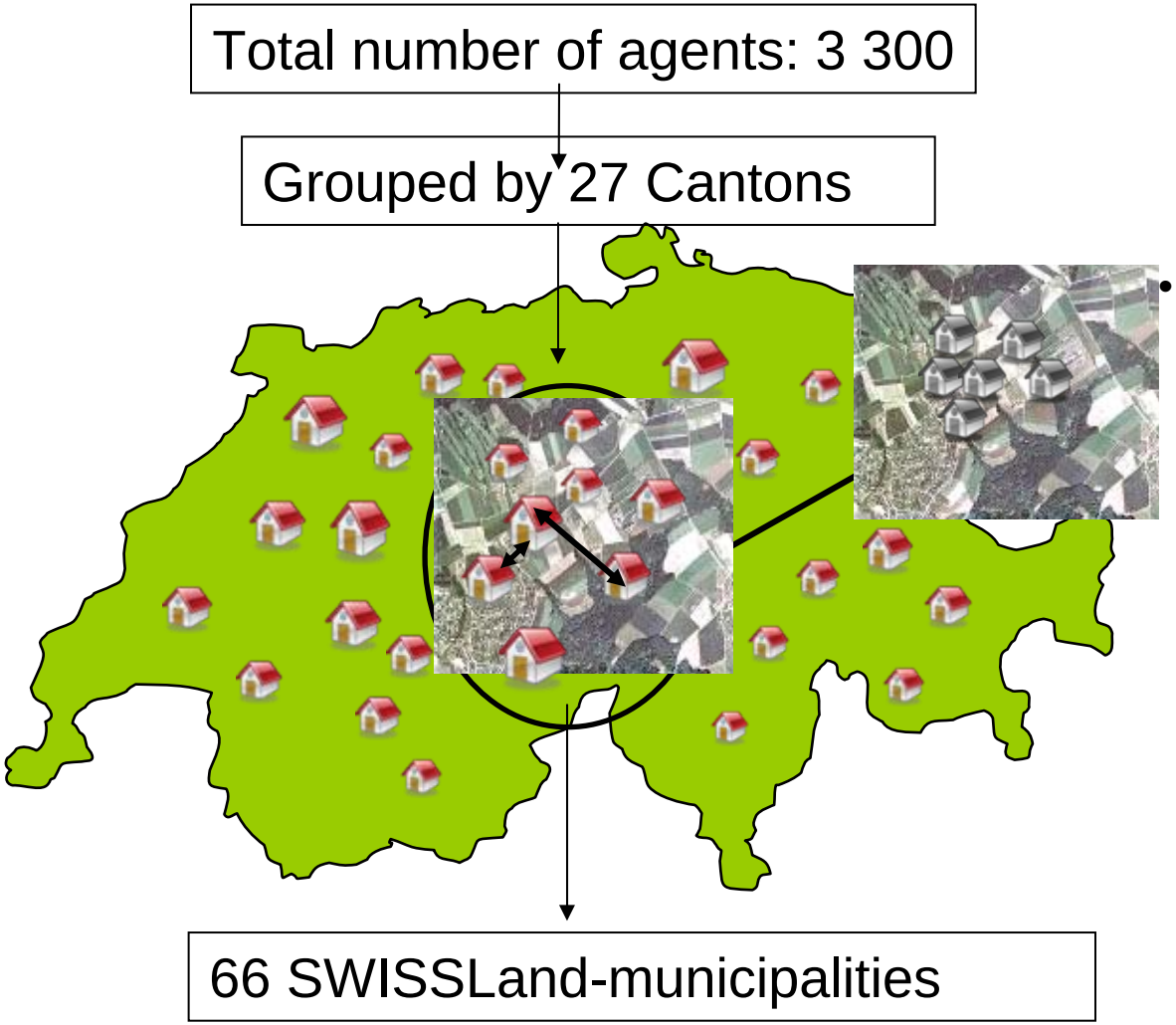
Land trade takes place only on municipality level. In Switzerland one municipality consists of about 50 farms.

Modelling the land market



- **Every SWISSLand-municipality gets the spatial structure of a one of the 10 reference municipalities**

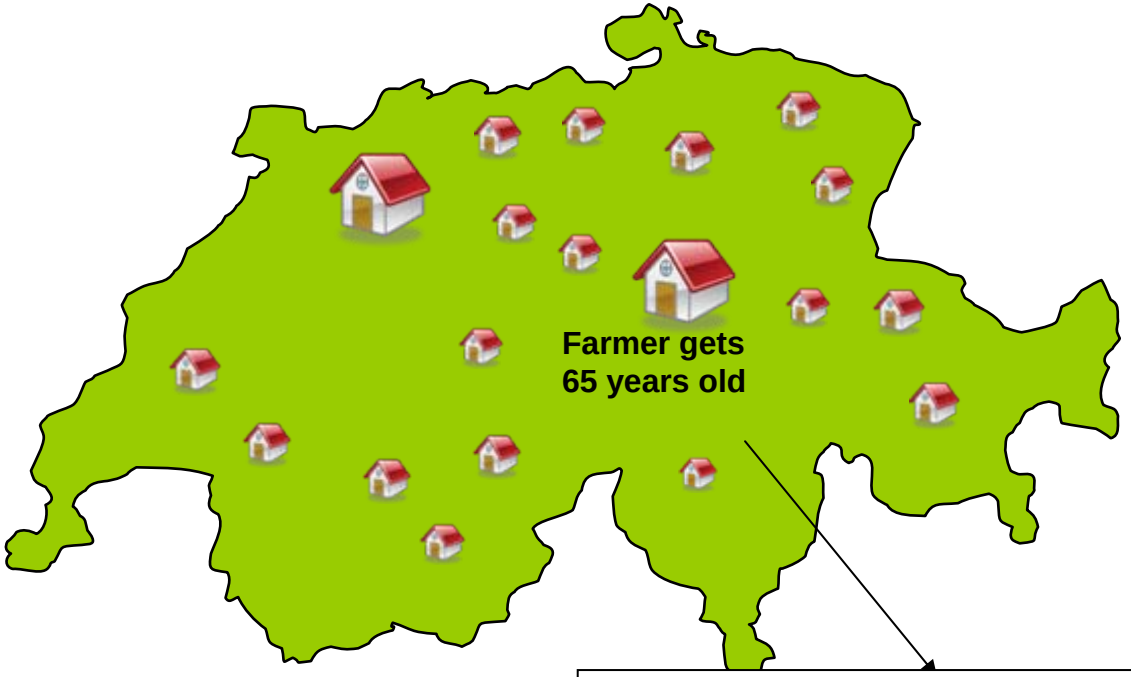
Defining groups of interacting agents



- **Every SWISSLand-municipality gets the spatial structure of a one of the 10 reference municipalities**

Defining rules for farm succession

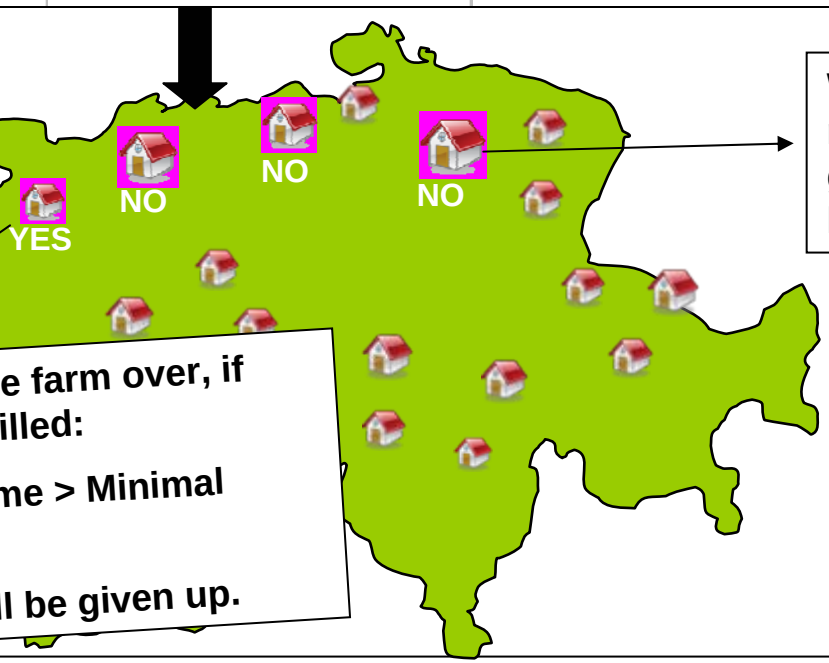
Farm succession rules



Rules for farms at the retirement age

- Survey on farm succession behaviour in Switzerland (2004)

Region	Farm size	Successor: No	Successor: yes
Tal	0_10_ha	75%	25%
Tal	10_20_ha	54%	48%
Tal	>_20ha	32%	68%



When the farmer reaches the retirement age, the farm will be given up and the land will be leased to neighboring farms

Successor takes the farm over, if one criterion is fulfilled:

1) Household Income > Minimal Income

If not , the farm will be given up.

Modeling land allocation

Land supply: Parcels of land from the abandoned farms

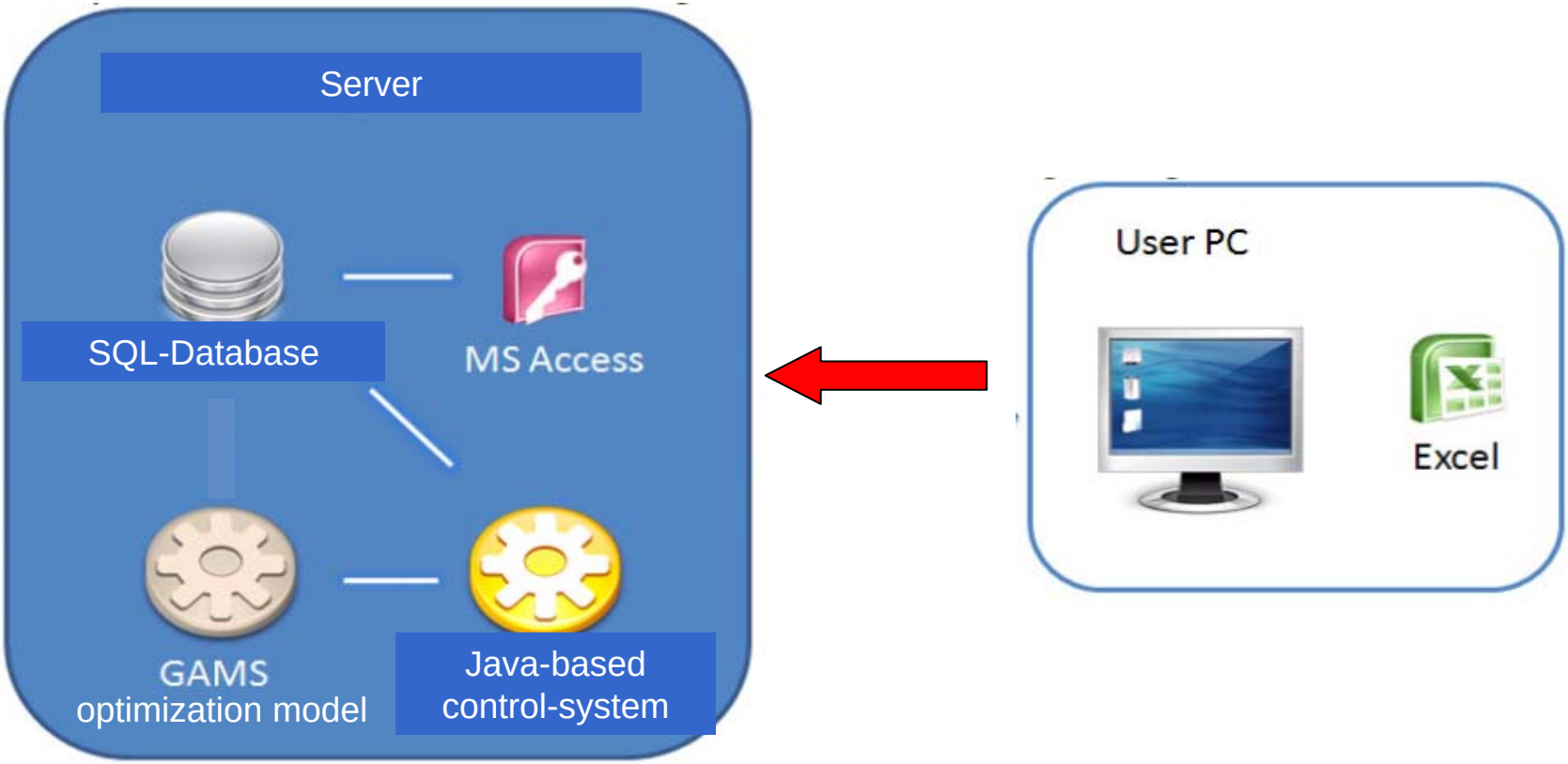
Land demand: For each parcel, the 5 neighboring farms can be interested in renting the parcels.

Land allocation

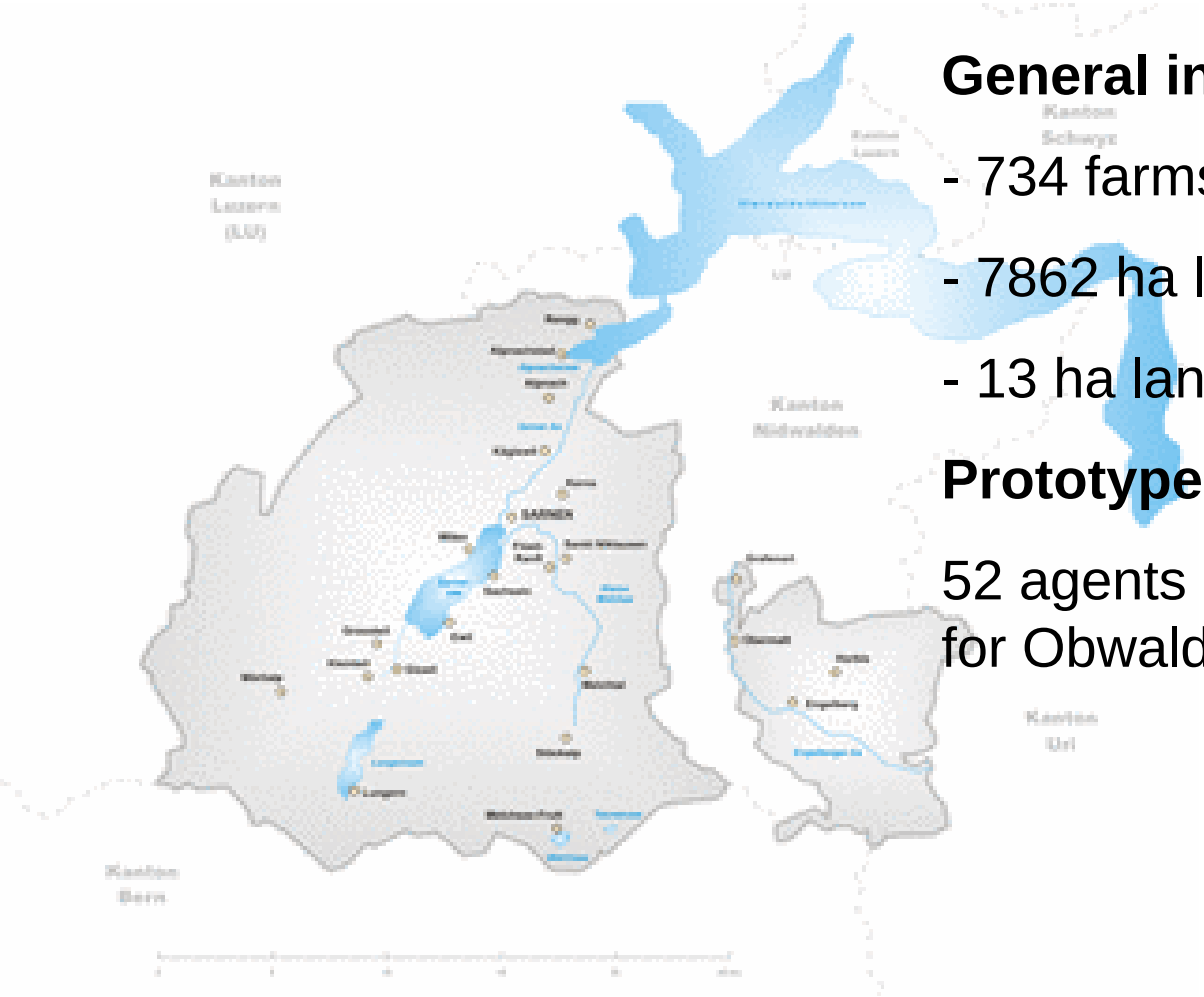
- Each interested farm is optimized
- The farm which reaches the highest additional income gets the parcel.
- This process is repeated until all parcels are distributed to the neighboring farms.

Technical implementation

•*In close collaboration with a software engineering firm*



Prototype for canton Obwalden



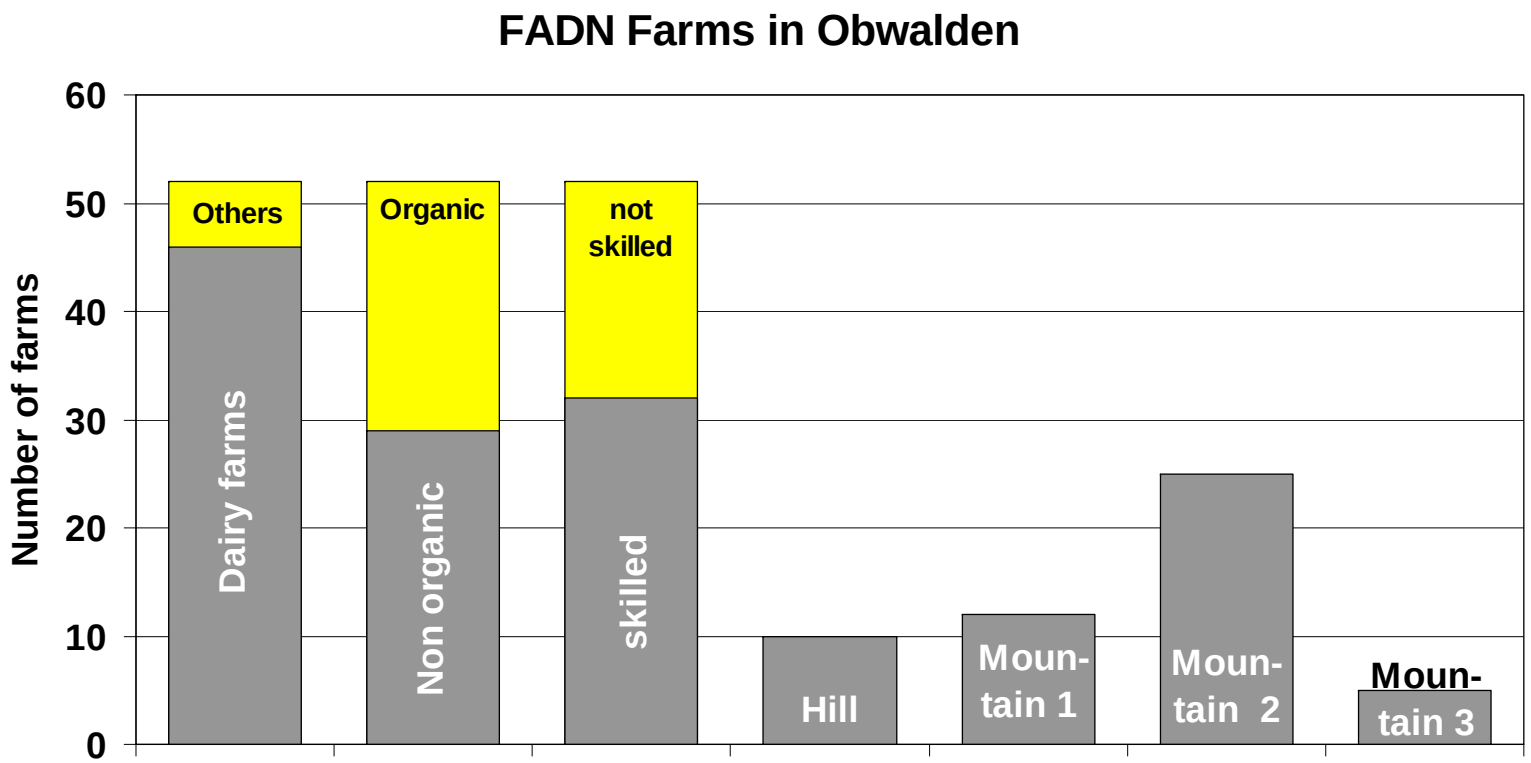
General indicators 2008 (BFS)

- 734 farms
- 7862 ha land
- 13 ha land / farms

Prototype

52 agents create one municipality for Obwalden

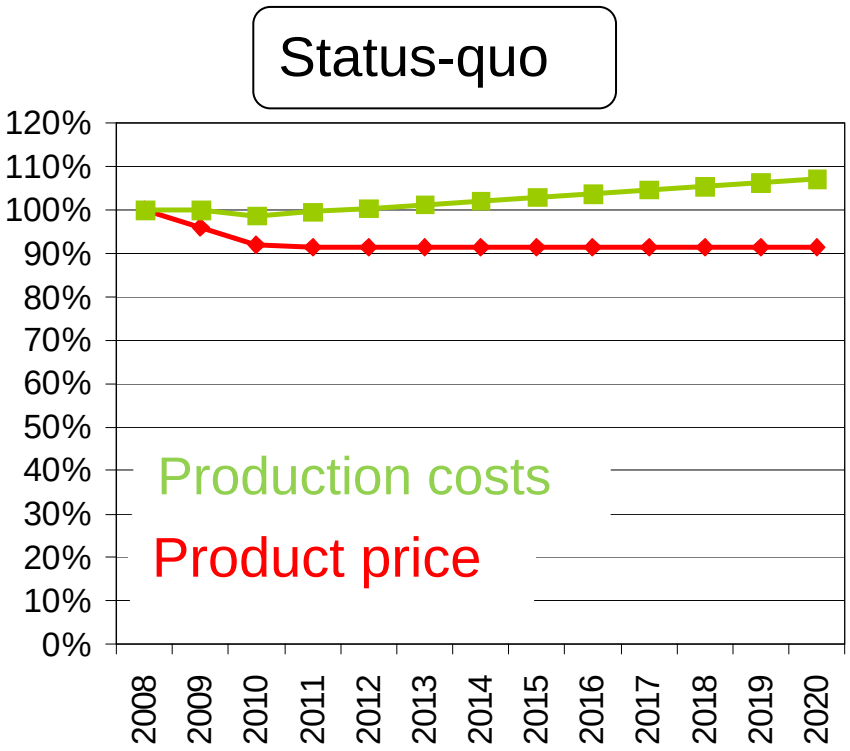
Canton Obwalden

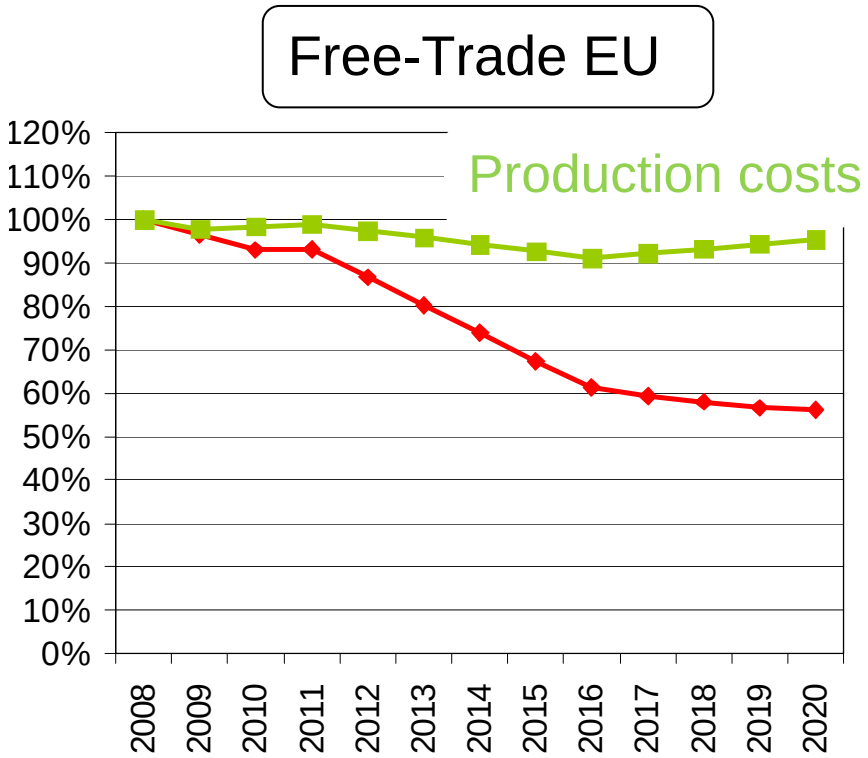


Model forecast until 2020

- Policy scenario
  - **Status Quo:** Slight tariff reduction until 2011. No changes from 2011 to 2020
  - **Free-Trade EU:** Free trade with the European Union: Tariff reduction from 2011-2017 on the European level
  - No change in direct payments

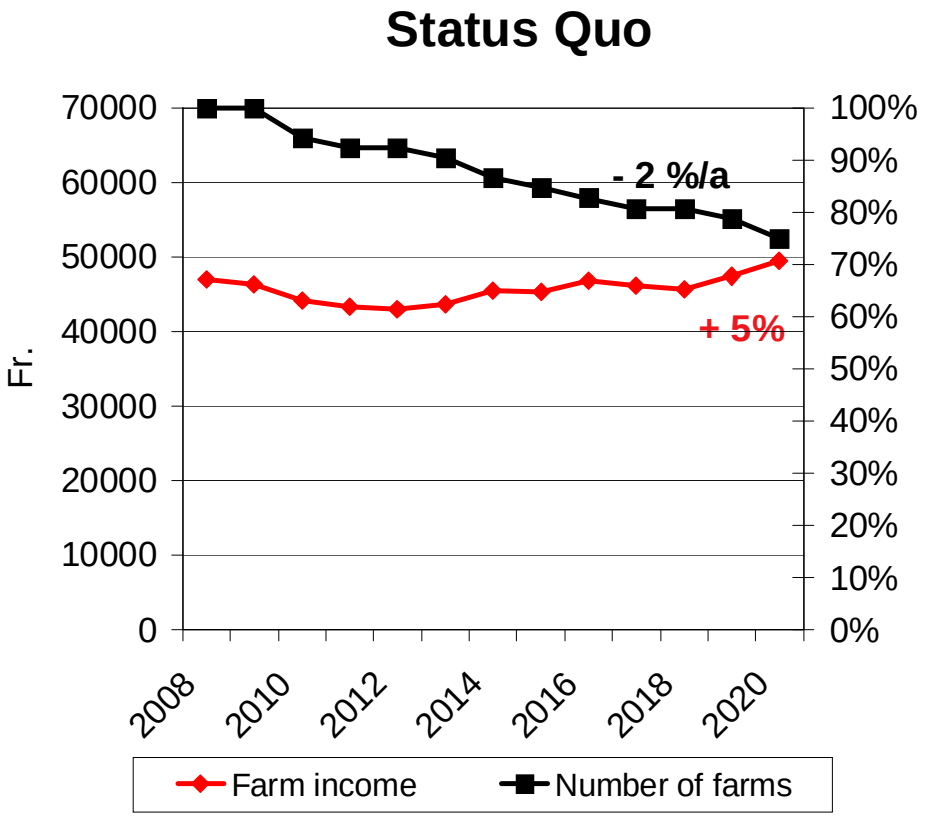
Price assumptions until 2020

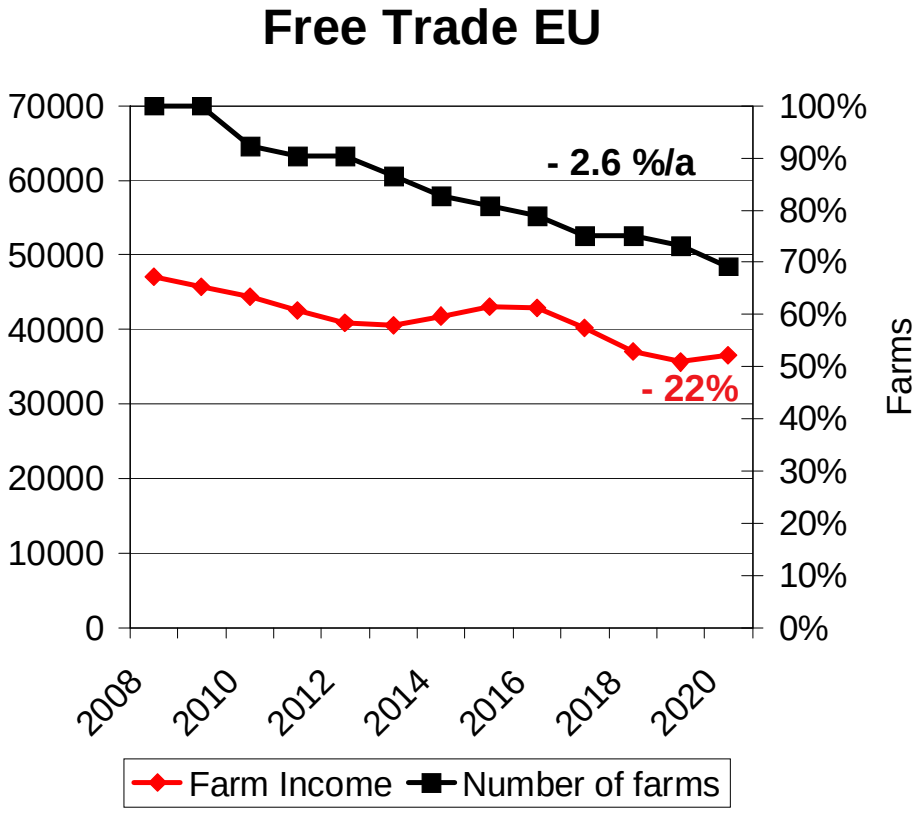




Source: Swiss ministry of agriculture, 2009

Model results: Average farm income and number of farms until 2020

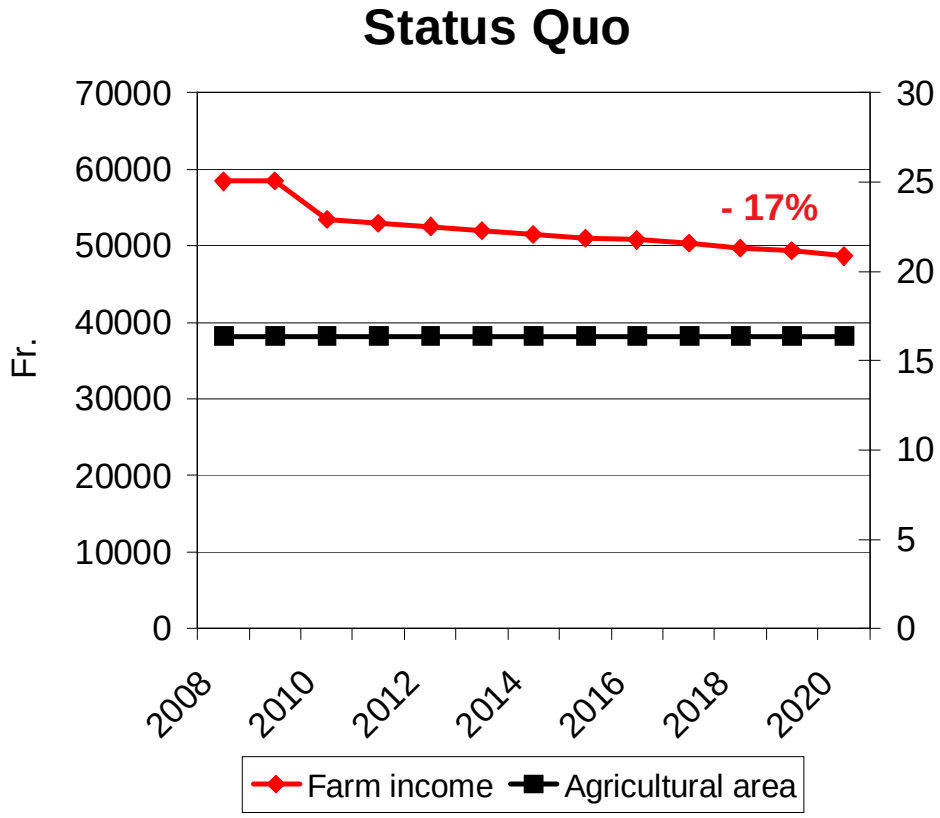




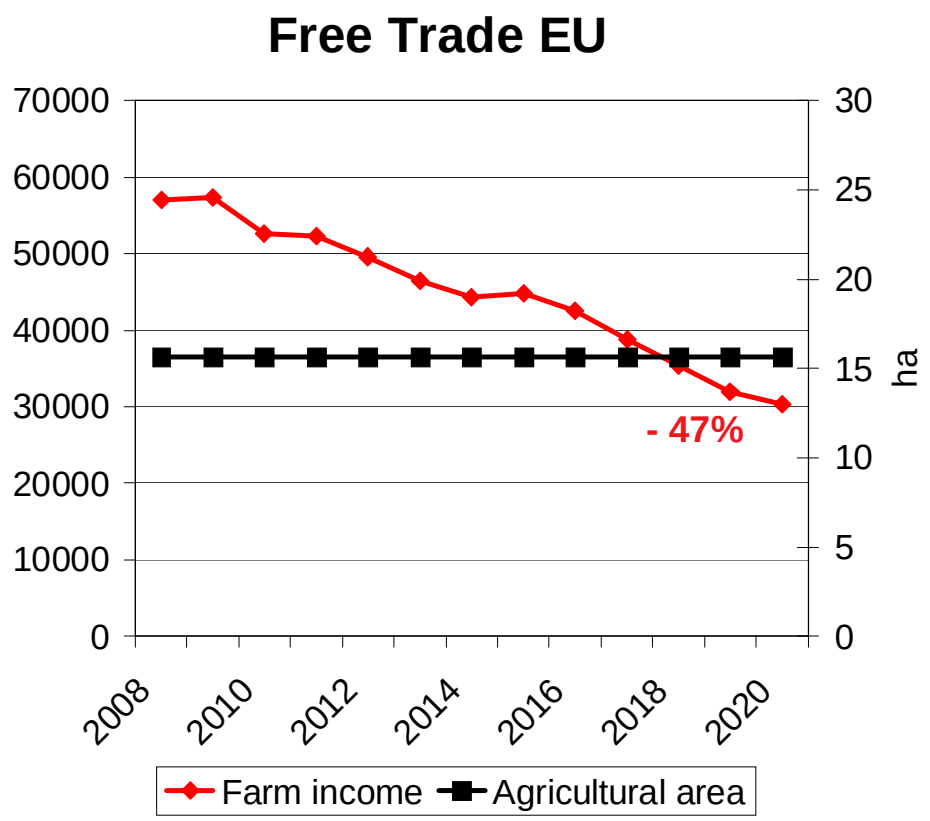
All agents

All agents

Model results: Average farm income for those without growth until 2020

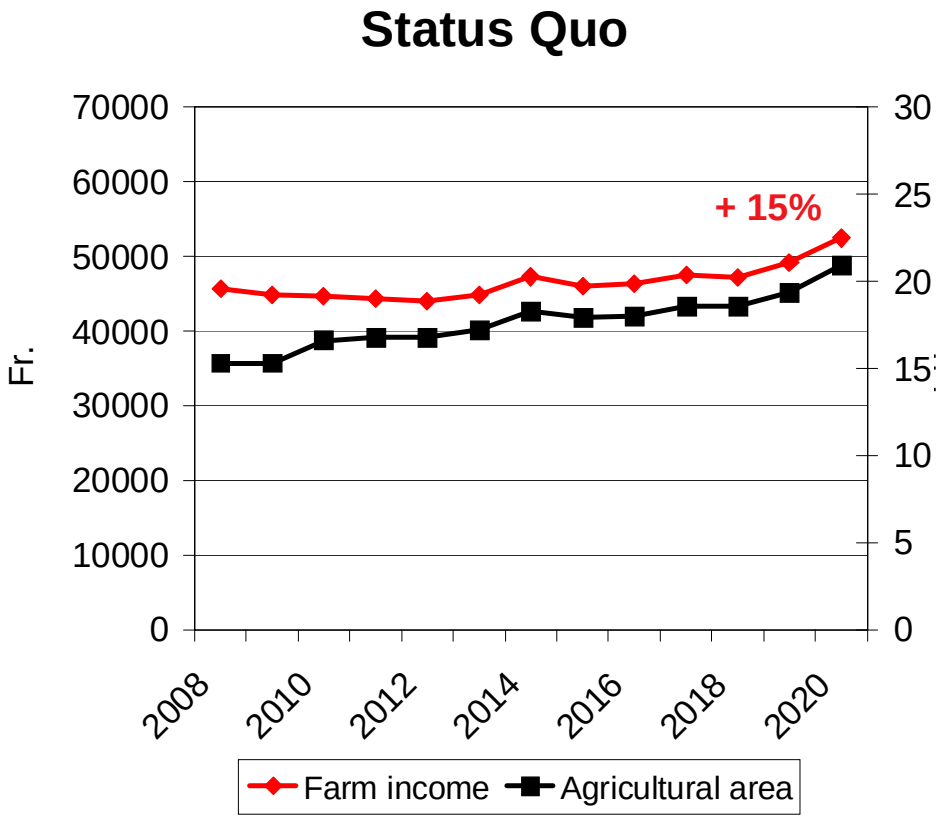


35% of all agents

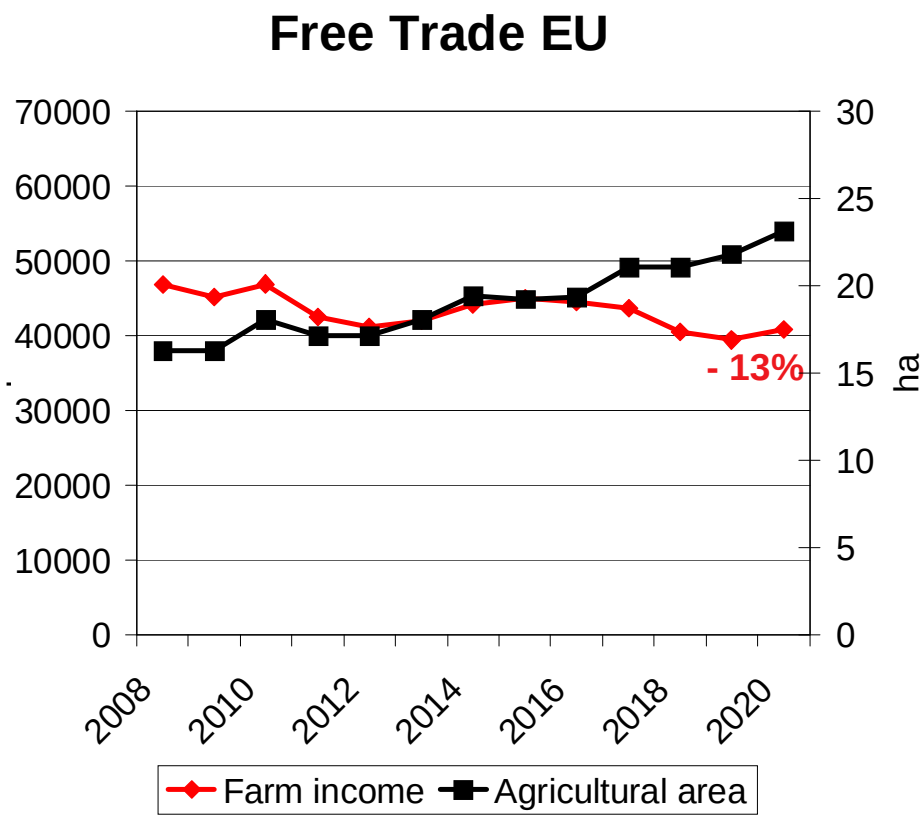


27% of all agents

Model results: Average farm income of farms with growth until 2020

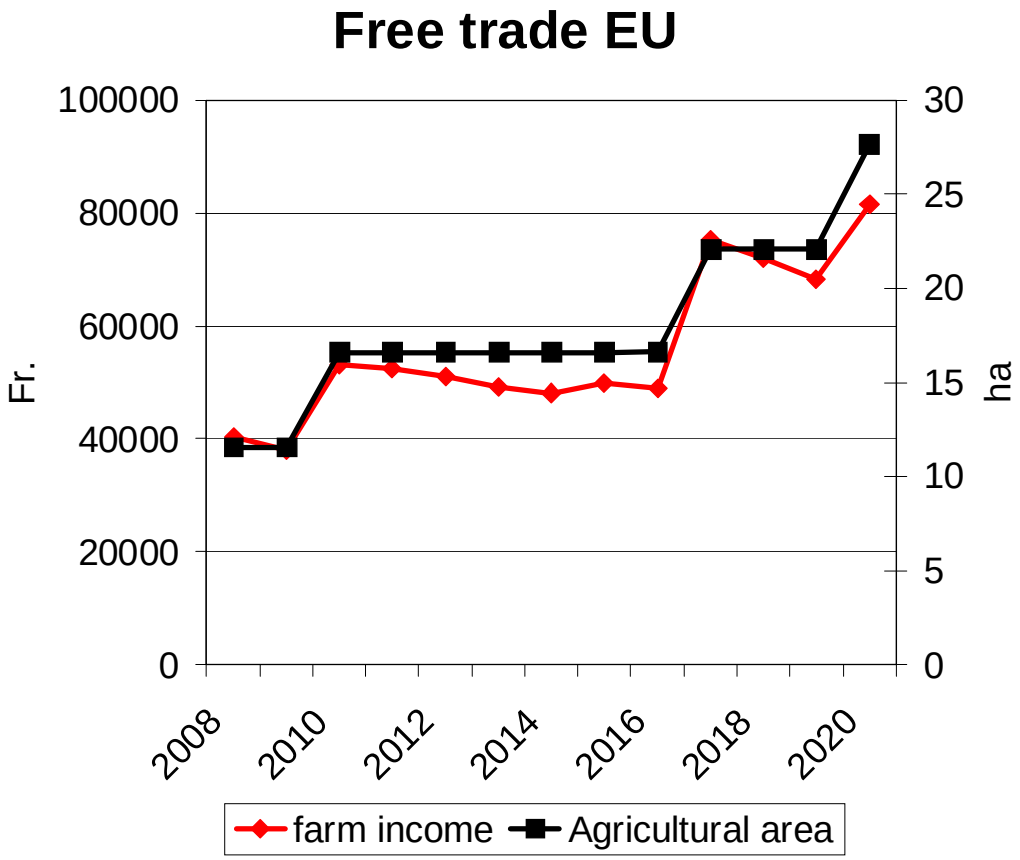


36 % of all agents



35 % of all agents

Model results: Average farm income for those with investments



Summary and conclusions

- Objective of Swissland: Improving the modeling of reality by taking into account farm variety.
  - Defining an agent population based on FADN data enables this.
  - The sectoral scale requires huge amount of data.
    - Therefore a balance between complexity and simplicity is required.
- The prototype show, that the use of different data sources to estimate the agent's behavior is a feasible approach to get more plausible model results.

Optimizing the agents

- Defining production activities
- Taking into account technical, ecological and financial constraints
- Each agent has a defined objective function
- Maximizing the household income
- Data-base: FADN-data
- Splitting up total costs of FADN-farms to single production activities
  - Labour costs are split up by standard labour requirements factors

Modelling realistic production decisions

Positive mathematical programming (PMP)

Optimization model

$$Max\ Z_t = \sum_z p_{zt} x_{zt} - \sum_z d_{zt} x_{zt}$$

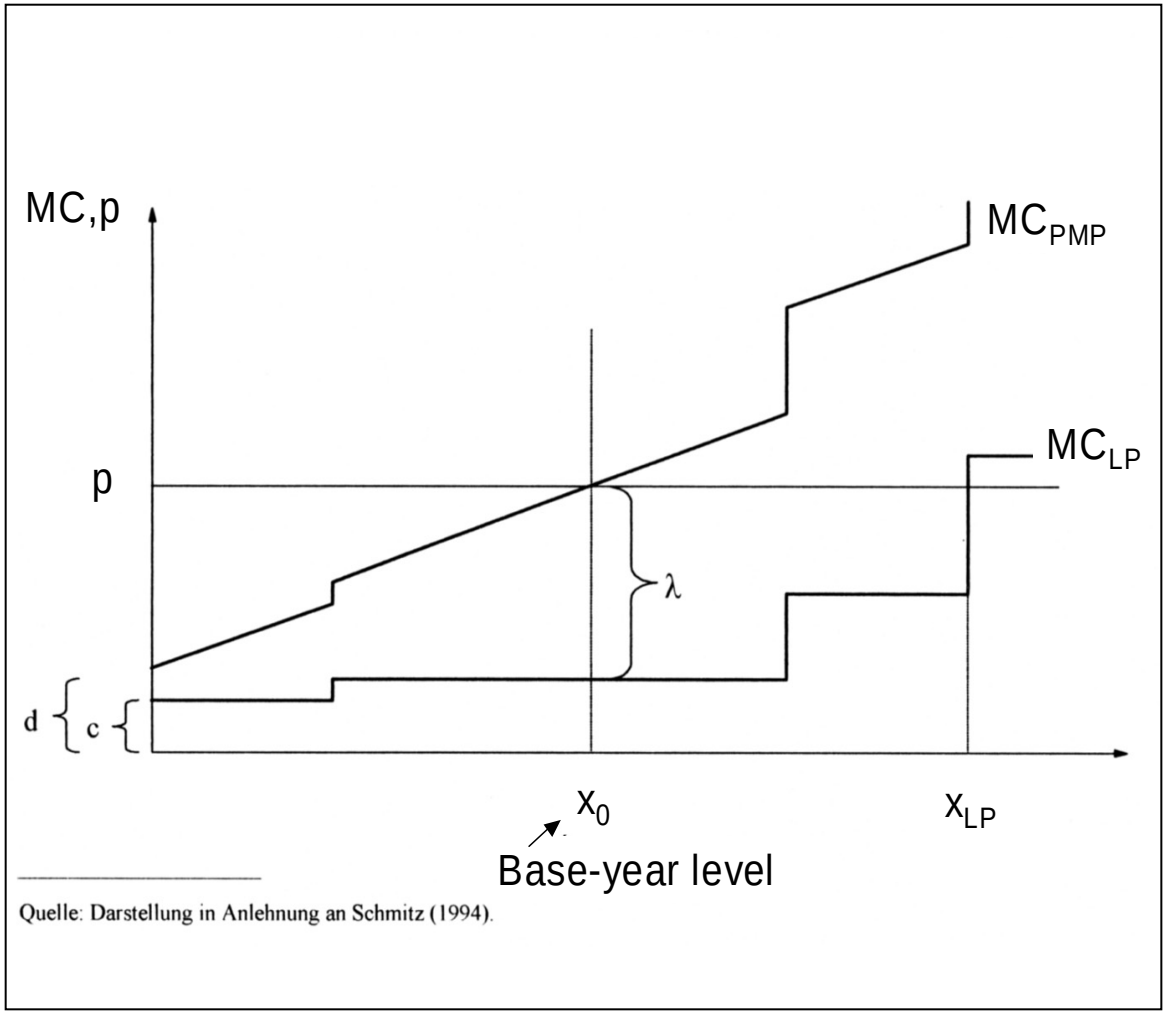
$$Ax_{zt} < b_{zt}$$

$$x_{zt} > [0]$$

Base-year Calibration

- The agent‘s behaviour in terms of production planning is more realistic than using linear programming

Estimating the marginal cost function of the agent



Quelle: Darstellung in Anlehnung an Schmitz (1994).

Optimizing the agents

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- Maximizing the household income
- Data-base: FADN-data
- Splitting up total costs of FADN-farms to single production activities
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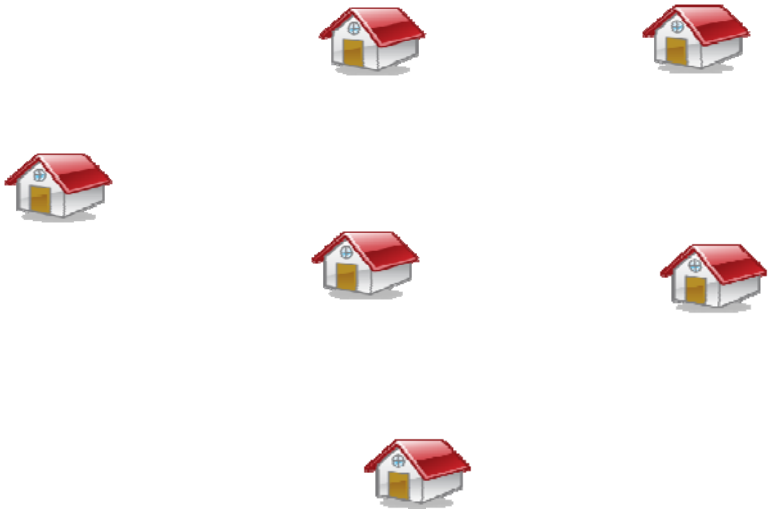
Conclusions

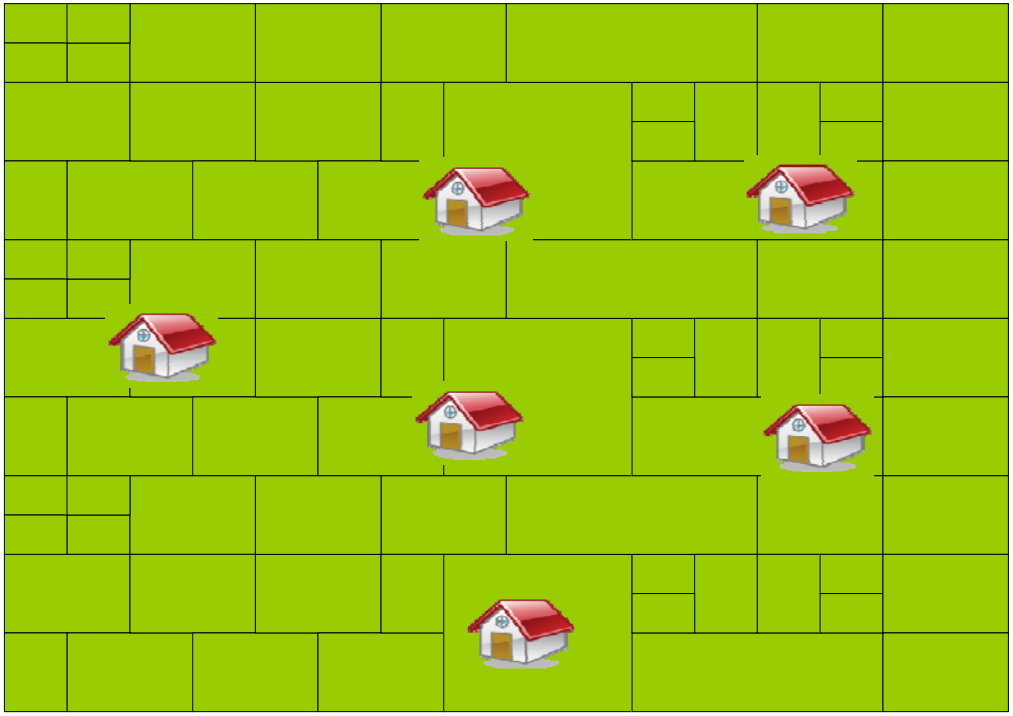
- FADN data as an important future source for agent-based models
- Do data requirements have to be changed due to this new application?

Agent-based models...



(Parker et al. 2002)

Agent-based models...



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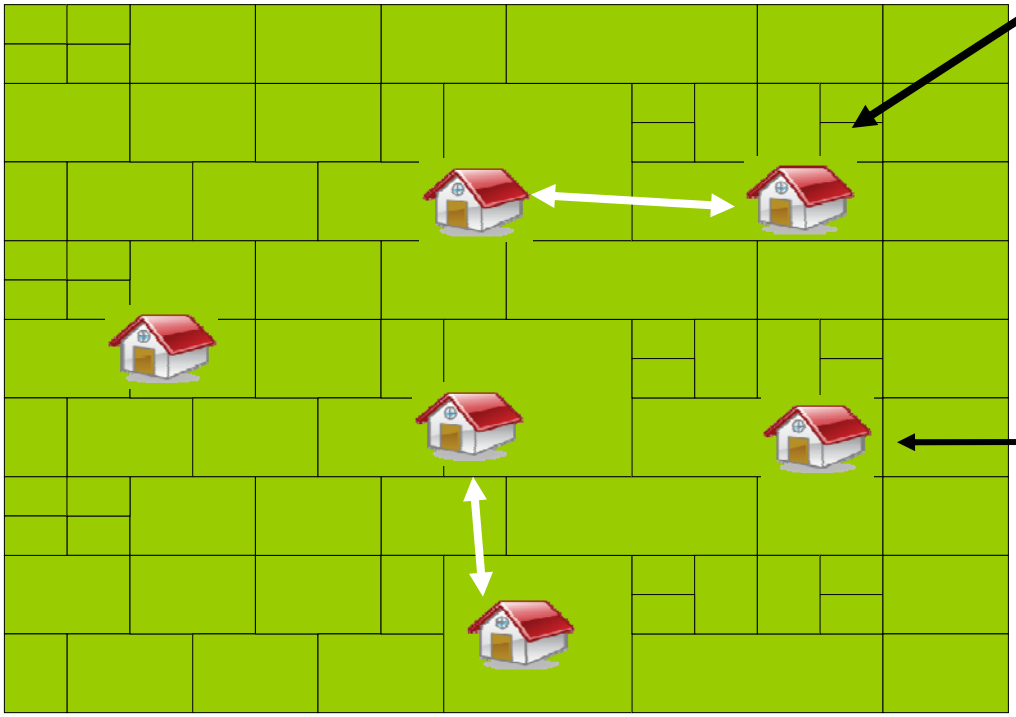
Agent-based models...



Land leasing out agent
(65 years, < 30 ha)
→ Farm abandonment
or farm sucession

Land leasing agent
(< 35 years, >40 ha)
→ riskfriendly

(Parker et al. 2002)