



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Balman, A.; Happe, K.; Kellermann, K.; Kleingarn, A.: Agricultural Policy Switchings – an Agent-Based Approach. In: Brockmeier, M.; Isermeyer, F.; von Cramon-Taubadel, S.: Liberalisierung des Weltagrarhandels – Strategien und Konsequenzen. Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V., Band 37, Münster-Hiltrup: Landwirtschaftsverlag (2001), S.401-411.

AGRICULTURAL POLICY SWITCHINGS - AN AGENT-BASED APPROACH

von

A. BALMANN*, K. HAPPE**, K. KELLERMANN und A. KLEINGARN

1 Introduction

A limitation of livestock density, i. e. tying animal production to farmed land, has become an issue in recent political discussions. Whereas it has been part of some voluntary management agreement programs for quite some time, the limit of two livestock units (LU) per ha has now been brought forward also on a national and European level (cf. ZMP 2001).¹ Generally this measure is associated with positive effects on the environment and some policy makers argue that a limitation would create incentives for farmers to reorganize production. In order to receive direct payments farms with a high livestock density are expected to develop diversification strategies. One such strategy is to rent additional land. This is the intention of policy makers. However, farms that are already very specialized in e. g. pig or poultry production may also respond inversely: If land is available only at enormous prices and if reducing the number of livestock is not attractive, an intensive livestock farm may no longer be interested in farming land at all because it would then have to farm the land without subsidies. Consequently, instead of diversifying a farm may choose to specialize even more, and eventually reduce its acreage. Hence, the land market is particularly affected by a choice in favor or against diversification or specialization. And, reciprocally, depending on the conditions on the land market, the relative attractiveness of these strategies will depend on other farms' behavior and thus on the existing farm structure. For regions with a low animal density it could mean that intensive livestock farms will increase their acreage. Since in these regions only a few farms are affected by the policy change, the adjustment has little impact on the land market. In regions with a high animal density the policy impact on the land market is expected to be strong and some farms are expected to diversify while others will have to specialize.

The intention of this paper is to analyze the effects of such a policy switching for a region which is, on the one hand, more diversified than an intensive production region, but, on the other hand, does not have a particularly low animal density as well. The region of "Hohenlohe" located in Baden-Württemberg displays such characteristics (cf. MLR 2000, various years). Apart from intensive pig and turkey production, there are also a number of dairy, farrowing, and crop farms located in the region. Farm sizes are relatively small and below the average in West Germany. Whereas average incomes and land rents are relatively high, structural change has been comparatively slow. The dominating organizational form is that of a family farm. To tackle the problem of how farms interact, the study is based on agent-based simulations. This means, we simulate the adjustment process with a spatial and dynamic model that considers approximately 2600 heterogeneous, individually behaving farms. These farms are spatially distributed in a region with a size of about 75000 ha of agricultural land. Since data for 2600 individual farms is not available, the model was fitted to the agricultural

* Alfons Balmann, Fachhochschule Neubrandenburg, Fachbereich AL, Brodaer Str. 2, 17033 Neubrandenburg, e-mail: mail@alfons-balmann.de (Anne Kleingarn und Konrad Kellermann sind Studierende an der Humboldt-Universität zu Berlin).

** Kathrin Happe, Institut für Landwirtschaftliche Betriebslehre 410B, Universität Hohenheim, 70593 Stuttgart, e-mail: khappe@uni-hohenheim.de.

¹ A livestock unit (LU) is defined as an animal with a living weight of 500 kg, i. e. a cow is 1.2 LU and a sow is 0.3 LU.

sector in Hohenlohe on the basis of data from a small number of real farms operating in the region. These selected farms can be considered typical for the region.

2 Agent-based systems

An agent-based system (ABS) consists of a number of interacting autonomous entities which are understood as agents. RUSSELL and NORVIG (1995, p. 33) have defined agents as "...anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors." According to this definition an agent could equally be a computer program which produces output from input (cf. JENNINGS et al. 1998), or a gum machine that distributes a certain number of gums. FRANKLIN and GRAESSER (1996) attempt to give a more precise definition of an agent: "*An **autonomous agent** is a system situated within and a part of an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to effect what it senses in the future.*" According to this definition people as well as thermostats could be understood as agents. Therefore, FRANKLIN and GRAESSER propose a classification of agents according to certain properties (table 1). They consider the first four items to be the minimum requirements for an agent, i.e. an agent should be able to react autonomously and goal-directed to signals in their environment. In as far as other criteria are fulfilled, these are specialized agents.²

Table 1: Classification of agents (FRANKLIN and GRAESSER 1996)

Property	Meaning
reactive	responds in a timely fashion to changes in the environment
autonomous	exercises control over its own actions
goal-oriented	does not simply act in response to the environment
temporally continuous	is a continuously running process
communicative	communicates with other agents, perhaps including people
learning (adaptive)	changes its behaviour based on its previous experience
mobile	able to transport itself from one machine to another
flexible	actions are not scripted
character	believable "personality" and emotional state

Agent-based systems are constructed "*from the bottom up*" since the system's behavior is not controlled by a single central planner on the aggregated level, but it is primarily the result of many individually acting and interacting agents with differing behaviors. Because of this, agents can be endowed with a larger number of properties and behaviors than conventional top-down approaches would allow (BALMANN and HAPPE 2001b). For reasons of consistency between the micro and the macro level conventional models need rather restrictive axiomatic assumptions about individual behavior. ABS are more flexible because behavioral assumptions are not given by the approach as such but can be defined according to the specific problem. This, e. g., allows for the implementation of bounded rationality or heterogeneous agents. *Flexibility* also applies to the framework conditions within which agents act. Neither convex production functions nor the existence of perfect markets are necessary conditions for the computability of a model. Non-convexity can be taken into account because the behavioral models of individual agents are less complex than they would be on an aggregated level. Hence, the problem of NP-completeness is less severe. Instead of perfect markets bi- or multilateral interactions between agents can be modeled. As much as ABS are more flexible with respect to assumptions, these need to be well founded and documented. Moreover they have to be justified and a reasonable connection between the underlying assumptions and the model results has to be established and communicated to addressees. Because of the high dimensionality of ABS, it is possible to generate *complex structures* like chaos, path dependence, multi-

² Other authors (e. g. FERBER 1999) have defined agents in a different way with slightly different properties.

phase dynamics, which are endogenous to the model, (cf. BALMANN 1995), i. e. the state of the system changes from within the system. Hence, the speed of change does not have to be defined exogenously, but it is determined by the model itself. One could say that the model is evolving (cf. BERGER and BRANDES 1998) and it is even possible that the system remains in a state far from equilibrium for a comparatively long time. Furthermore, these systems can show emergent structures which are states of order arising from the interaction of many entities of a system (self-organization). These structures are only visible in systems consisting of a large number of entities, such as the effects of the 'invisible hand' on markets. Another aspect which could become relevant with respect to ABS in agricultural economics is the relatively easy and straightforward integration of *spatial relationships*. This has been an important aspect in agricultural research ever since.

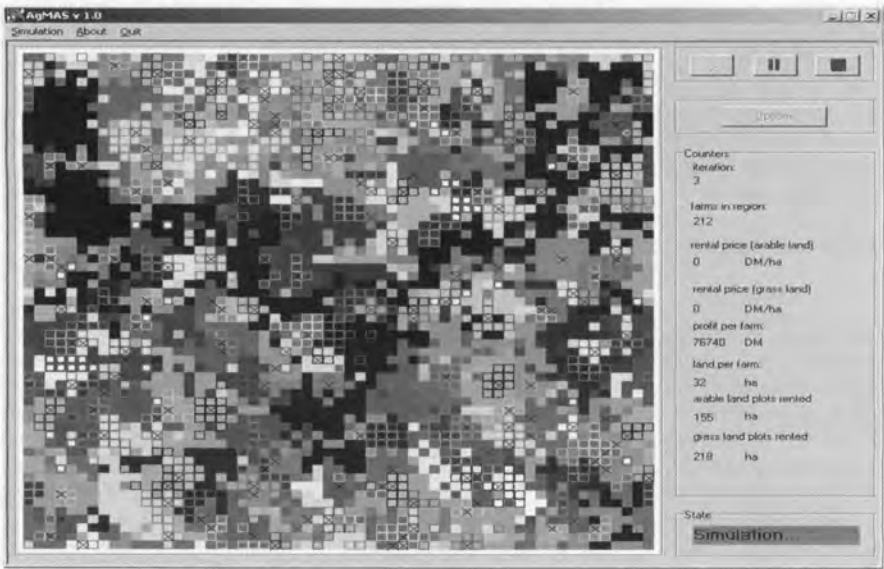
3 The model

The region of 'Hohenlohe' which is modelled is located in the northeast of Baden-Württemberg. It comprises about 75000 ha of agricultural area which is divided up into 30000 plots just like on a chessboard. Each plot has a size of 2.5 ha. About 75% of the plots are arable land, and 25% of the plots are grassland. The model is initialized with 2600 farms that are located in the region. These farms can be understood as agents. Each farm agent acts autonomously and follows the individual goal of household income maximization. For this, farms can engage in off-farm activities (off-farm labour, financial investments) and 13 different production activities (e. g. dairy, cattle feeding, piglet production, fattening pigs, turkeys, arable farming, meadows, forage production). Farms have the option to invest in 28 different objects (buildings, machinery of different sizes), they can buy and sell milk quota as well as animal manure. The investment alternatives allow for some economies of size, i. e. with increasing size, labor can be used more effectively and average acquisition costs per unit decrease. For instance, in crop production, economies of scale exist up to a size of 250 ha. Moreover, farms can increase and decrease their acreage by renting and letting land. Figure 1 shows the graphical user interface of the simulation. For a better representation, it shows only 10% of the original size of the model. The plots marked with an X represent farmsteads. Plots of the same colour belong to the same farm, plots with a marked border are owned land, other plots are rented land. Black plots denote idle land which cannot be utilised, i. e. it can neither be rented nor owned.

Although all farms in this model act autonomously, develop individually and have different management abilities, in each period they all follow the same decision pattern. On the basis of adaptive expectations farms maximize household income on the basis of a mixed-integer linear programming. Farms quit either if they are illiquid or if the expected household income does not cover the opportunity costs of the own production factors. Sunk costs are taken into account for asset capital as well as for human capital. For the latter it is assumed that every 25 periods (years) there is a generation change, where farms can drop out at special conditions.

Despite the optimization procedure, the cognitive abilities of farmers are limited. For example, there is no direct communication between farms. Moreover, there is no co-operation between farms to share machinery or merge farms. Strategic behavior, meaning that farmers anticipate their neighbors' decisions and include this into their own decision making, is not considered. This could be regarded a restrictive assumption. The region initially displays a comparatively small-scaled farm structure hence, it can be expected that strategic behavior is hardly present (BALMANN and HAPPE 2001a). Therefore in theory, competitive behavior seems plausible. In addition to the interactions of farms on the land market, the farms' development also depends on the changing economic conditions. These can be accounted for by defining the appropriate policy and price scenarios exogenously.

Figure 1: Graphical user interface of the simulation software*



* an earlier version of the model is presented in BALMANN (1997)

4 Calibration and data

The following simulations try to capture the effects of a limited livestock density on farms in Hohenlohe. For this, the model is first calibrated in order to represent the central characteristics of agricultural production in Hohenlohe. Calibration occurs on the farm level and the aggregate level. On the farm level, 12 different basic farm types are defined on the basis of data from 12 real farms in Hohenlohe (cf. table 2), each of which contributes data to the German Farm Accountancy Data Network (FADN). The main selection criterion was that the farms should be typical, i. e. they should be able to cover Hohenlohe's range of farm types with respect to size, main production area, full-time or part-time farming.

Table 2: Characteristics and frequencies of the specified basic farms

Variable	A	B	C	D	E	F	G	H	I	J	K	L
Organization												
specialization	pigs	pigs	dairy	dairy	crop	crop	mixed	pigs	dairy	mixed	crop	pigs
full-time	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	no
Land												
total (ha)	22.5	72.5	67.5	30	37.5	60	50	112.5	12.5	17.5	10	20
arable (ha)	22.5	72.5	40	12.5	37.5	60	22.5	102.5	5	12.5	10	20
pasture (ha)	0	0	27.5	17.5	-	-	27.5	10	7.5	5	0	0
Livestock												
cattle	-	-	90	52	-	-	63	25	28	5	-	-
cows	-	-	39	26	-	-	28	-	12	-	-	-
sows	40	128	-	-	40	-	64	170	-	-	-	128
fattening pigss	300	600	-	-	-	-	-	0	-	100	-	-
turkeys	-	-	-	-	-	20000	-	-	-	-	-	-
Frequency	480	25	120	244	106	22	231	95	389	154	442	298

Accordingly, 8 full-time and 4 part-time farms were chosen. Among them are dairy farms, pig farms, poultry farms, crop farms and mixed farms of different farm sizes (cf. table 3). The farms operate with selected production techniques that are considered to be typical for the

region. The required coefficients regarding investment alternatives, LP/MIP (linear programming/mixed integer programming) matrices, and the calculations of gross margins and profits are derived from standard farm management data samples published for German agriculture (KTBL 1997, LfL 2001, REGIERUNGSBEZIRK MITTELFRAANKEN 2001).

As the last row of table 2 shows, each of the specified typical farms is assigned a certain frequency. These frequencies are determined according to a method developed in BALMANN, LOTZE and NOLEPPA (1998). This is done in order to receive a farm structure that reflects the main characteristics of the region on the aggregate level. Aggregate characteristics are the number of farms (total and with respect to specialization and size), the total hectares of arable land and of grassland, the land used by farms with a certain organization and specialization, and the number of animals (dairy cows, sows, fattening pigs, turkeys). Since there is a certain trade-off in fitting the different characteristics, the frequencies were chosen by minimizing the weighted quadratic deviations between the model and the region (BALMANN, LOTZE and NOLEPPA 1998). The calibrated model fits the selected characteristics of the real region quite well (for land the average deviation is 4.5% and for livestock it is 5.8%). Strong differences only exist with respect to the number of farms (15% average). This is mainly due to the fact that there is a sample error in the German FADN. Particularly small farms often do not meet the respective criteria for participation. For instance, the smallest farm in the Hohenlohe sample which fulfilled the selection criteria had a size of 10 ha. Thus, it was particularly difficult to represent the many part-time farms which are smaller.

At the start of a simulation, each of the 2600 farms is further individualized with respect to its location on the spatial grid, and the age of the farms' machinery and buildings.³ To reflect different management abilities each farm receives an individual management coefficient which affects the farm's variable costs and thus its profitability and competitiveness. The model also assumes a simple nitrogen balance in which each ha of land has a maximum carrying capacity for organic nitrogen which corresponds to the nitrogen application limit defined in the "Düngeverordnung" (170 kg N/ha on arable land, and 220 kg N/ha on grassland).

5 Policy scenarios

This study aims to analyze the possible impacts of an agricultural policy switching towards a policy which limits livestock density. We have taken the Agenda 2000 as the reference scenario for the policy switching. Starting in 2000, the program is being implemented successively and - apart from non-agricultural issues, such as to give the European Union a new financial framework for the period 2000-2006 - it also determines a general framework for the CAP. Since at the beginning of 2001 not all measures were fully introduced, we only consider the implementation of the Agenda 2000 at the beginning of 2001.

Reference scenario: Agenda 2000 ("Agenda 2000")

Central changes as compared to a pre-Agenda situation are a reduction of intervention prices for products like cereals, beef, and milk. In return farmers receive higher direct payments. With respect to crop farming the payments depend on the land used in cereal, oil seeds, and legume production. In dairy farming the payments from 2005/06 on will depend on the milk quota and in beef production on the number of animals. Intervention prices for cereals are cut by altogether 15%. At the same time, direct payments are increased to 324 €/ha for cereals and oilseeds and 383 €/ha for protein seeds (reference yield: 51.4 dt/ha). As part of Agenda 2000 the compulsory set-aside is reduced to 10%, but voluntary set-aside is possible up to a level of 33%, and it is compensated for with 324 €/ha. Arrangements for silage maize are maintained, but increased. For beef intervention prices are cut by 20%. The bull premium is increased to 283 €/head. The annual premium for suckler cows is increased to 215 €/cow. All

³ No statistical data is available on this, the values have to be chosen randomly.

animals beyond an overall cattle livestock density of 2 LU/ha of forage area are not eligible for premiums. For dairy products intervention prices are cut by 15% from 2005/06 on. Milk quotas are maintained at current levels. A new direct payment of 215 € per dairy "premium unit" (cow with 5800 kg annual milk yield) per year is introduced, including the beef premium.

Alternative scenario I: Limited livestock density ("LU-Agenda")

The first alternative scenario is directly based on the reference scenario of the Agenda 2000. The only modification is the assumption that a farm is only eligible for receiving the full amount of direct payments if the farm's livestock density is below two livestock units (LU) per ha of farmland. If not, we assume that the payments are cut by 162 € for each LU exceeding the farm's limit of 2 LU/ha times the land which is farmed.

Alternative scenario II: Unitary premium, limited livestock density ("LU-Premium")

The second alternative scenario also considers the limited livestock density. Moreover, instead of the rather differentiated payments for different crops, it is considered that the farms receive a unitary payment of 250 €/ha of land, regardless of how the land is farmed. The payments for animals are those of the reference scenario.

6 Results

We will now focus on the two alternative policy scenarios defined above, both of which require farms to meet certain livestock densities in order to be eligible for direct payments. Results of these alternative scenarios will not only be analyzed on a sector level (which considers only averages), but a more detailed analysis on the farm level is carried out to illustrate the policy response of different farm types. Figure 2 shows the evolution of the average farm size.

The alternative policy scenarios show to have a strong effect on the structural adjustment process. For instance, the scenario Agenda 2000 with limited livestock density ("LU-Agenda 2000") fosters structural change with respect to average farm size. Farms initially exceeding the limit of 2 LU/ha with their existing production capacities aim at increasing their acreage in order to further fully utilize their production capacities. The effect is probably already weakened by the fact that farms have the option to export manure. But, the higher the density of intensive livestock farms is, the more difficult it is to export manure for this to be a profitable option. This is different for the scenario with a fixed premium for land use ("LU-Premium") which shows to inhibit the increase in farm sizes. This can be explained by the fact that many small dairy farms benefit from fixed premiums now granted for grassland. This was different under Agenda 2000 conditions. Thus the competitiveness of these dairy farms on the land market increases as compared to less grassland-dependent farm types. Consequently, more farms survive and the average acreage remains smaller. The scenario "LU-Premium" allows many

Figure 2: Evolution of average farm sizes

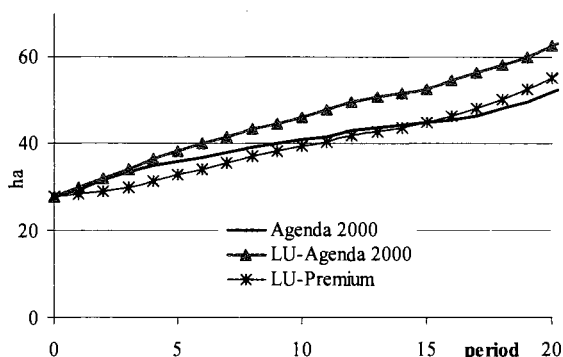


Figure 3: Livestock densities per farm and period

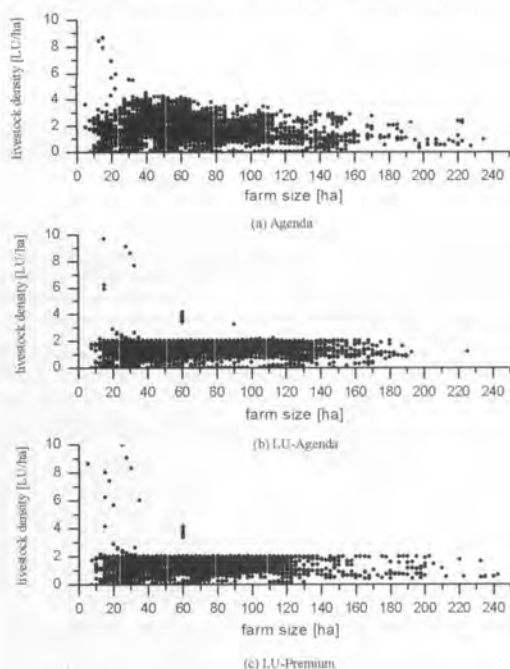
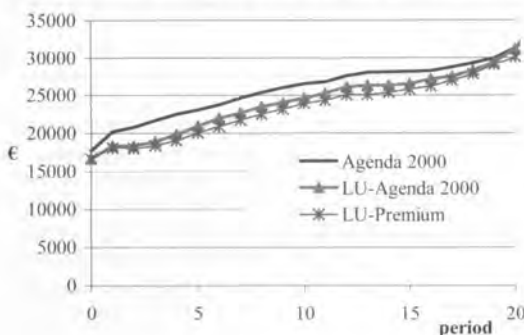


Figure 4: Evolution of average profits per farm



profits develop below the reference scenario "Agenda 2000". The average profit reduction of "LU-Agenda 2000" amounts to 1200 € per year and farm, i. e. a reduction of 4.4%. The average profit in the "LU-Premium" scenario is on average about 2200 € lower per year which corresponds to a reduction of 8%. On first glance this may not appear to be a strong effect. Nevertheless, three aspects are worth mentioning: Firstly, it should be considered that in the case of "LU-Agenda 2000" much more farms are driven out of the sector. Secondly, the average profit is already rather low in the reference scenario, i. e. the economic land rent is lower

small farms, the majority of which are dairy farms, to survive at least during the first 15 periods of the simulation.

Nevertheless, the limit on livestock density is very effective in both alternative scenarios. According to figure 3 the majority of farms chooses to actually limit their livestock density to a level below 2 LU/ha in all periods. There are only a few exceptions, where it is more profitable for the farm to accept the levy of 162 €/LU. Thus, the initial thesis that the limit may cause inverse responses by some farms is not confirmed, i. e. farms do not lay off all land and specialize in livestock production. The average regional livestock density declines from about 1.8 LU/ha to 1.3 LU/ha for both scenarios. Livestock density is based on the actual land farmed in the region and manure exports out of the region are not considered. Hence a limit is likely to reduce other environmental problems related to a high local concentration of livestock production.

Having shown that the alternative policy scenarios are indeed effective in leading to a lower livestock density, it has to be asked at what costs this happens. A starting point for analysis is the impact on farm incomes. Figure 4 shows that for both scenarios farm

than the rental prices and thus there is a kind of functional income disparity (cf. BALMANN 1999). And thirdly, one should consider that the farms are affected very heterogeneously by policy switching. While some farms may even benefit, the profits of other farms may become even negative. This point is clearly supported by table 4.

For both scenarios the income effects depend on several factors. One is the initial reduction of subsidies, as figure 5 shows. But, according to the figure transfer payments in the alternative scenarios show an increasing trend and are only temporarily below the reference scenario which shows a downwards trend. There are different reasons for this development:

Table 4: Average results after 20 periods for the 12 initial farm types¹⁾

Initial farm types	Dairy farms				Crop farms			Pig and Poultry farms			Mixed farms			
	I	D	C		K	F	E	B	A	L		G	H	J
Reference	"Agenda 2000"													
surviving farms ²⁾	[%]	31%	44%	65%	57%	69%	91%	85%	95%	99%	85%	100%	78%	
size	[ha]	28.80	33.05	59.99	23.81	87.15	45.21	71.71	30.95	24.44	58.94	110.28	28.67	
on-farm income	[€]	32010	34287	38494	30737	24151	59016	33054	23843	45053	54437	85891	31923	
household income ³⁾	[€]	19895	27687	31699	13872	14632	38987	25293	14049	27141	43667	57134	13489	
livestock density	[LU/ha]	2.56	2.30	1.29	1.20	1.86	1.60	1.55	1.66	2.09	1.95	0.90	1.61	
Scenario 1	"LU Agenda 2000"													
surviving farms ²⁾	[%]	23%	47%	62%	47%	54%	86%	71%	95%	78%	86%	100%	70%	
size	[ha]	26.49	38.60	61.81	21.78	71.32	51.04	73.08	35.45	32.03	63.50	105.80	31.01	
on-farm income	[€]	31723	34428	37401	30536	15844	58968	28217	22978	42823	53354	81991	30928	
household income ³⁾	[€]	14082	25945	31188	9206	3975	35051	21067	13417	26889	40888	51630	10986	
rel. change ⁴⁾	[%]	-29%	-6%	-2%	-34%	-73%	-10%	-17%	-4%	-1%	-6%	-10%	-19%	
livestock density	[LU/ha]	1.91	1.75	1.30	0.48	3.36	1.00	1.25	1.35	1.58	1.58	0.82	1.22	
Scenario 2	"LU Premium"													
surviving farms ²⁾	[%]	50%	74%	91%	50%	49%	85%	67%	94%	77%	94%	99%	89%	
size	[ha]	20.88	39.17	64.55	13.91	51.48	46.02	64.07	28.97	28.86	66.33	94.86	20.90	
on-farm income	[€]	35135	38124	42221	30293	11358	57281	27273	22897	41524	58927	77991	32456	
household income ³⁾	[€]	13683	27681	35463	6464	-320	31453	19649	12019	25453	46152	49522	9441	
rel. change ⁴⁾	[%]	-31%	0%	12%	-53%	-102%	-19%	-22%	-14%	-6%	6%	-13%	-30%	
livestock density	[LU/ha]	1.71	1.68	1.36	0.33	4.64	0.91	2.70	1.36	1.69	1.68	1.09	1.11	

1) farm types changes are not considered here

2) as compared to initial number of farms of this type

3) profits plus off-farm labour income and interest earnings

4) compared to reference

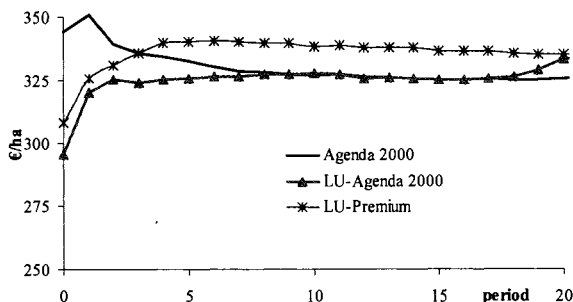
1) farm types changes are not considered here

2) as compared to initial number of farms of this type

3) profits plus off-farm labour income and interest earnings

4) compared to reference

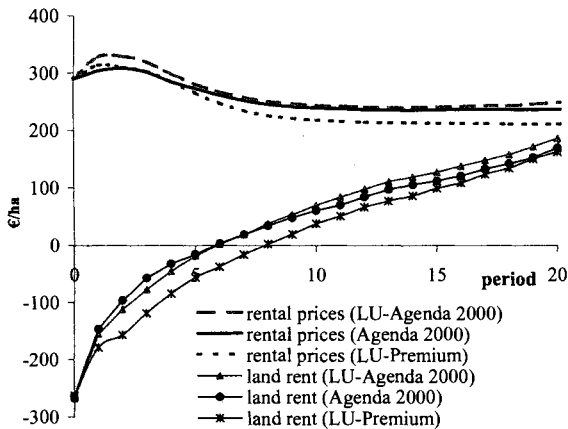
Figure 5: Evolution of average transfer payments per ha



As for the reference scenario the transfer payments are declining because of structural adjustments mainly by dairy farms that close down (cf. table 4), sell their milk quotas, and leave the sector. Even though the assumed quota price with an annual opportunity cost of 0.05 € per kg is rather low, quota leaves the region and therefore direct payments for dairy cows decline. In the

case of the alternative scenarios transfer payments initially are lower, but only after a few periods, farms have adjusted their farm organization such as to meet the payment criteria. After period 8 transfer payments in the "LU-Agenda 2000" scenario equal the payments of the reference and even increase towards the end of the simulation. In the scenario "LU-Premium"

Figure 6: Evolution of rental prices for land and land rents



the average level of transfer payments even exceeds the reference level after 3 periods only. Apart from the transfer payments, profits generally depend on the relation of productivity and land rents.

According to figure 6 all policies affect both land rents and rental prices. Under Agenda 2000 conditions the limitation of the livestock density ("LU-Agenda 2000") leads to lower land rents during the first 8 periods as compared to the reference as well as to higher

rental prices. Because animal production capacities are fixed in the short run, the affected farms attempt to increase their acreage with the effect that rental prices increase irrespective of the fact that a number of farms receive lower transfer payments (mainly intensive livestock farms) and thus have lower land rents. Since already in the starting situation about 50% of the agricultural land in the region is rented, profits are declining. The fact that after about 8 periods the economic land rents for the "LU-Agenda 2000" scenario overtake that for the reference scenario without livestock restrictions is remarkable. This is because of the productivity impact of a faster structural change induced by the limitation of livestock density. Since more farms with a low productivity leave the sector, the remaining farms perform better and have better opportunities to exploit economies of scale.

7 Summary and conclusions

Summarizing the results, we can conclude that the impacts of a main policy switching occurs on very different levels. If farms are heterogeneous, they are affected individually and respond very differently. This can even mean that more restrictive policies may have positive impacts on some farms while other farms may suffer badly. The alternative policy scenarios presented above fall into this category. A policy that requires farms to meet certain animal density criteria in order to receive transfer payments can be quite effective because it creates the 'right' incentives in the sense of a stimulation of structural change - provided that the requested animal densities follow the 'right' goal. However, this is not free of charge. Particularly in livestock production adjustment costs can be very high. This is due to sunk costs, but also due to the fact that adjustments in livestock production often require farmers to learn about and implement new and different production technologies. The transition process in East Germany gives a good example. Even 10 years after the fall of the Berlin wall, the successors of former collective farms are still increasing their physical productivity in livestock production at rates which cannot reflect normal technological progress but rather a catch-up process towards what is technologically possible (BALMANN, CZASCH and ODENING 2001).

Thus, from a policy perspective one has to conclude that policy switchings that affect animal production should either be introduced slowly or should be announced in due time such that farmers can respond without incurring enormous adjustment costs. But, since policies often reflect spontaneous reactions to public concerns, this is often not the case. From a scientific and from a modeling perspective, one has to conclude that the simulations presented above give a starting point for further investigations. Even though the model is already very differ-

entiated with respect to individualization as well as dynamic and spatial issues, many promising extensions are not yet implemented: One may additionally consider technological progress, more differentiated landscapes, heterogeneous preferences of farmers, etc. Moreover, the model may be applied to different regions and alternative market scenarios.

The presented simulations are based on a modeling approach that has been developed originally to analyze the dynamics of structural change. On the basis of this intention it allows to study long term policy effects. The obtained results shed some light on policy effects that often are ignored by conventional policy analysis, such as dynamical and distributional impacts on efficiency and incomes. From this point of view, agent-based policy models seem to be very promising. But the question is how valid and how convincing the model and its results are from politicians' and economists' perspectives. This is discussed in more detail in BALMANN and HAPPE (2001b). The arising problems should be understood as a matter of the research questions to which ABS are applied rather than a problem which is due to the method itself. It is reality which is so complex, and ABS models aim to reflect this. Moreover, ABS are a rather young field of research which owes its power mainly to increasing computing power. The application of ABS allows to explore their opportunities and to learn about them.

References

- BALMANN, A. (1997): Farm-Based Modelling of Regional Structural Change. *European Review of Agricultural Economics* 25 (1), 85-108.
- BALMANN, A. (1999): Path Dependence and the Structural Development of Family Farm Dominated Regions. IX European Congress of Agricultural Economists, Organized Session Papers, Warsaw, Poland, August 24-28, pp. 263-284.
- BALMANN, A., CZASCH, B. and ODENING, M. (2001): Employment and Efficiency of Farms in Transition: An Empirical Analysis for Brandenburg. Berlin 2000, XXIVth International Conference of Agricultural Economists. Proceedings. Forthcoming.
- BALMANN, A. and HAPPE, K. (2001a): Applying Parallel Genetic Algorithms to Economic Problems: The Case of Agricultural Land Markets. IIFET Conference "Microbehavior and Macroresults". Proceedings.
- BALMANN, A. and HAPPE, K. (2001b): Agentenbasierte Politik- und Sektoranalyse – Perspektiven und Herausforderungen. *Agrarwirtschaft* 50 (8), 504-515.
- BALMANN, A., LOTZE, H. and NOLEPPA, S. (1998): Agrarsektormodellierung auf der Basis 'typischer Betriebe'. Teil 1: Eine Modellkonzeption für die neuen Bundesländer. *Agrarwirtschaft* 47 (5), 222-230.
- BERGER, T. and BRANDES, W. (2000): Evolutionäre Ansätze in der Agrarökonomik. *Agrarwirtschaft* 47, 275-282.
- BERGER, T. (2001): Agent-based Spatial Models Applied to Agriculture. A Simulation Tool for Technology Diffusion, Resource Use Changes, and Policy Analysis. *Agricultural Economics* 1536, S. 1-16.
- FERBER, J. (1999): Multi-Agent Systems: An Introduction to Distributed Artificial Intelligence, Addison-Wesley.
- FRANKLIN S. and GRAESSER A. (1996): Is it an Agent, or just a Program? A taxonomy for Autonomous Agents, in Proceedings of the Third International Workshop on Agent Theories, Architectures, and Languages, Berlin, Springer.
- KTBL (1997): KTLB-Taschenbuch Landwirtschaft 1997/1998, München.
- LFL, LANDESANSTALT FÜR LANDWIRTSCHAFT DES LANDES BRANDENBURG (2001): Datensammlung für die Betriebsplanung und die betriebswirtschaftliche Bewertung landwirtschaftlicher Produktionsverfahren im Land Brandenburg. Vol. 2, Tetow/Ruhlsdorf.
- MLR, MINISTERIUM LÄNDLICHER RAUM DES LANDES BADEN-WÜRTTEMBERG (2000) and various years: Landwirtschaftliche Betriebsverhältnisse und Buchführungsergebnisse. Wirtschaftsjahr 1998/99, Vol. 48.

- REGIERUNGSBEZIRK MITTELFRANKEN (2000): Deckungsbeiträge, Variable Kosten, AKh-Bedarf der wichtigsten landwirtschaftlichen Produktionsverfahren, incl. Sonderkulturen. http://www.regierung.mittelfranken.bayern.de/wir_f_s/wissensw/landwirt/db2000.pdf
- RUSSEL, S. and NORVIG, P. (1995): Artificial Intelligence: A Modern Approach. Englewood Cliffs, NJ.
- ZMP (2001): Neuausrichtung der Gemeinschaftsaufgabe, Verbesserung der Agrarstruktur und des Küstenschutzes' (GAK): Zielsetzung und Inhalte der Änderungen. Retrieved from Internet on 28.8.01. www.zmp.de/oekomarkt/vbereich/pages/planak.pdf