Applying Parallel Genetic Algorithms to Economic Problems

The Case of Agricultural Land Markets

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IIFET 2000

Organisation

why not to use standard economics?

economic applications of genetic algorithms

what are genetic algorithms and how do they work?

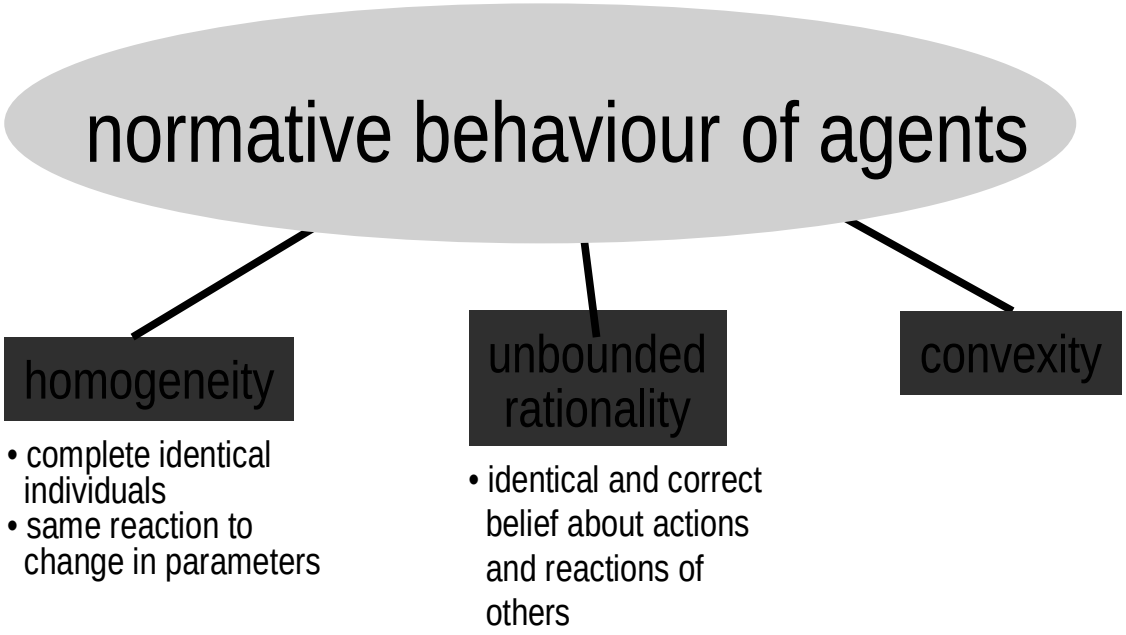
example: land allocation model

3 market scenario simulations

conclusions

Why not to use standard economics?

The usual case:



\+ analytical analysis

\- Do economic agents behave like models want them to?

Why not to use standard economics?

replace normative behaviour

instead: GENETIC ALGORITHMS

GA is search and updating procedure

search for ‘best’ farm behaviour out
of a set of possible behaviours

Economic applications of GA

	model type	game type	Nash Equil.	GA type
Arifovic (1994)	simple cobweb	symmetric	pure strategies	standard
Dawid/Kopel (1998)	cobweb heterogeneous production structure	symmetric	mixed strategies	adjusted GA switching gene
Balmann (1998)	land auction market	asymmetric	mixed strategies	adjusted GA for land market
Balmann/Happe (2000)	land auction market	asymmetric	mixed and pure strategies	parallel GA

GA - steps to undertake

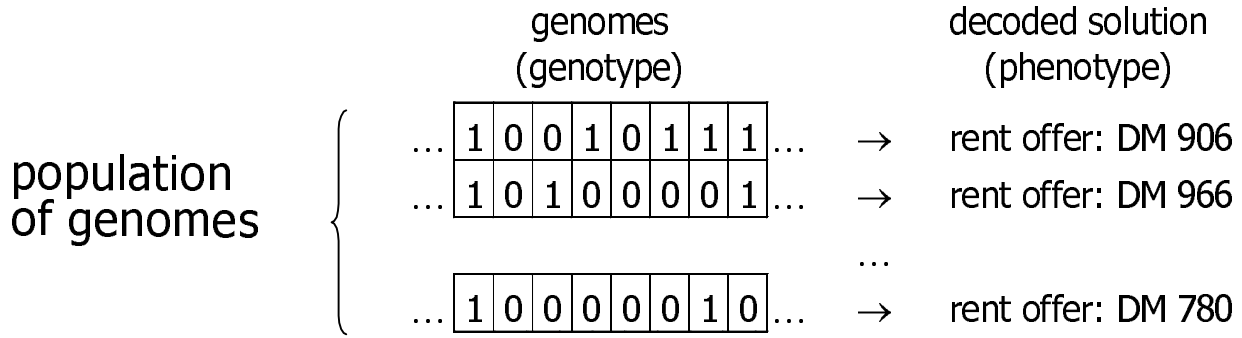
provide genetic information:

representation of strategy/solution as a string of genes

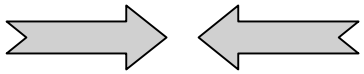
define population:

to apply genetic operators

apply genetic operators: selection, crossover, mutation



Genetic Algorithms - rules

variety generation  variety restriction

rules:

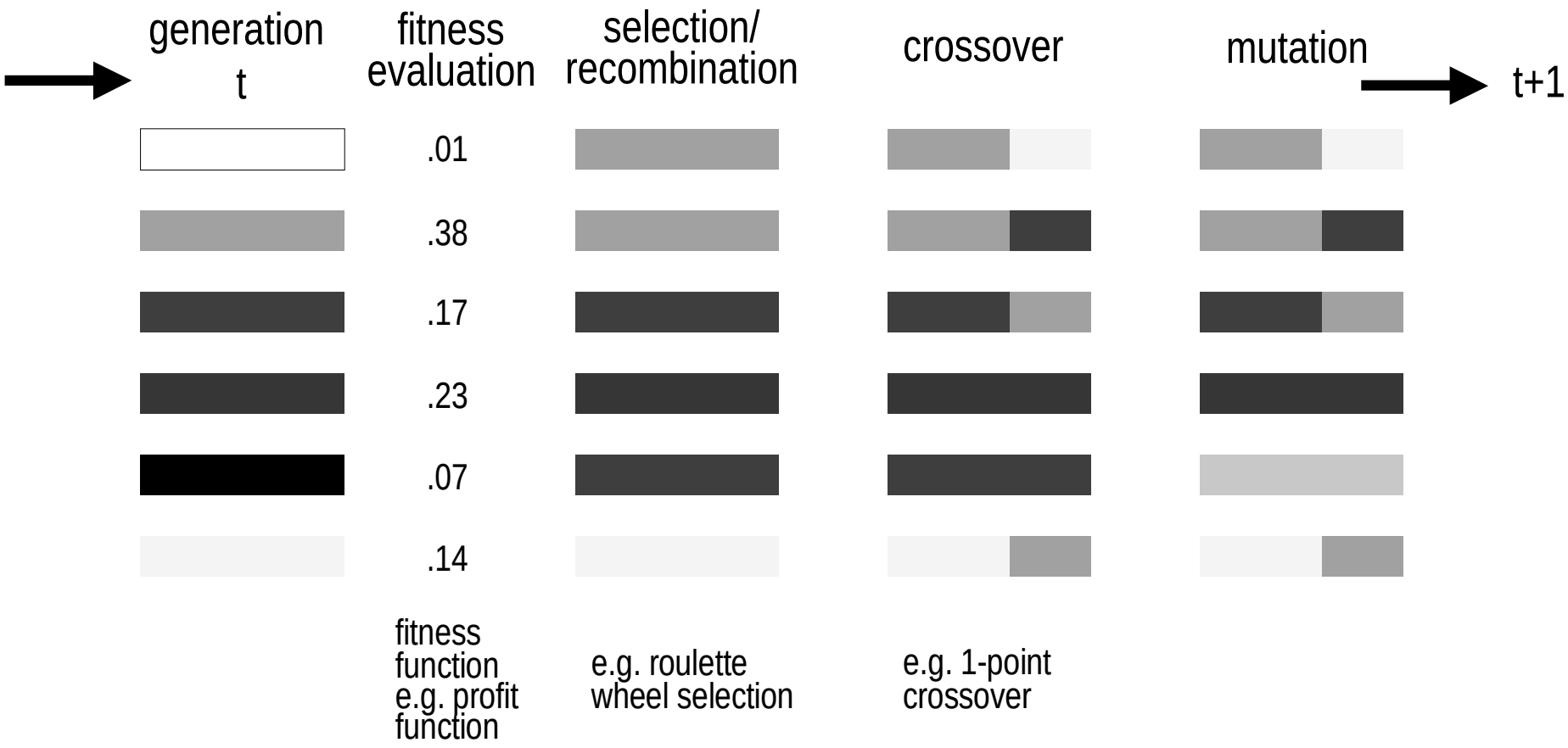
do not change only one variable at a time

do not rely on local analysis and prediction

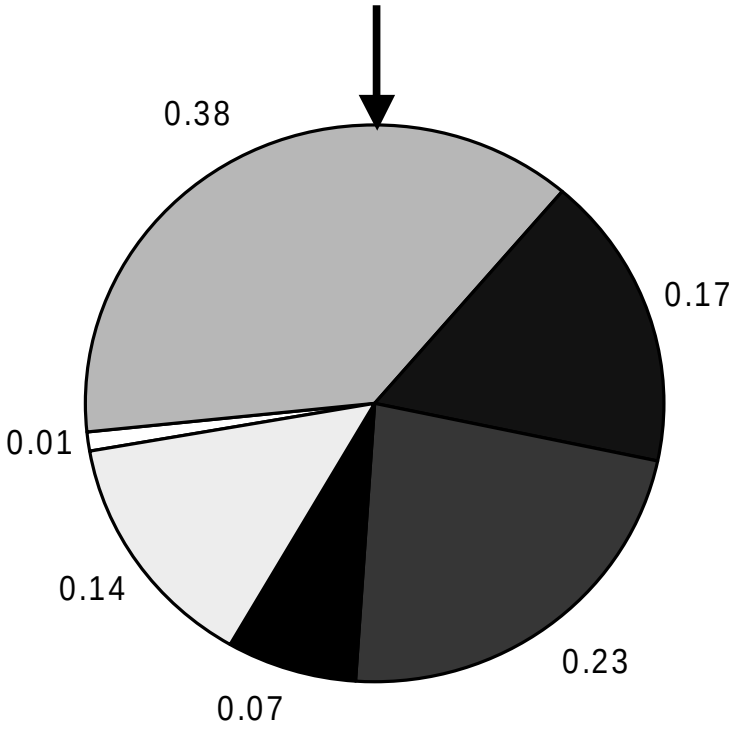
change all variables at the same time

forget failures and keep successful solutions

How a GA works...



Roulette wheel selection



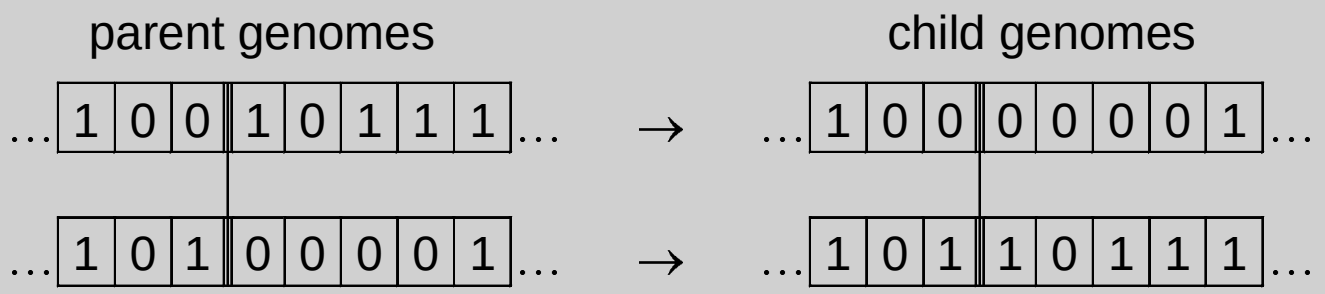
variation:
spin the wheel only
for certain genomes
(e.g. fitness = 0)

circle = total fitness of population

coloured pieces = fitness of one strategy in population

Crossover

1-point crossover



Some general remarks on GA

imitation of basic ideas of natural evolution

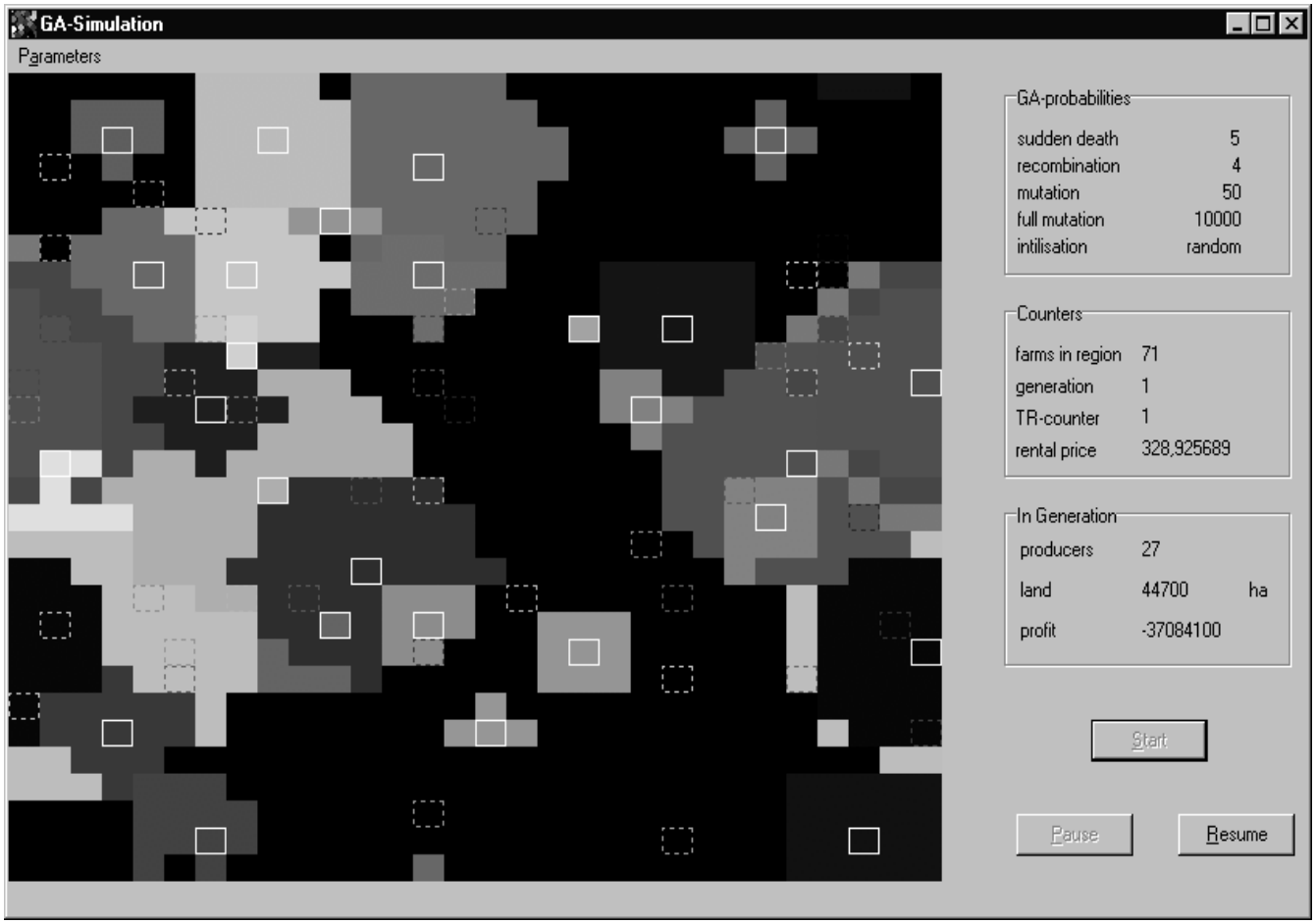
but, biological evolution is much more complex

efficiency aspects of

- chosen encoding scheme (e.g. binary code vs. gray code)
- fitness function
- implementation of operators (e.g. selection)

extend GA models reflect more complex reality

Example: land allocation model



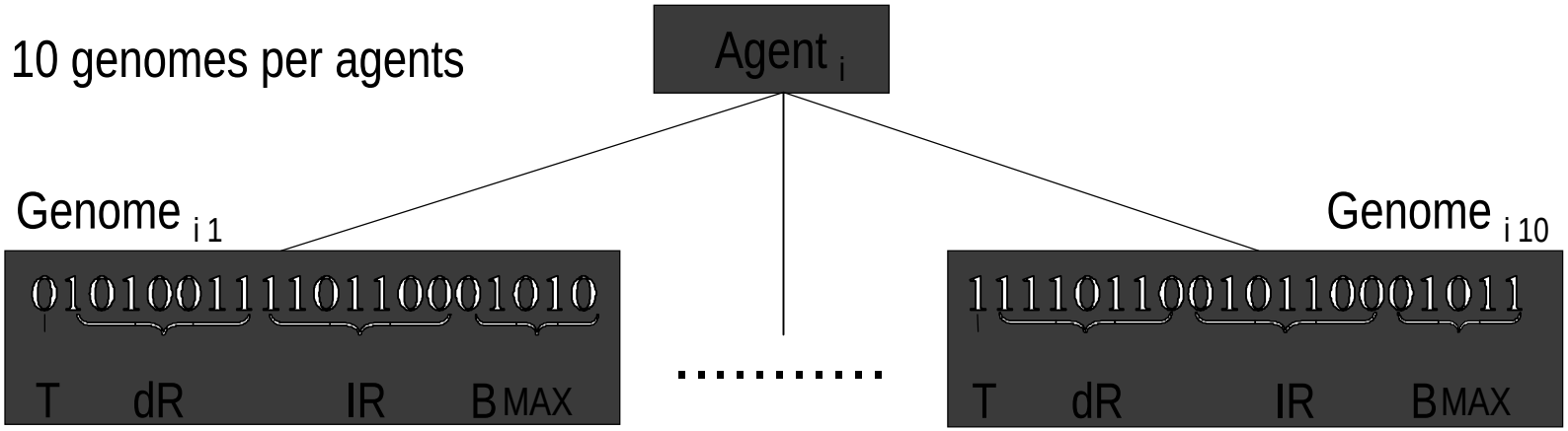
standard economics ⇨ economic applications ⇨ GA ⇨ model ⇨

Multiple GA

Allows

agents develop strategies adopted to location and neighbourhood

agents to have homogeneous populations of strategies, but the population of all agents to have heterogeneous strategies



Behaviour of agents

4 strategy parameters of agent i

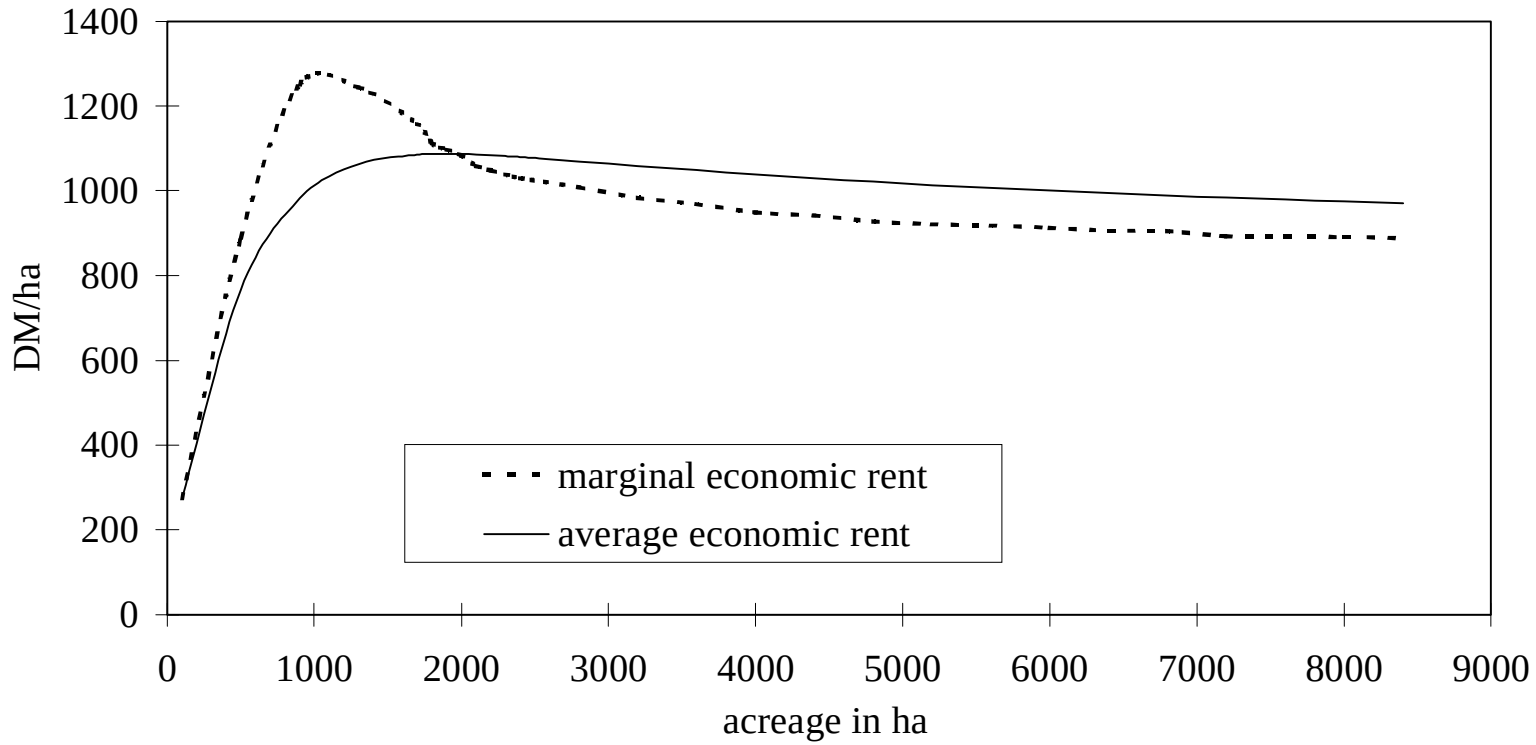
- T_i: participate, yes - no
- IR_i: initial rent offer
- dR_i: rent differentiation coefficient
- B_{MAXi}: max. desired area of a farm

coded on a genome

rent offer of agent i:

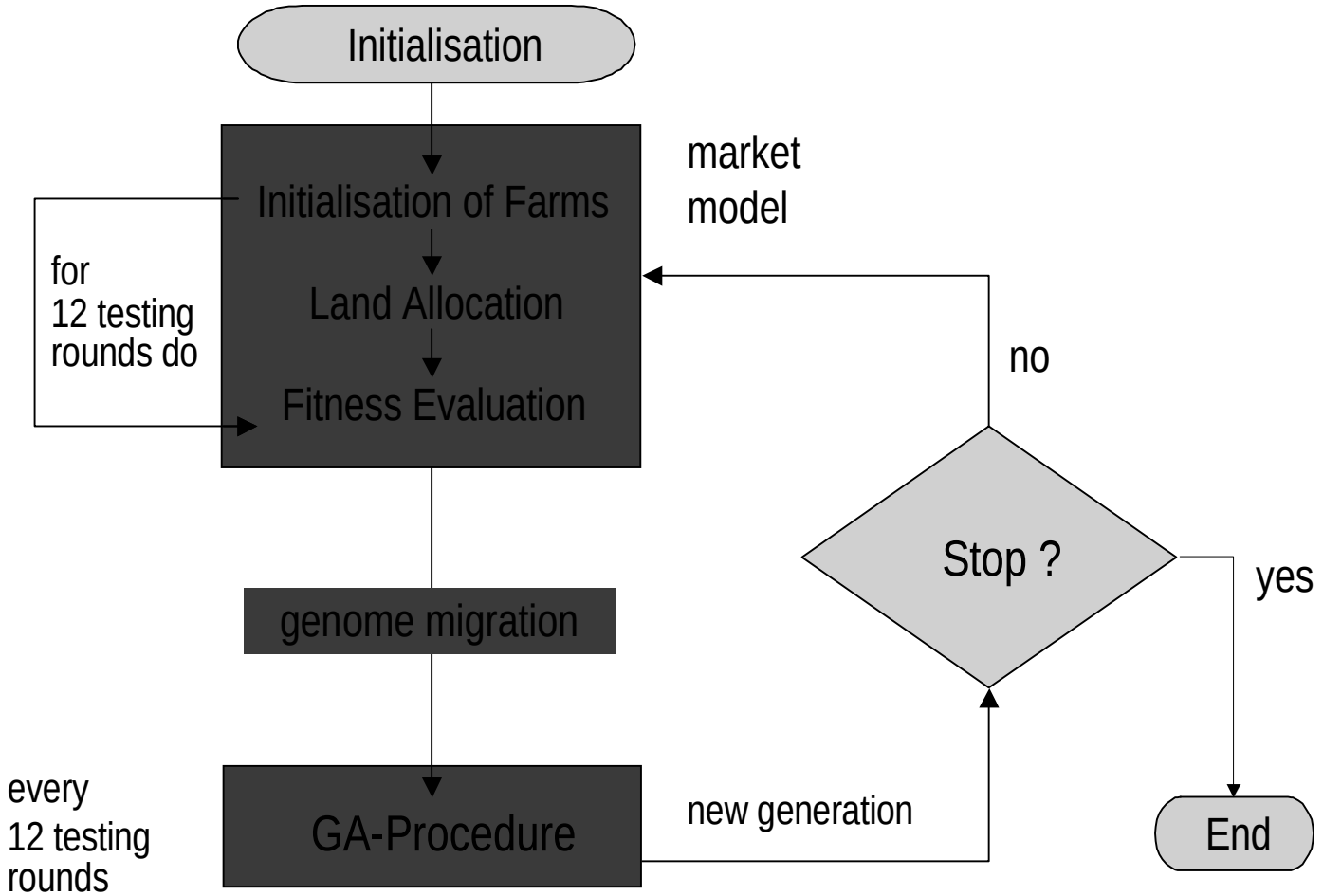
$$P_i = \begin{cases} IR_i - dR_i \cdot B_i - TC_i(\cdot) & \text{for } T_i = 1 \text{ and } B_i < B_{\max,i} \\ \text{no bid} & \text{for } T_i = 0 \text{ or } B_i \geq B_{\max,i} \end{cases}$$

Economic rent function



Source: own calculations, after Peter (1993)

Flow chart of model



3 Scenario

Scenario 1 - unlimited market access

region size: 57600 ha

~ 200 farm agents

transport costs of 20 DM/ha and km distance

Scenario 2 - limited market access, large region

region size: 90000 ha

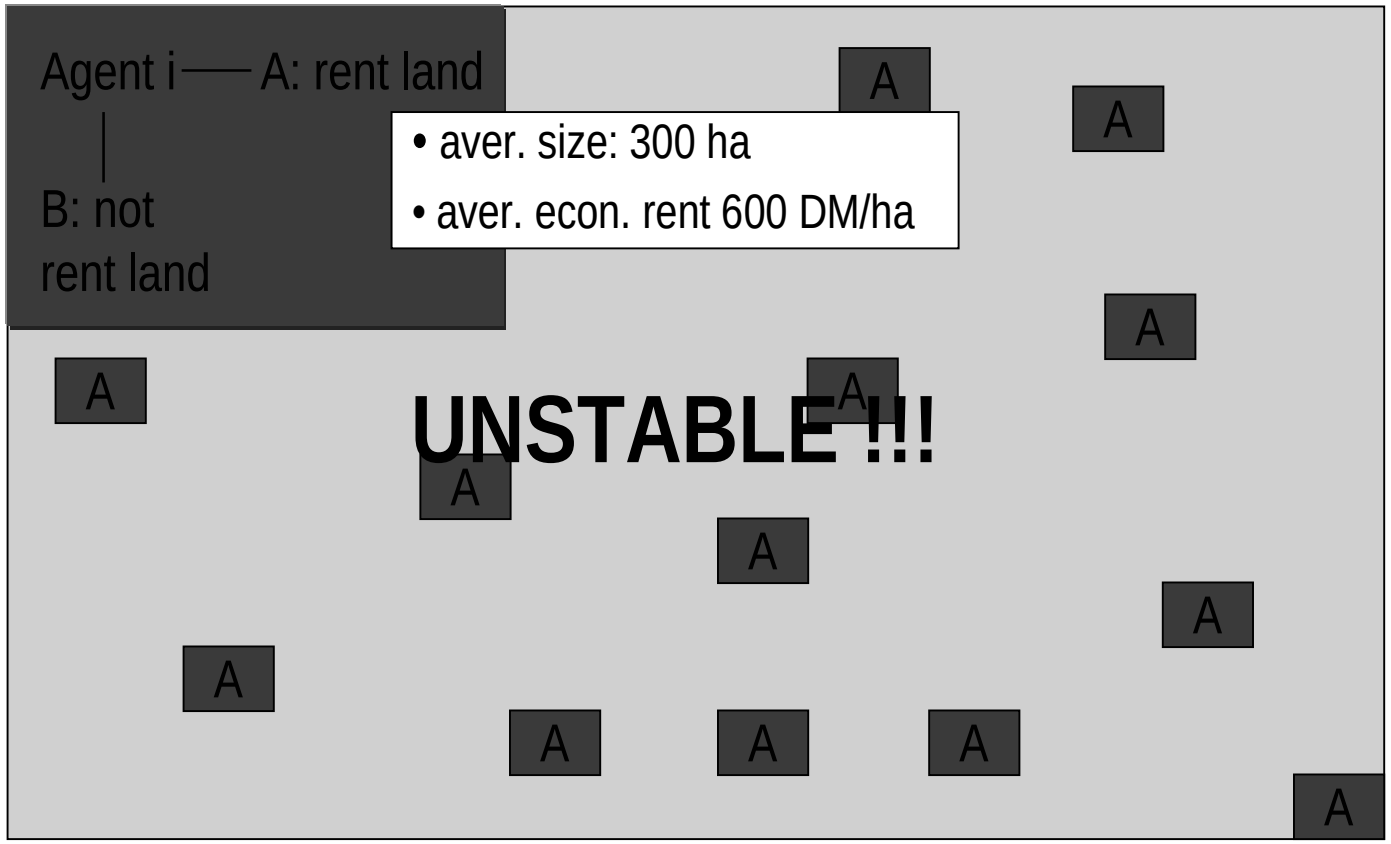
~ 43 farm agents

Scenario 3 - limited market access, small region

region size: 12100 ha

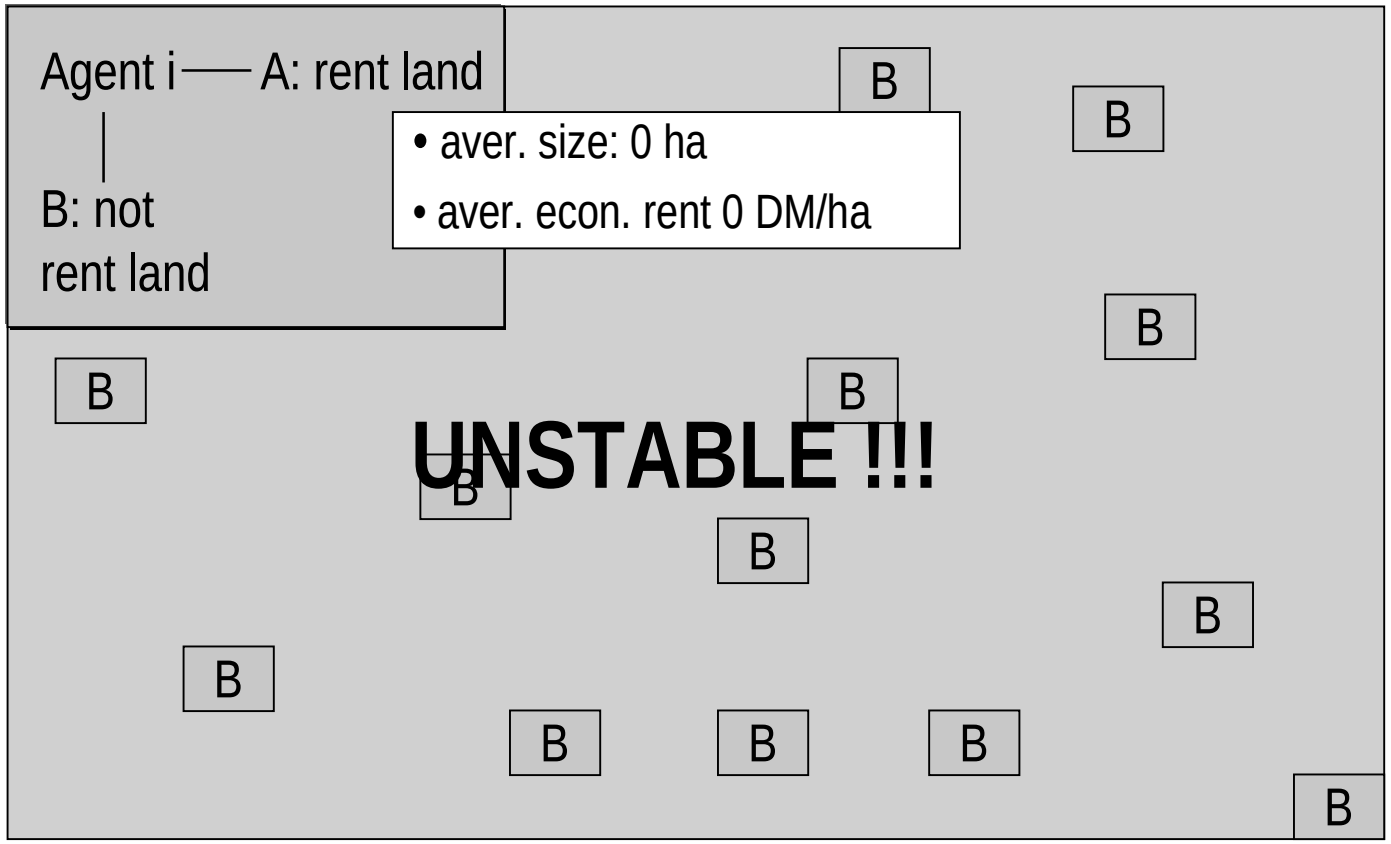
4 farm agents

Equilibrium Considerations



optimum: farm size ~ 2000 ha, ec. rent 1087 DM/ha

Equilibrium Considerations



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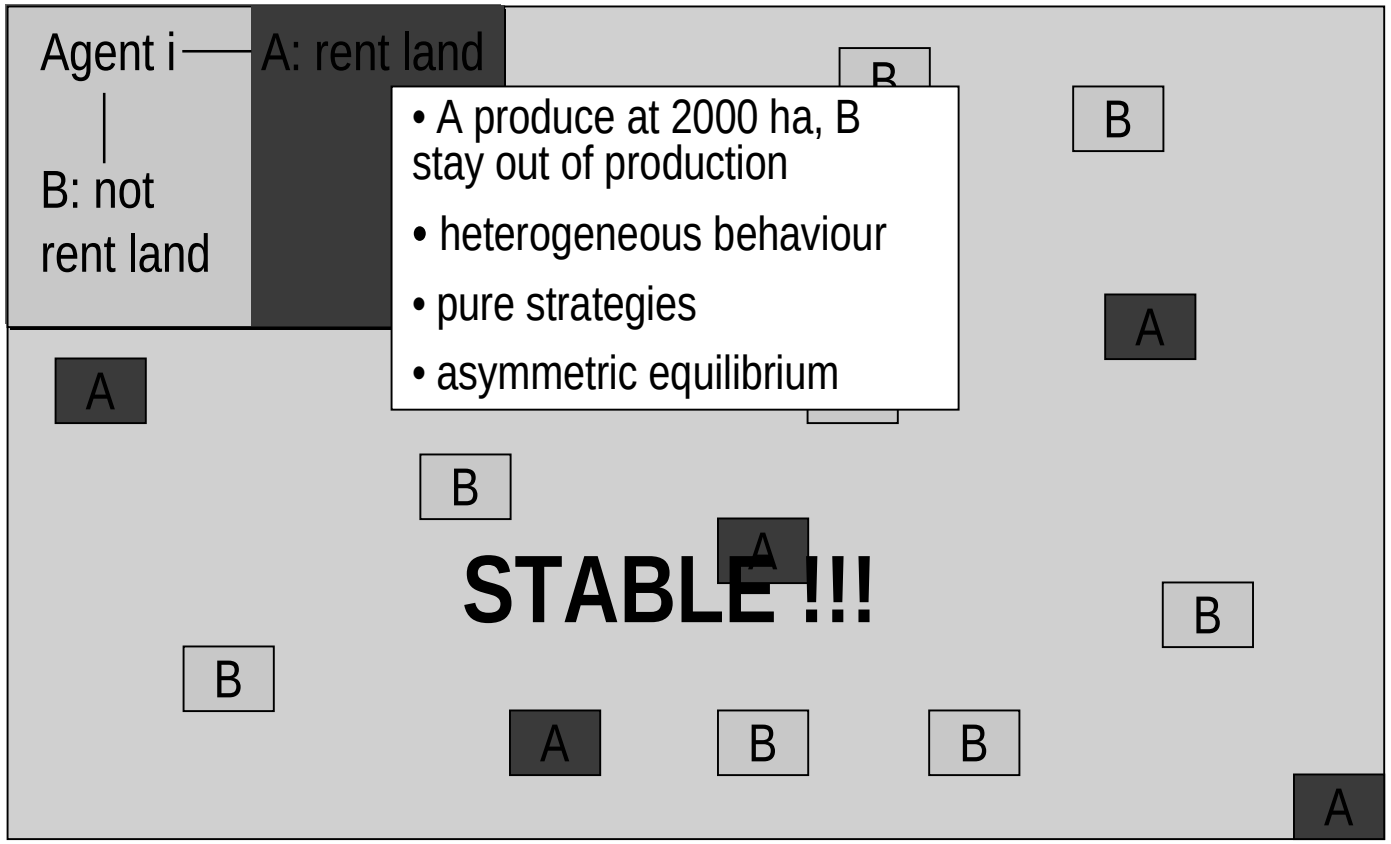

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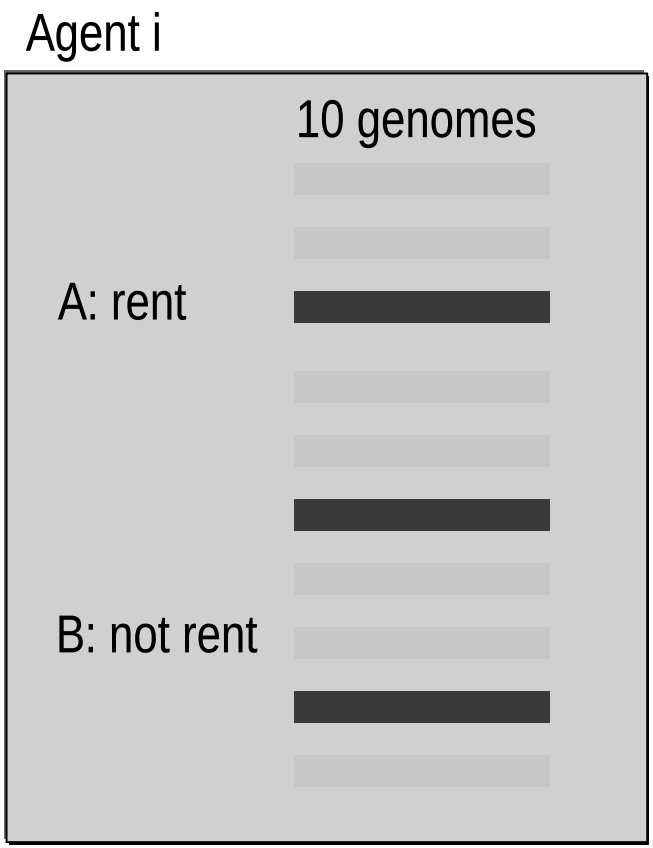


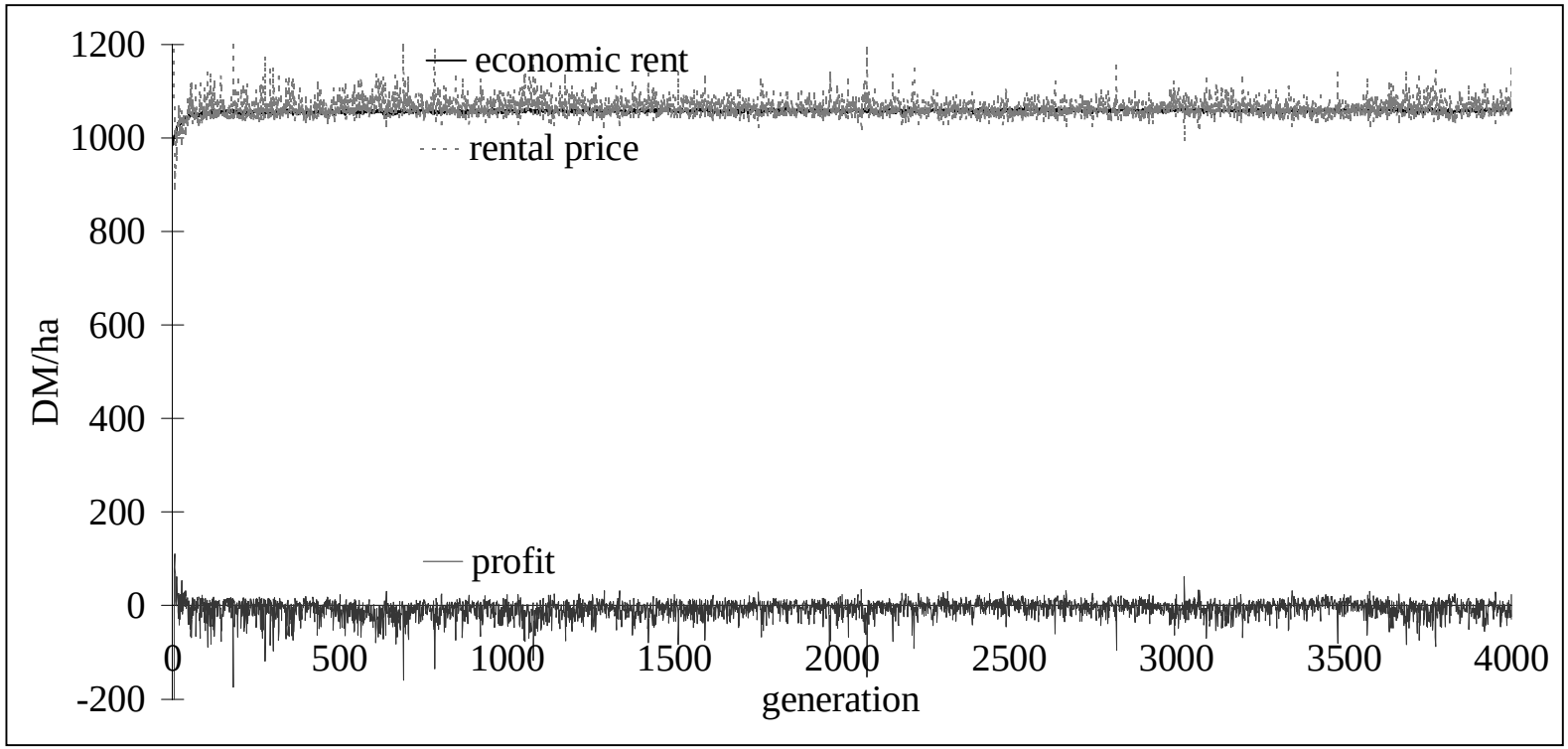
mixed strategy

probability distribution of A or B

equilibrium productionstructure on sector level

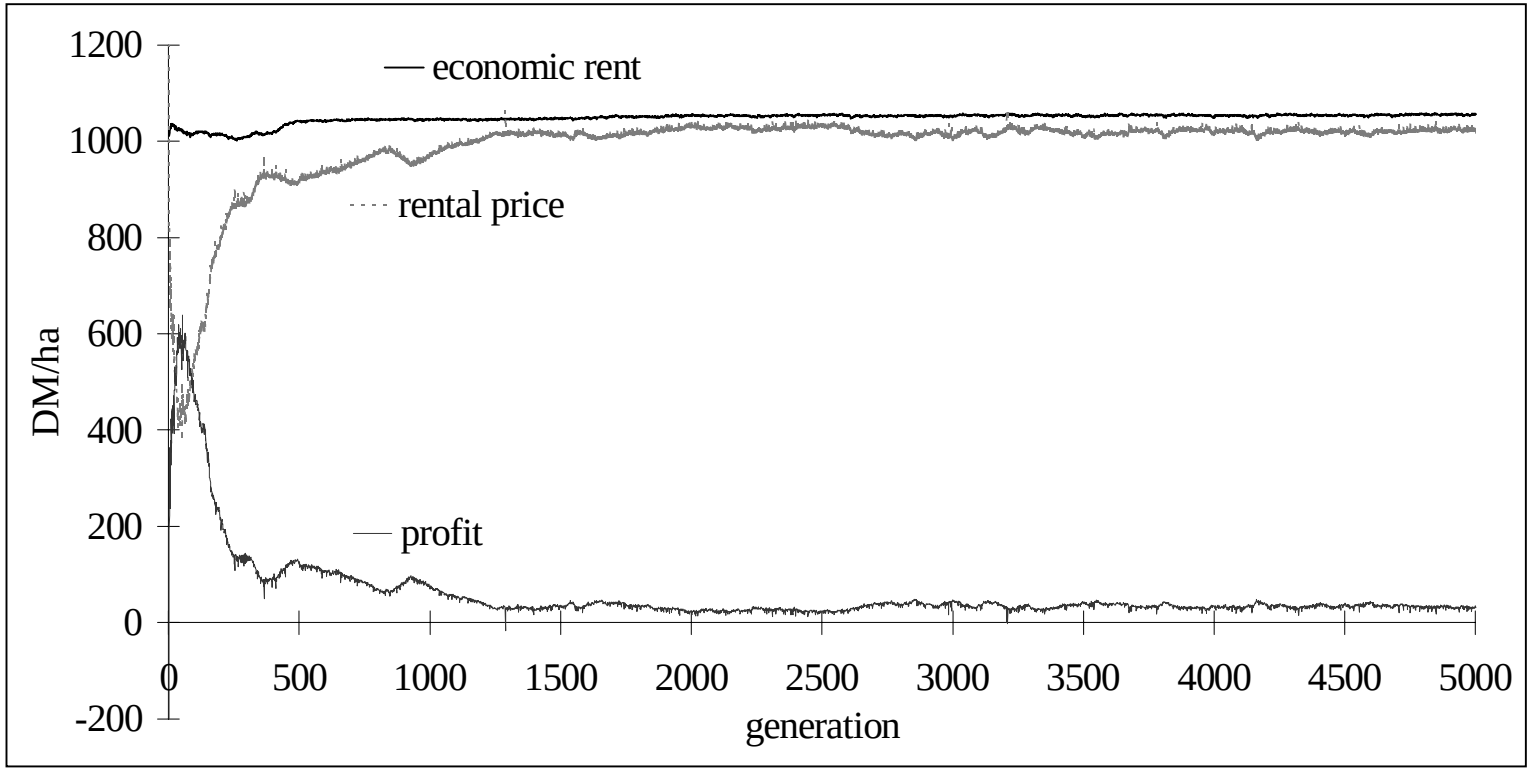
optimum: farm size ~ 2000 ha, ec. rent 1087 DM/ha

Scenario 1: results



Unlimited market access: economic rents, rental prices, and profits
(203 agents, 57600 ha, transportation costs 20 DM per ha and km, = 0.95

Scenario 2: results



Limited market access, large region: economic rents, rental prices, and profits
(43 agents, 90000 ha, transportation costs 20 DM per ha and km, = 0.95)

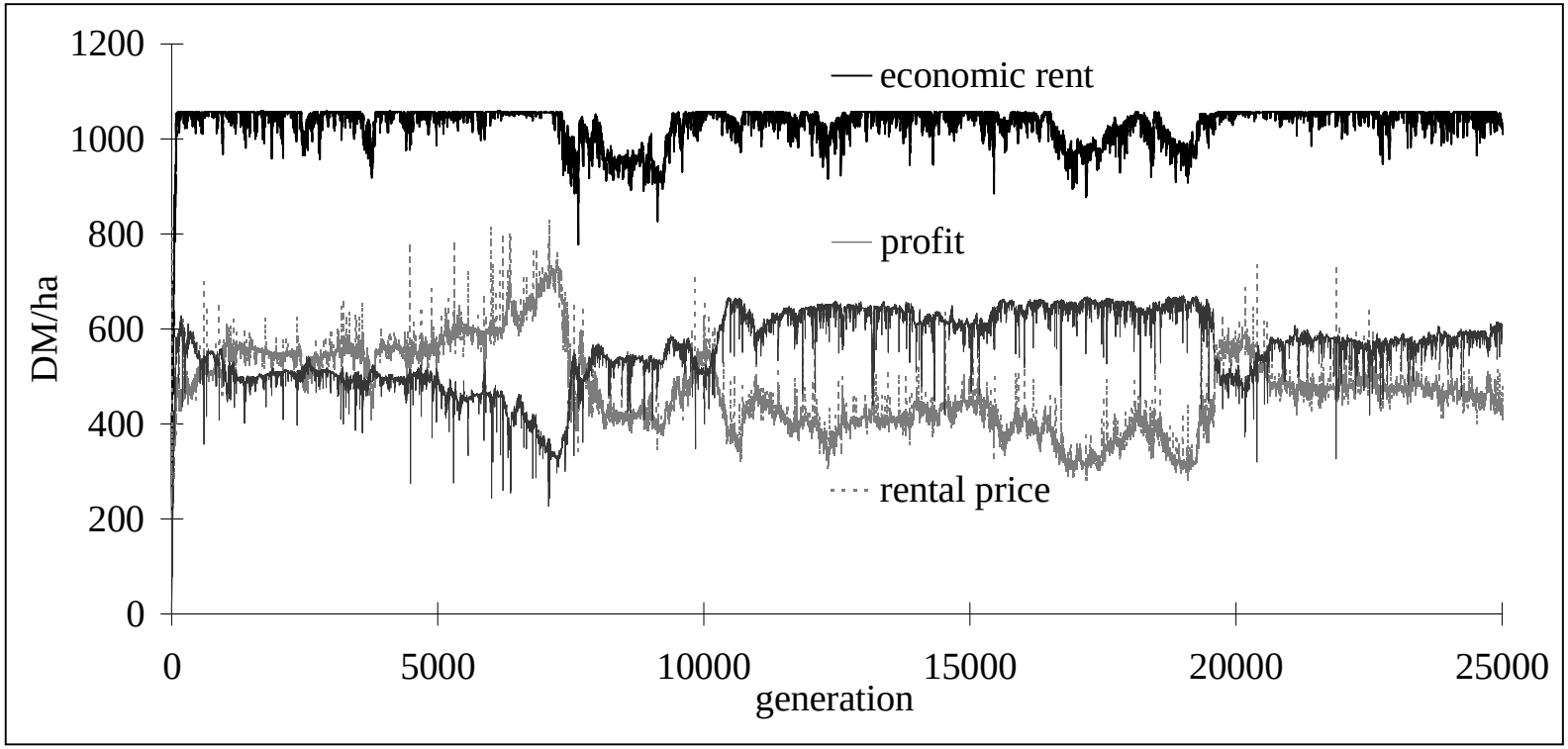
Scenario 2: results

Theoretical and realized profits depending on transportation costs (TC) in DM per ha and km, data in ha or DM per ha)

				simulation results generations 3000 to 5000				*calculated figures* [a]
No.	*TC*	*region size (ha)*	*β*	*average acreage*	*economic rent*	*rental price*	*profit Π/B*	*W/B-∂W/∂B for B = 2200 ha*
1	0	90000	0.95	2288	1117	1104	13	14
2	20	90000	0.95	2267	1054	1020	34	36
3		90000	0.95	2956[b]	1030[b]	961[b]	69[b]	76[f]
4	60	90000	0.95	2240	950	888	62	79
5	120	90000	0.95	2143	806	662	144	144
6	200	90000	0.95	1927	667	482	185	231
7	20	6400	0.95	3168[c]	1052[c]	551[c]	501[c]	76[f]
8		12100	0.95	3000[d]	1062[d]	544[d]	517[d]	76[f]
9		12100	0.95	2999[e]	1047[e]	543[e]	504[e]	76[f]

[a] Calculated differences between marginal and average economic rent (W) according to Figure 6 for an acreage of 2200 ha and an ideal location of plots.
[b] Periods 2000 - 25000. [c] Periods 7000 - 13000. [d] Periods 3000 - 10000. [e] Periods 2000 - 25000. [f] *B*=3000 ha.

Scenario 3: results



Limited market acess, small region: economic rents, rental prices, and profits
(4 agents, 12100 ha, transportation costs 20 DM per ha and km)

Final remarks

results of Scenario 1 comply with comparative static equilibrium conditions

results of Scenario 2 are less obvious

oligopolistic market behaviour does only emerge under very restrictive conditions (Scenario 3)

Final remarks

validity of the model

- dynamic aspects were neglected (frictions)
- differences between social and biological processes
- GA are a crude simplification and represent naive behaviour
- danger to create artifacts
- behaviour of parallel GA is very hard to study

further use:

- GA cannot yet replace conventional models
- GA can serve as an extension of conventional models