Adjustment Costs of Agri-Environmental Policy Switchings

A Multi-Agent-Approach

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Outline

- Motivation: Actual challenges for agricultural policy modeling
- Why Multi-Agent Systems (MAS)?
- Presentation of a spatial and dynamic multi-agent model for the analysis of structural change in agriculture
- Data: Region, farms, and production
- Policy simulations of the "Agricultural Turn"
- Assessment and perspectives of MAS in agricultural policy analysis

Motivation: Challenges for Policy Modeling

Direction of policy change in the EU

- Agricultural policy:
  - Globalization and liberalization of trade
  - Reduction in public spending

  } less protection ↙ "transition"?

  - More farm specific subsidy regulations
  - Rediscovering agricultural entrepreneurship
  - "Agricultural Turn" ("Agrarwende")

- Environmental policy
  - Increasing relevance of the subsidiarity principle

  } "local action"

↙ Thesis: New questions demand for
new decision support systems for policy makers

Motivation: Challenges for Policy Modeling

- Question:

  Do agricultural economists use their opportunities to satisfy the changing demand for policy advice?

- New opportunities:
  - improved availability of information (e.g. IT, GIS)
  - exponentially increasing computing capacities ("Moore's law")
  - new methods „from the bottom up“

- Suggestion: Policy analysis with Multi-Agent Systems

Why Multi-Agent Systems?

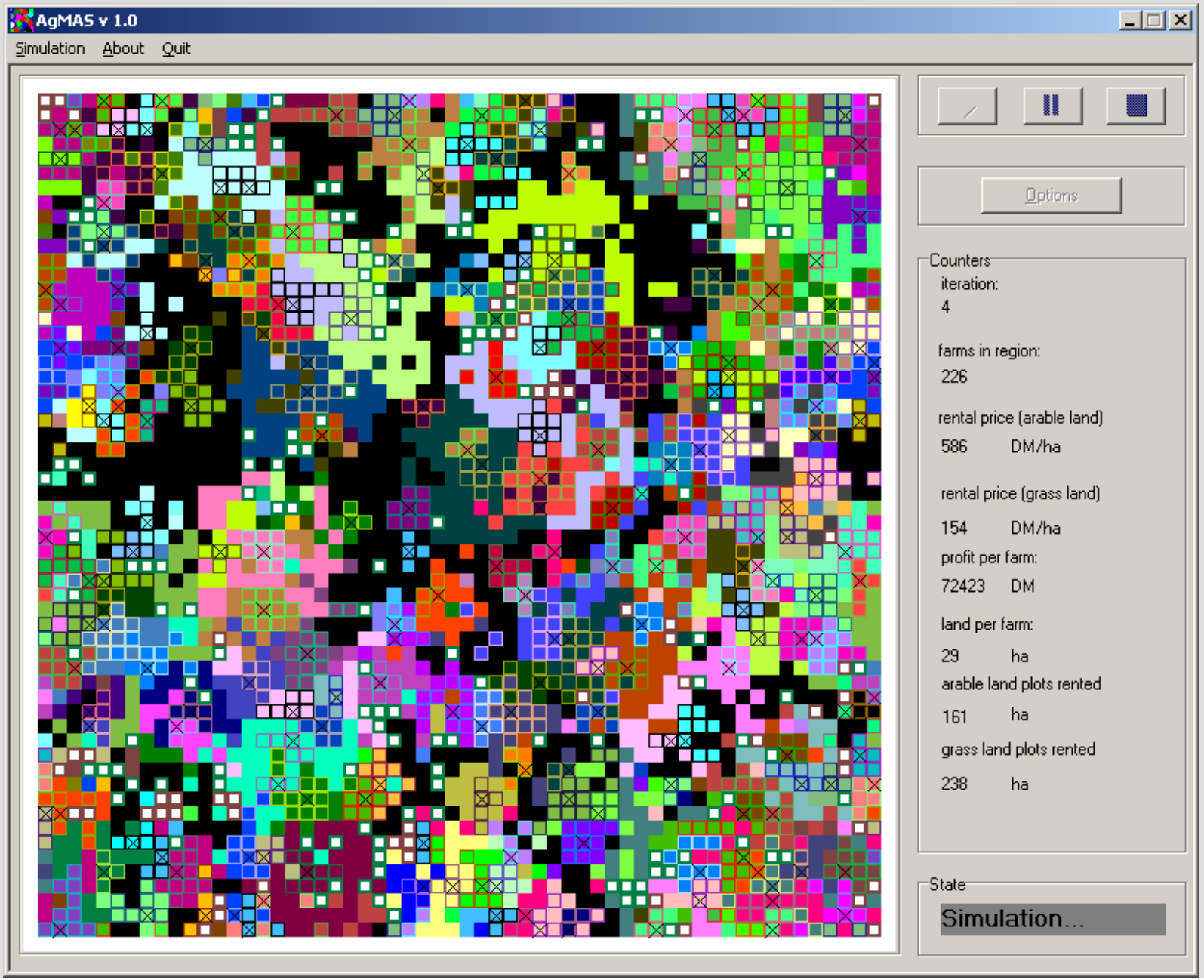
- "Bottom up" approach
  - flexible behavioral foundation on the individual level
    (e.g. bounded rationality, heterogeneous objectives and abilities)
  - flexible general frameworks and conditions
    (e.g. non-convex functions, imperfect markets)
- Self-organization
  - spontaneous order and emergence
  - endogenous change
- Easy and straightforward consideration of spatial aspects
  - particularly relevant for agricultural models
  - use and generation of geographical information

The Model

Consider:

- An idealized agricultural region divided into quadratic plots of equal size (2.5 ha)
- Land is of homogeneous quality
  (but differentiated into grassland and arable land)
- A number of farms (agents) operates in the region
- A map where all plots used by a certain farm have the same color
- Plots representing a farmstead are marked by a cross

The Model


AgMAS v 1.0
Simulation
About
Quit
Options
Counters
iteration:
4
farms in region:
226
rental price (arable land)
586 DM/ha
rental price (grass land)
154 DM/ha
profit per farm:
72423 DM
land per farm:
29 ha
arable land plots rented
161 ha
grass land plots rented
238 ha
State
Simulation...

The Model

- Farms are equipped with
  - owned land and rented land
  - grassland and arable land
  - buildings, machinery, animals
  - equity capital and debts
  - family labor
  - heterogeneous management capabilities -> different variable costs

The Model

- Farms
  - act autonomously and simultaneously (agents)
  - 13 agricultural production activities
  - 28 different investment opportunities
  - labor force and capital can be used on-farm and off-farm
  - loan capital (short-term and long-term)
  - employment of hired labor
  - land rental activities
  - farms can close down

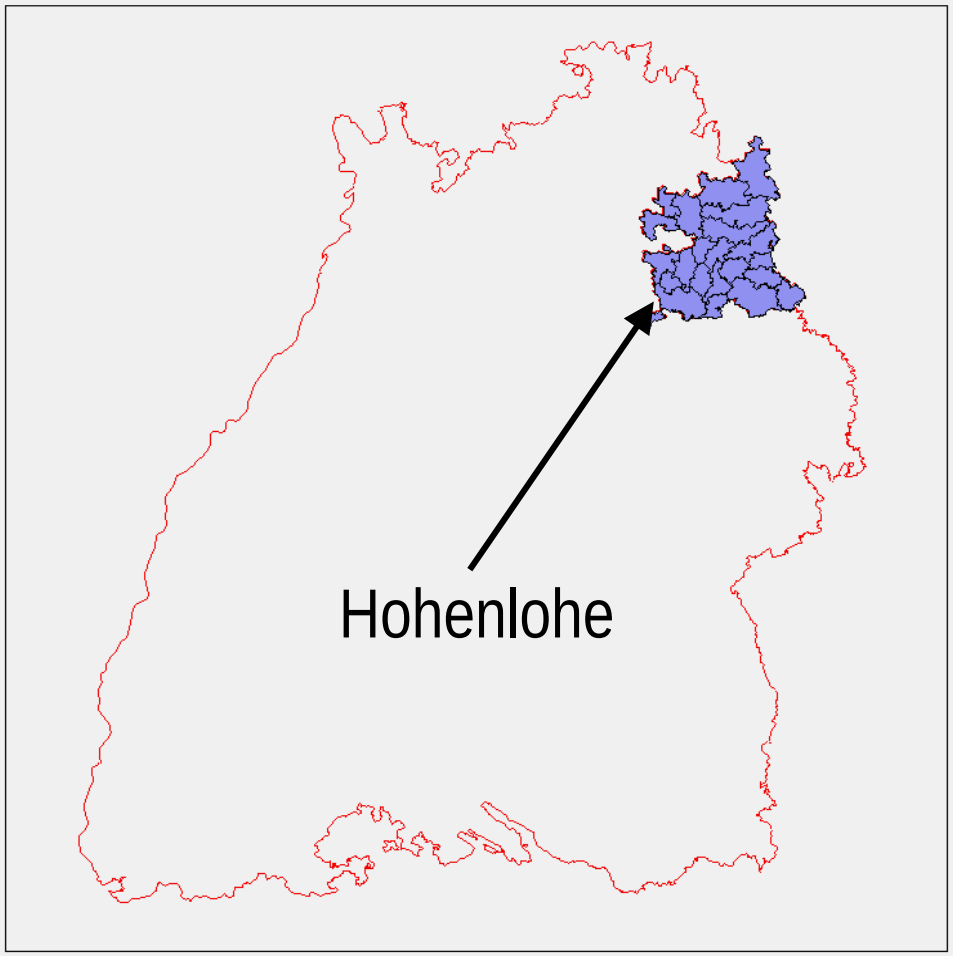
The Model

- Farms' decisions
  - Goal: maximize farm-household income
  - adaptive expectations
  - mixed-integer linear programming

The Model

- Land market
  - pure rental markets (arable land and grassland)
  - land allocation by an iterative auction
  - farms bid according to their shadow prices under consideration of their transportation costs
- Other input markets
  - investments are irreversible (sunk costs)
  - economies of scale (up to an acreage of 200 ha)
  - generation change:
    every 25th period off-farm employment opportunities are improved
- Output markets and policies
  - alternative scenarios

Region



- Selection of 12 „typical“ farms from FADN (year 1997/98)
- Regional data from township statistics of Baden-Wuerttemberg
- Production coefficients from standard farm data samples

Data

- Definition of typical farms

Variable\Farm	A	B	C	D	E	F	G	H	I	J	K	L
Organization												
cash crops					X	X					X	
dairy			X	X					X			
pigs and poultry	X	X						X				X
mixed							X			X		
full-time	X	X	X	X	X	X	X	X				
part time									X	X	X	X
Land												
total (ha)	22.5	72.5	67.5	30	37.5	60	50	112.5	12.5	17.5	10	20
arable land (ha)	22.5	72.5	40	12.5	37.5	60	22.5	102.5	5	12.5	10	20
grassland (ha)	0	0	27.5	17.5			27.5	10	7.5	5	0	0
Animals												
cattle			90	52			63	25	28	5		
cows			39	26			28		12			
sows	40	128			40		64	170				128
fattening pigs	300	600						0		100		
turkeys						20000						
Frequency	**480**	**25**	**120**	**244**	**106**	**22**	**231**	**95**	**389**	**154**	**442**	**298**

Data

- Adjustment of model region towards real region

Variable	Units	Hohenlohe	Model	Error
Farms				
total	farms	3013	2606	-14%
cash crop	farms	459	570	+ 24%
dairy	farms	906	753	-17%
pigs and poultry	farms	988	898	-9%
mixed	farms	516	385	-25%
Land				
total	ha	72448	73503	+1%
arable land	ha	55043	54943	0
grassland	ha	17405	18560	+7%
Land farmed by				
cash crop farms	ha	9569	9715	+2%
dairy farms	ha	21683	20283	-6%
pig and poultry farms	ha	27766	29260	+5%
mixed farms	ha	14421	14245	-1%
Livestock				
cows	animals	21072	22361	+6%
sows	animals	99787	95718	-4%
fattening pigs	animals	169901	174400	+3%
turkeys	animals	450000	440000	-2%

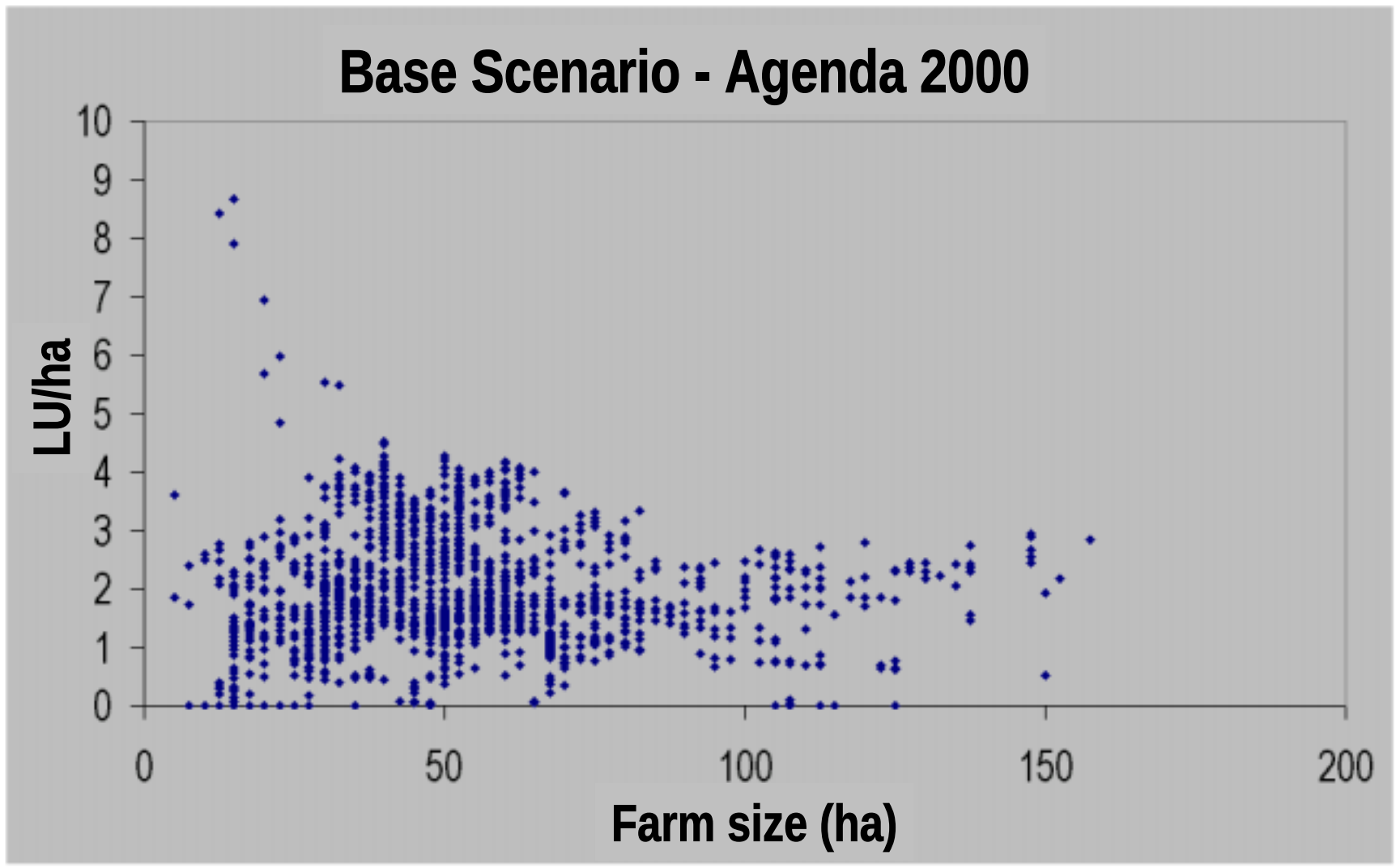
Policy scenarios

- Agenda 2000 (base scenario)
  - nutrient legislation (phosphate, nitrogen)
  - production dependent premiums
  - direct payments (lump sum)
- Alternative scenario I (Agenda 2000 LU)
  - like Agenda 2000
  - limitation on livestock units (LU) (cut in premiums if LU/ha > 2)
- Alternative scenario II (Premium LU)
  - like alternative scenario I (Agenda 2000 LU)
  - equal premium for arable and grassland (independent of use)

○ Proposed by new
Federal Minister of Consumer Protection, Food and Agriculture

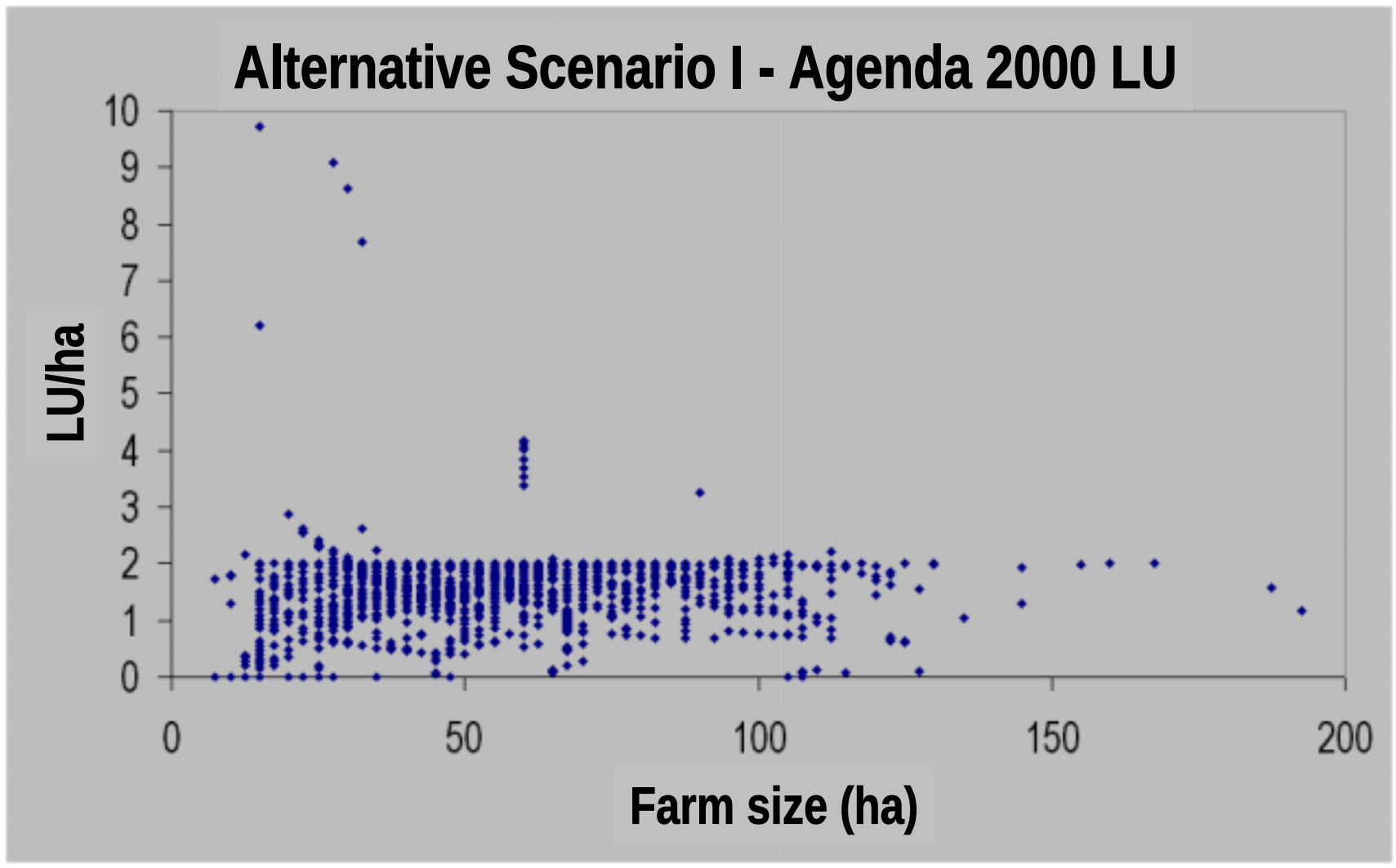
Results

- Livestock density on farm level



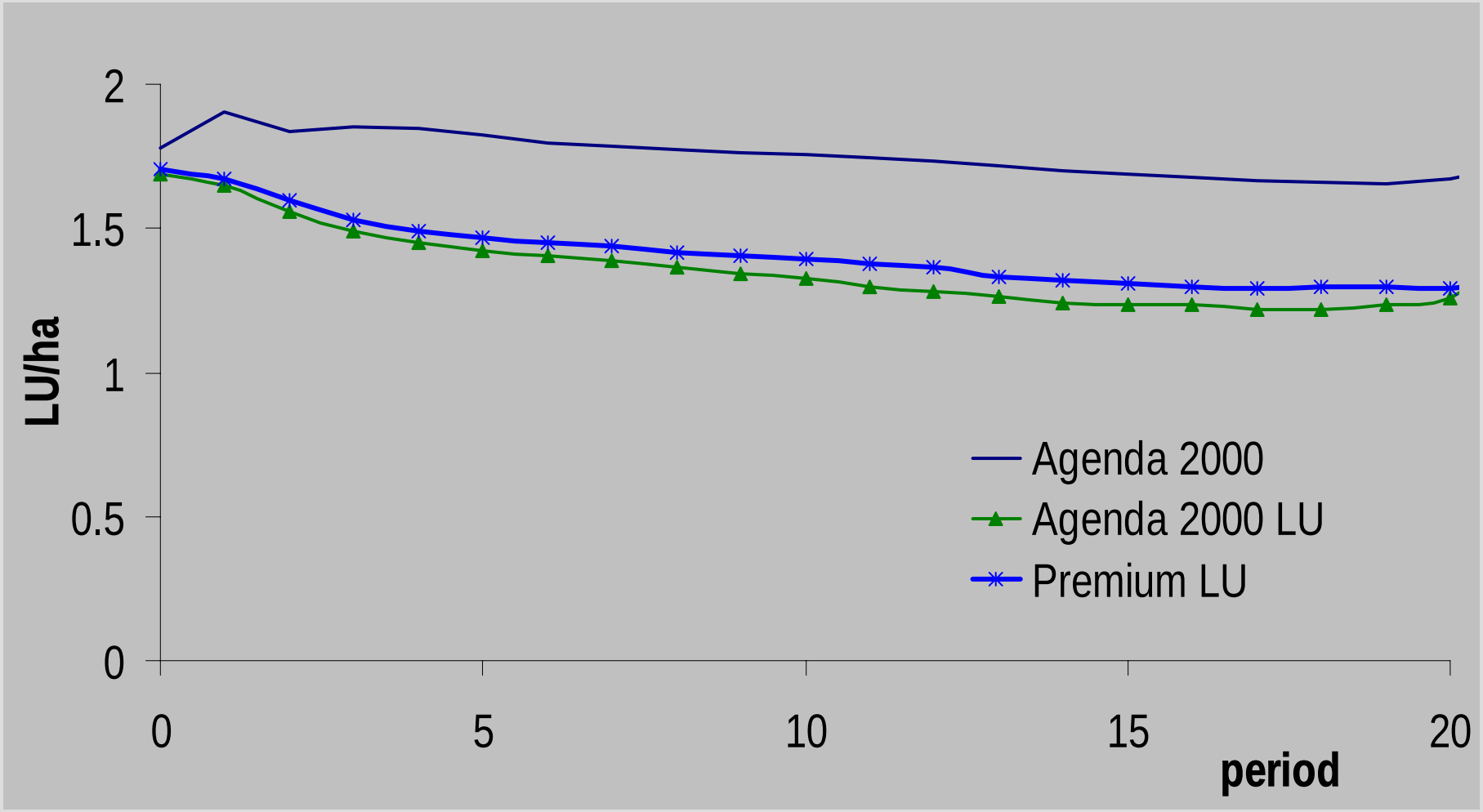
Results

- Livestock density on farm level



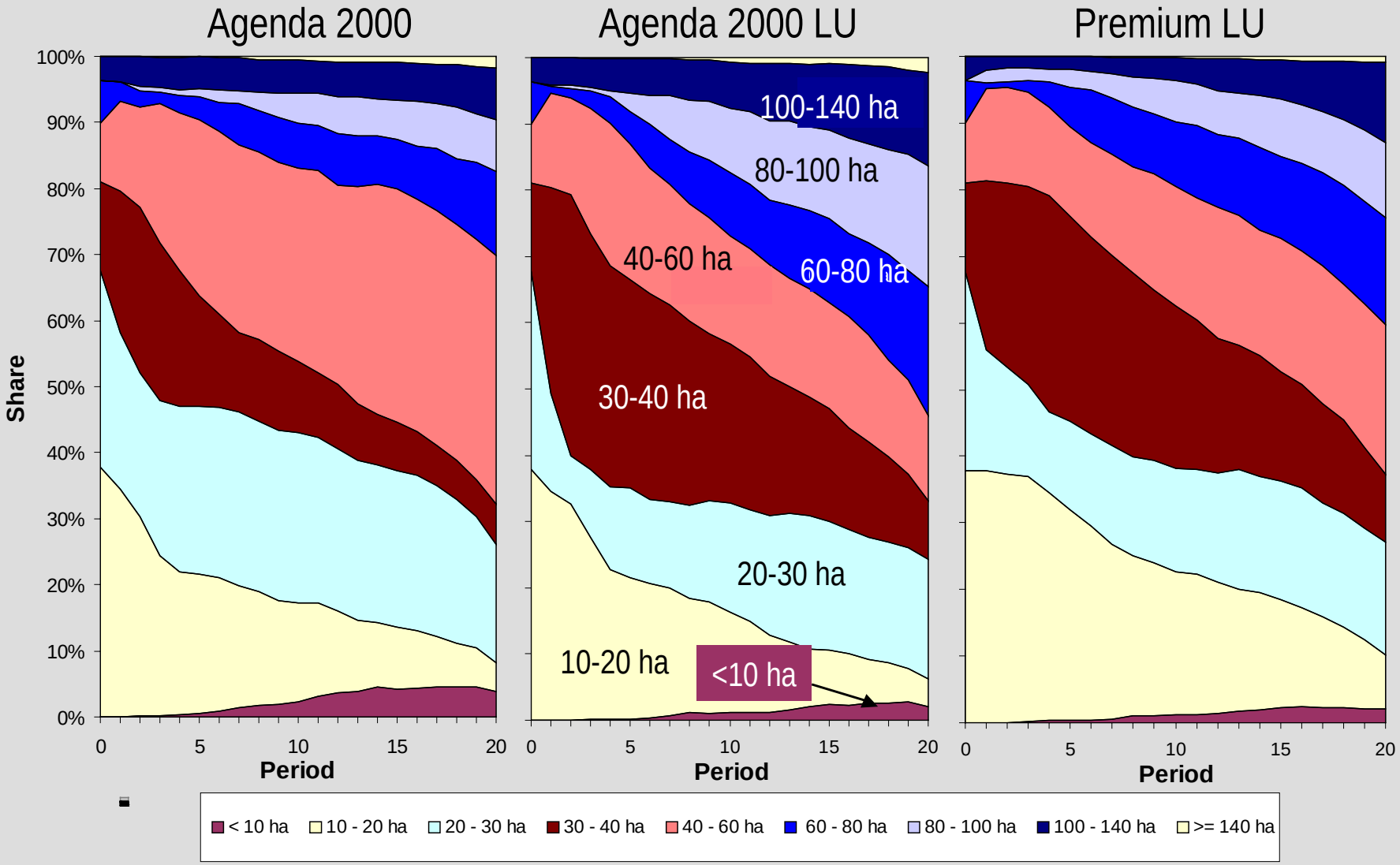
Results

- Policy impacts on animal density



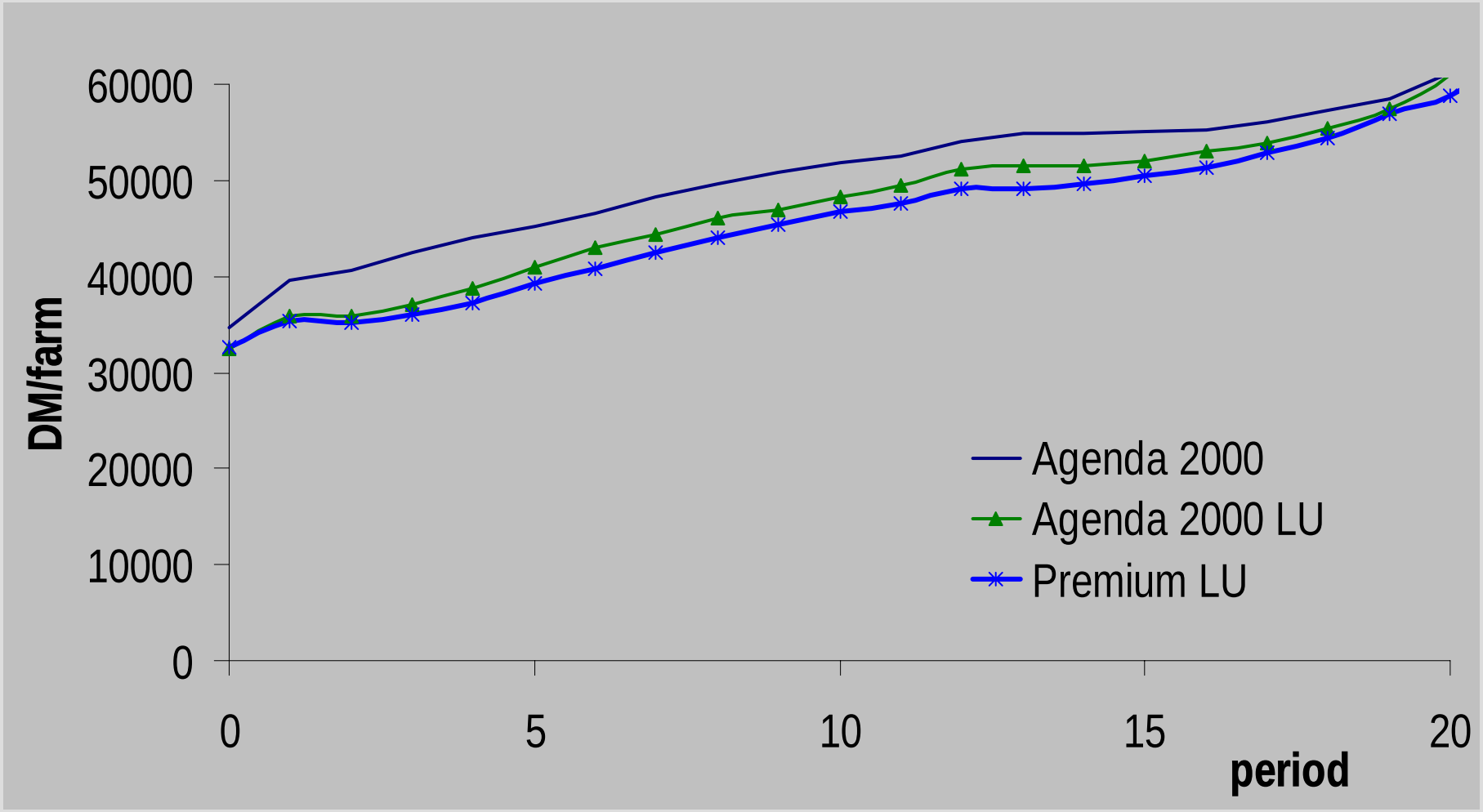
Results

- Policy impacts on structural change



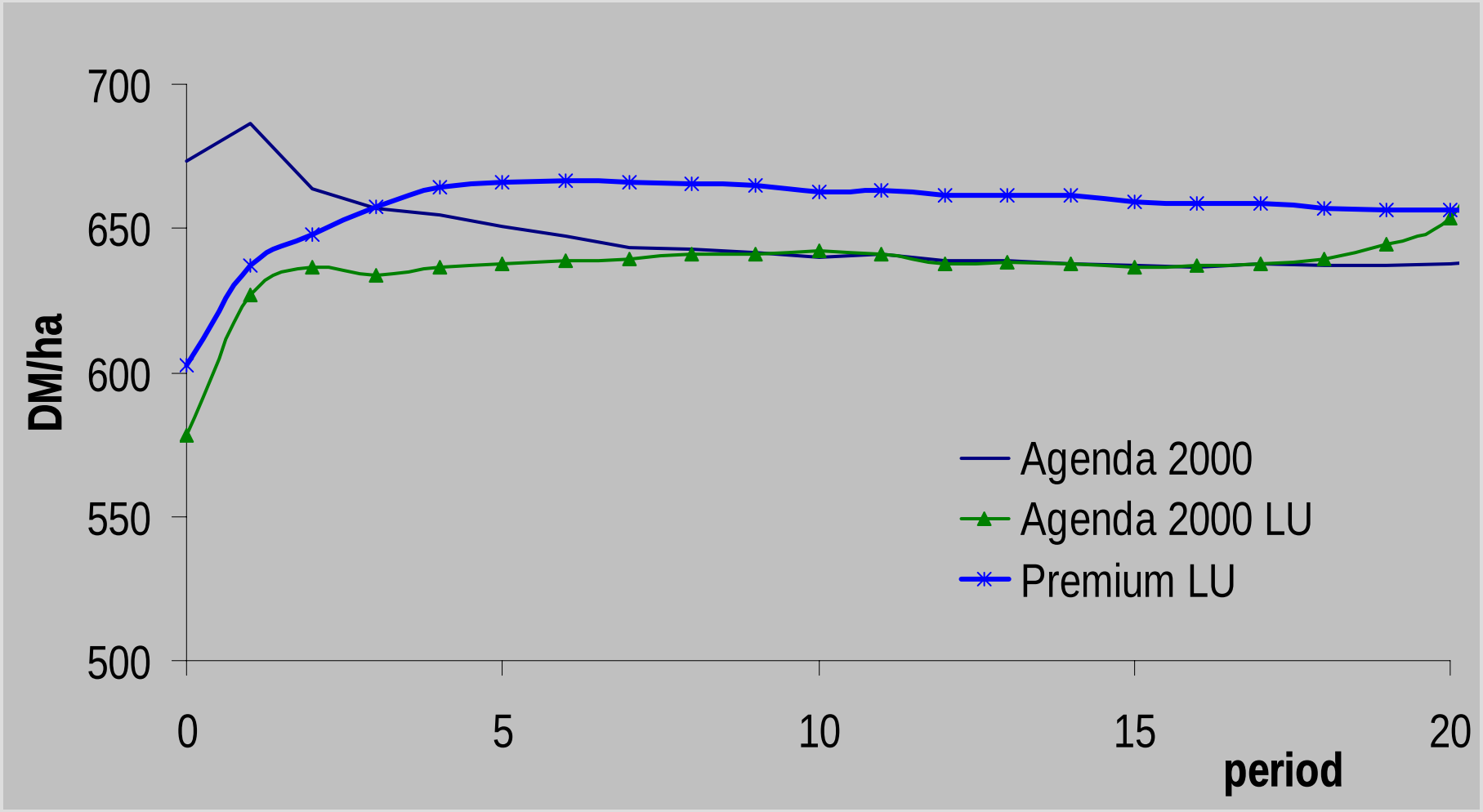
Results

- Policy impacts on farm profits



Results

- Subsidies



Results

- Summary
  - Limitation of livestock density is effective
    - impact on production and land use
  - But also
    - impacts on structural change
    - impacts on farmers' incomes
    - relation of subsidies to income worsens (higher rental prices in the short-run)

Assessment: Policy Analysis with MAS

- "Insights":
  - MAS are able to capture policy impacts on local interaction
  - simulations illustrate complexity of policy impacts
  - simulations allow to quantify policy impacts
- General usefulness of MAS approach
- Supplement of conventional "top down" approaches

- But:
  - Is the model valid?
  - Can the model convince economists and policy makers?
  - What is the scientific value?

Assessment: Policy Analysis with MAS

Validity / persuasiveness

- Problem: validation of complex models is generally difficult
  - but: results show robustness against model revisions
  - but: results fit empirical phenomena like persistently unexploited economies of scale and income disparities very well
- Problem: particular assumptions are controversial
- Problem: particular results are controversial
  - but: results support particular interpretations

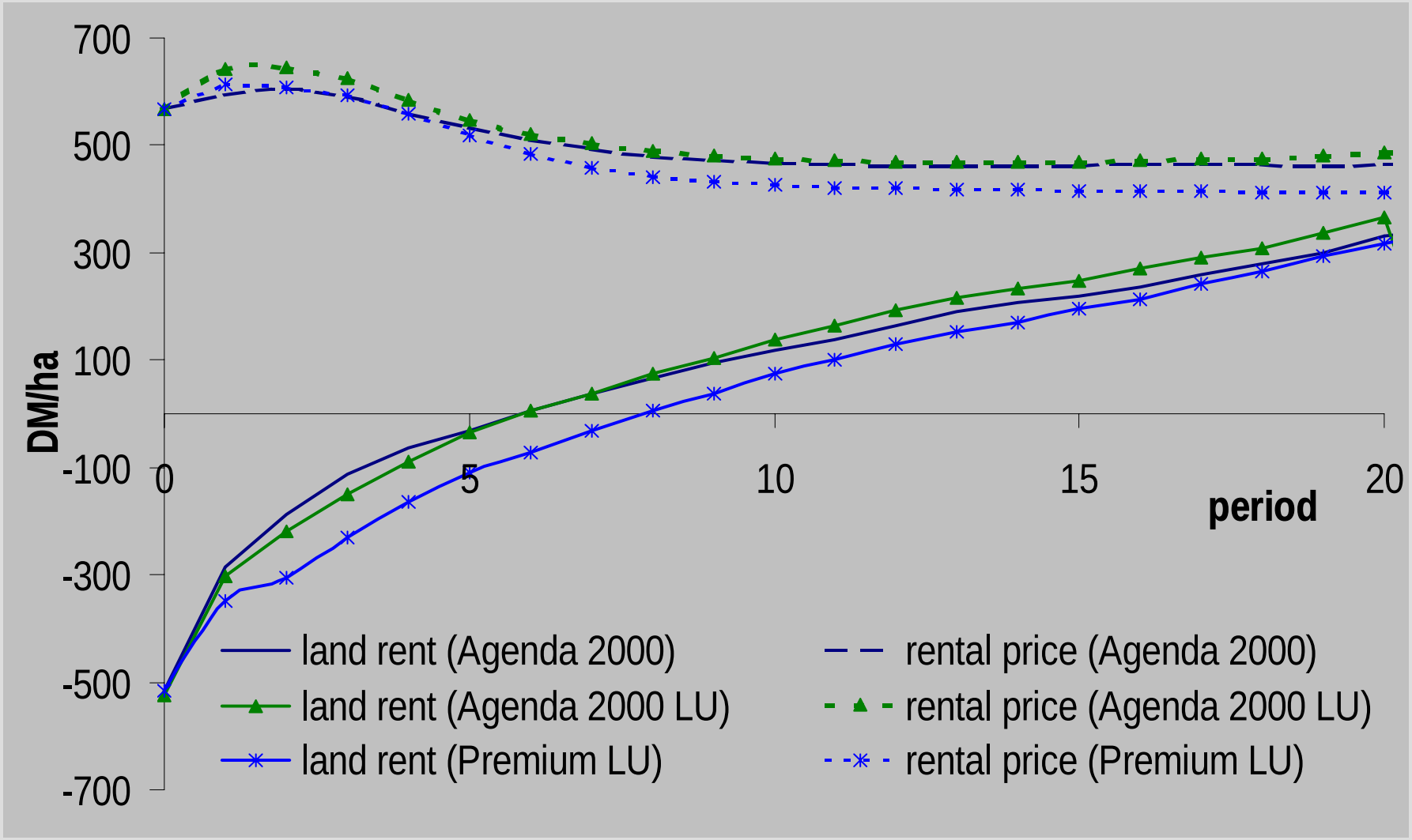
Assessment: Policy Analysis with MAS

Scientific value?

- Simulation of complex argumentation allows
  - quantitative assessment (even of controversial arguments)
  - test of consistency
  - improvement of theories
  - development of empirically testable theses
- Potential for further development of the MAS approach

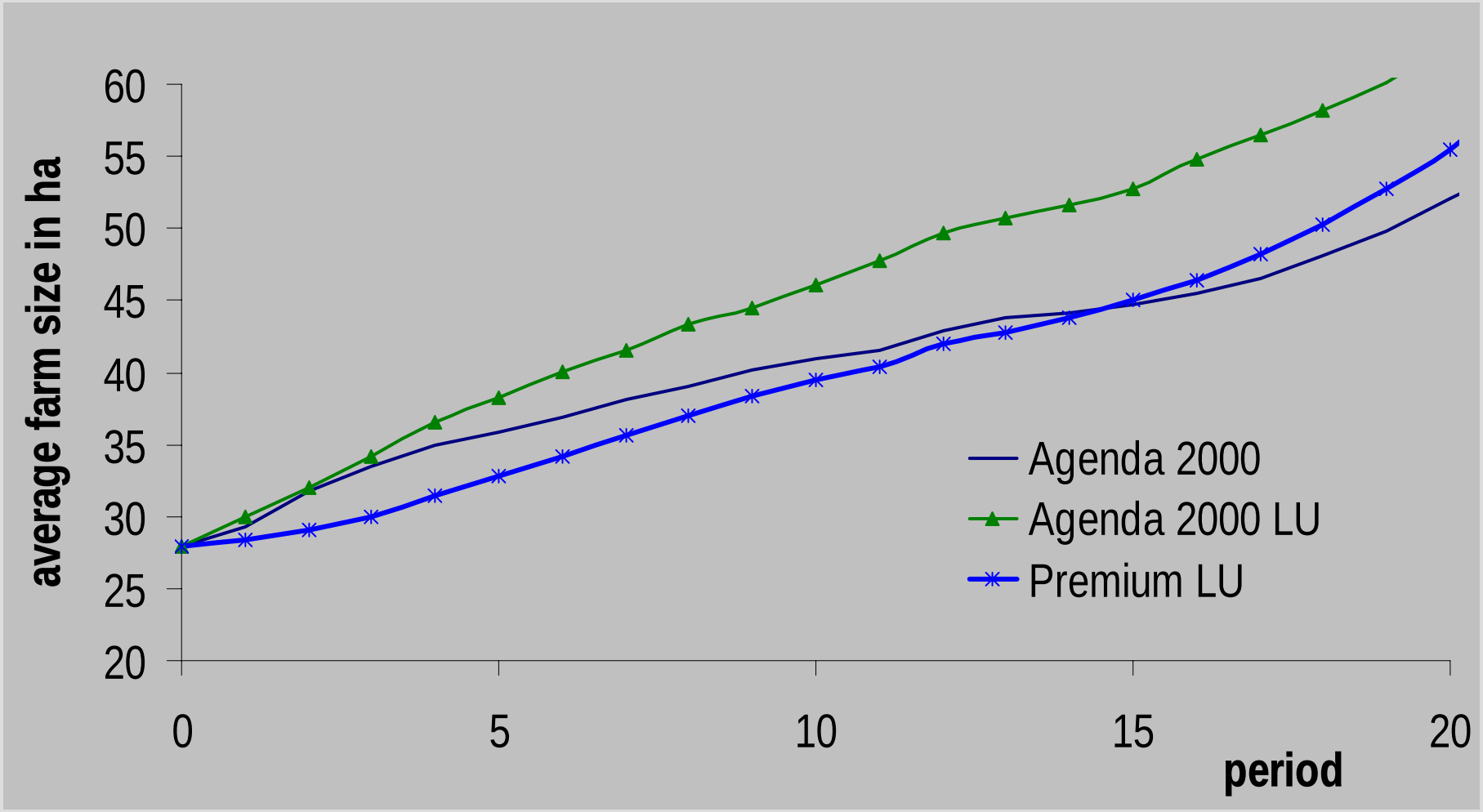
Results

- Land rents and rental prices

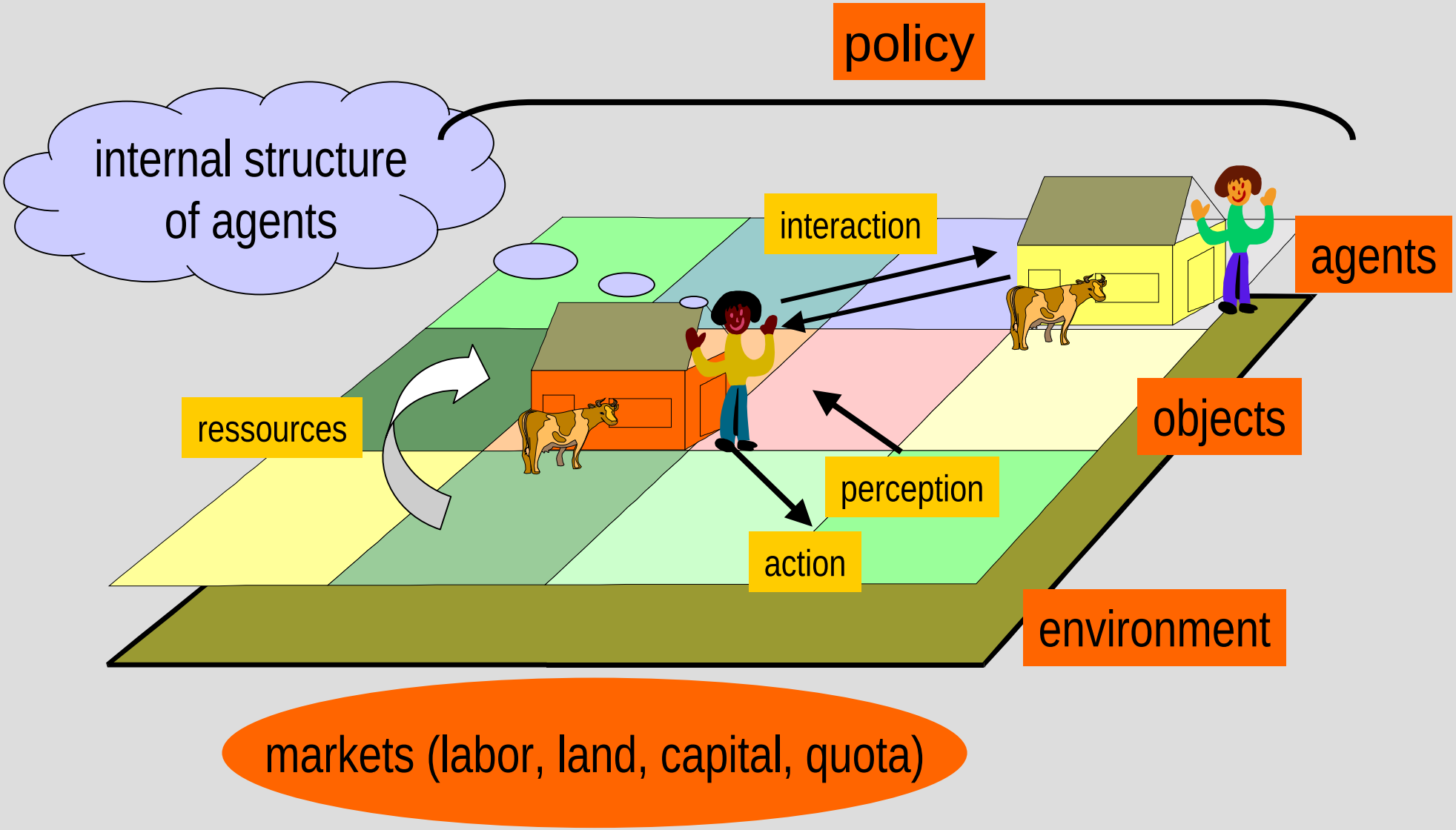


Results

- Policy impacts on structural change



Modeling Agricultural Regions



Data

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full-time	X	X	X	X	X	X	X	X				
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Perspektiven in der Landnutzungsforschung

- Erweiterungsmöglichkeiten
  - Beispiel: Berger (1999)
    - Analyse von Strukturwandel und Ausbreitung technischer Neuerungen für eine ausgewählte Region in Chile
    - Ausgewählte qualitative Erweiterungen:
      - heterogene Bodenqualitäten
      - räumliches Bewässerungsmodell (Wasserrechte, Return Flows)

      } Relevanz für Landnutzung und Umwelt

      - heterogene Akteure (Unternehmerische vs. traditionelle Landwirte)
      - soziale Netzwerke (Kommunikation innerhalb sozialer Gruppen)

      } Sozio-Ökonomische Relevanz

Perspektiven in der Landnutzungsforschung

- Persönliche Perspektiven
  - Exemplarische und realitätsnahe Politikanalysen für ausgewählte Regionen Baden-Württembergs (gemeinsam mit J. Zeddies und K. Happe)
  - Anbindung des Modellansatzes an GIS
  - Bioökonomische Modellierung
  - Entwicklung des Modellansatzes zu einem interaktiven Spiel, bei dem Spieler die Rolle von Landwirten oder von Politikern einnehmen können
  - Nutzung des Spiels für "experimentelle Spiele"
  - Entscheidungsfundierung auf der Basis künstlicher Intelligenz (z.B. mit genetischen Algorithmen)
  - Entwicklung von Multiagentenmodellen zur Simulation von Institutionen und Organisationen

Outline

- Preliminary remarks:

  Actual challenges for agricultural policy modeling
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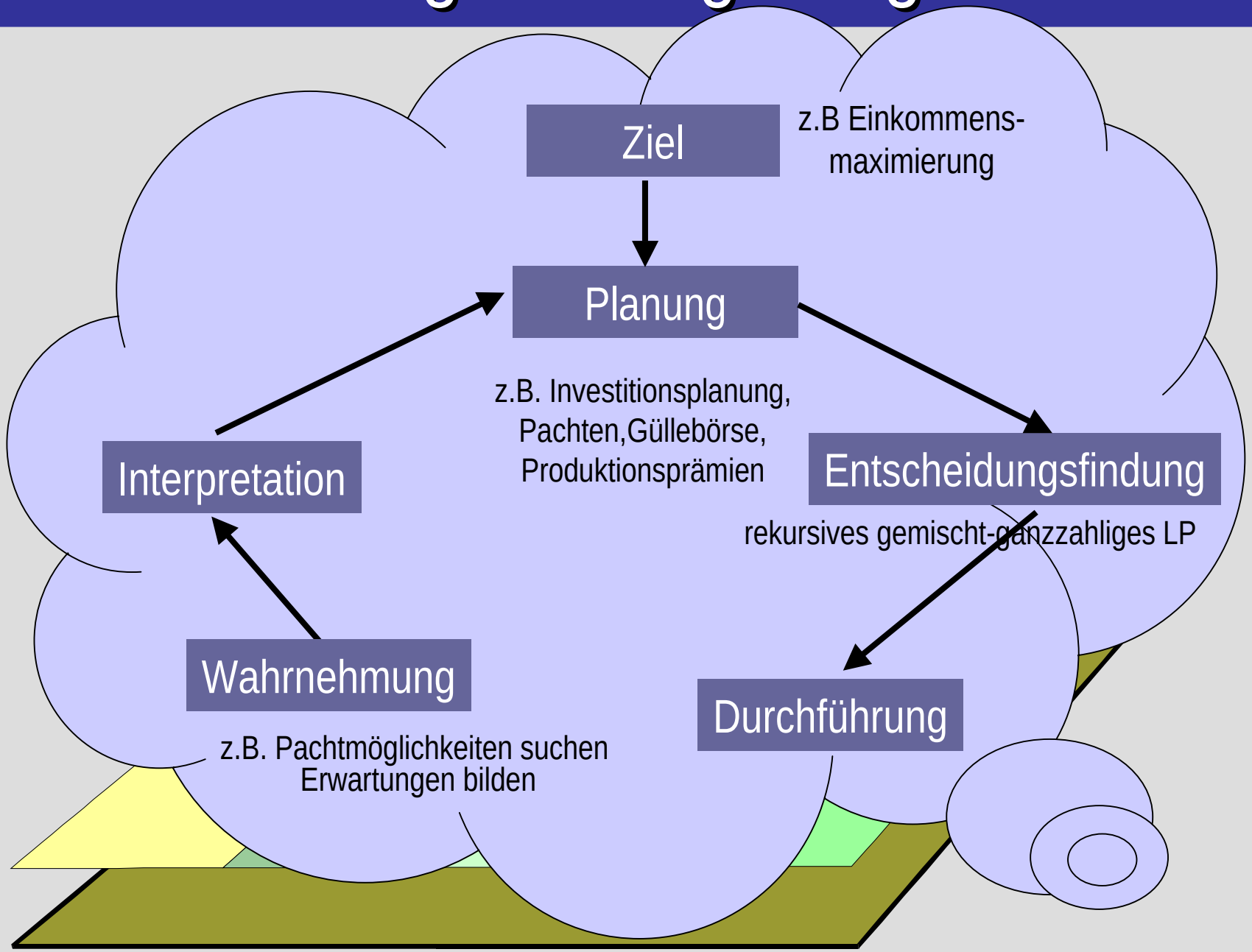
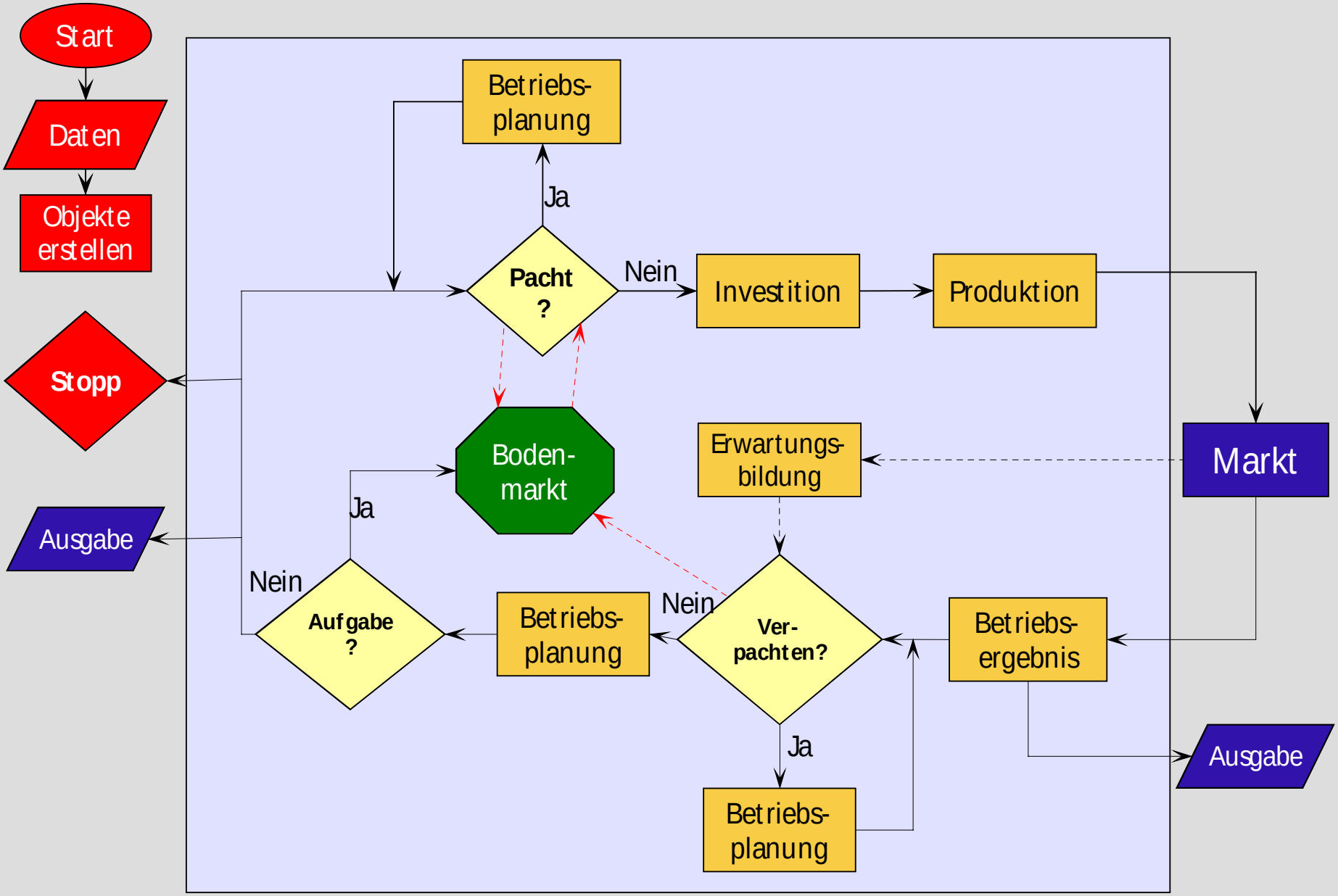
Zur Modellierung einer Agrarregion



Das Modell


Start
Daten
Objekte erstellen
Betriebs-planung
Ja
Pacht ?
Nein
Investition
Produktion
Stopp
Boden-markt
Erwartungs-bildung
Markt
Ausgabe
Ja
Nein
Aufgabe ?
Betriebs-planung
Nein
Ver-pachten?
Betriebs-ergebnis
Ja
Ausgabe
Betriebs-planung

Einordnung Multiagentensysteme

- Validität / Überzeugungskraft
  - Problem: Eingeschränkte Validierungsmöglichkeiten komplexer Modelle
    - Aber: Ergebnisse zeigen sich gegenüber Modellvariationen sehr robust
  - Problem: Kontrovers diskutierte Annahmen
  - Problem: Kontroverse Bewertung der Ergebnisse
    - Aber: Ergebnisse stützen bestimmte Positionen
  - Problem: Vermittelbarkeit komplexer Zusammenhänge

Einordnung Multiagentensysteme

- Wert des Modells / Wert komplexer Simulationen?
  - Simulation komplexer Argumentationsketten/Theorien erlaubt
    - Quantitative Bewertung
    - Konsistenzprüfung
    - Theorieentwicklung
    - Ableitung empirisch testbarer Hypothesen
  - Entwicklungspotential des Modells / der Modellkonzeption