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**Integrating small farms in agent based models**

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**Abstract:** In German agriculture structural change is mainly a result of the outmigration of smaller farms from the sector. The decisions of these farmers to leave or stay in the sector, are not based solely on financial data and market expectations. Other aspects are important such as the preservation of the cultural landscape, the continuation of the family tradition, or self-realisation. Only if these goals are adequately integrated into land use models, one can hope that the type and magnitude of reactions predicted by the model will be similar to that observed in reality. The main goal of this paper is to present a model approach that allows for the integration of non-monetary aspects into an agri-economic land use model. The approach is tested for a sample of 20 farms located in a municipality in the Bavarian Alps. The results show that the choice of the farmers’ attitude has a larger impact on results than the peculiarities of the policy scenario. This holds especially for the emerging farm structure but also for the general land use intensity.

**Keywords:** Farmer attitude, linear programming, agent based modelling, land market

**JEL codes:** Q12, Q15, R14

# **Integrating small farms in agent based models**

**Norbert Röder and Jochen Kantelhardt**

## **1 INTRODUCTION**

In Germany structural change is mainly a result of outmigration of small farms with a size of less than 20 ha from the sector (Salhofer et al., 2008). However, especially these farms are badly covered in statistical data like FADN. The agents in many agro-economic models (e. g. Agropolis, FARMIS) are derived from these data. As a consequence the main source providing land for the competitive and growing farms can be covered loosely only.

Furthermore, the decision taken by a farmer does not depend only on the quality of the site and his endowment with various production factors, such as machines, buildings, or workforce, but also on the agricultural support programmes. However, the decisions to remain in or leave the agricultural sector, or to conduct agriculture, are not based solely on financial data and market expectations. Other aspects are important such as the preservation of the cultural landscape “Heimat”, the continuation of the family tradition, or self-realisation. Only if these goals are adequately integrated into land use models, one can expect that the type and magnitude of reactions predicted by the model will be similar to that observed in reality. It can be shown that these “soft” aspects are of particular importance in smaller or part-time operated farms (Weineisen, 2008).

The main goal of this paper is to present and test a model approach that allows for the integration of non-monetary aspects into an agri-economic land use model. The model is capable of assessing the impact of a changing business environment on land use and structural change. Within the model prices, support programmes and area specific regimentations could be altered. The model is based on the agent-based, comparative-static approach of Kantelhardt (2003) and Schemm (2004). This farm-based approach has a special focus on the interactions between the farms on a local level and takes into account investment decisions. The agent’s decisions are based on a farm specific linear optimisation (LP). The model allows integrating preferences for different types of farming in the initialisation step of the farm specific activity LP matrix. With the help of four calibration variables (labour capacity, imputed wage, consideration of imputed costs, minimum income) it is possible to depict a wide variety of goals and behavioural features related to farming.

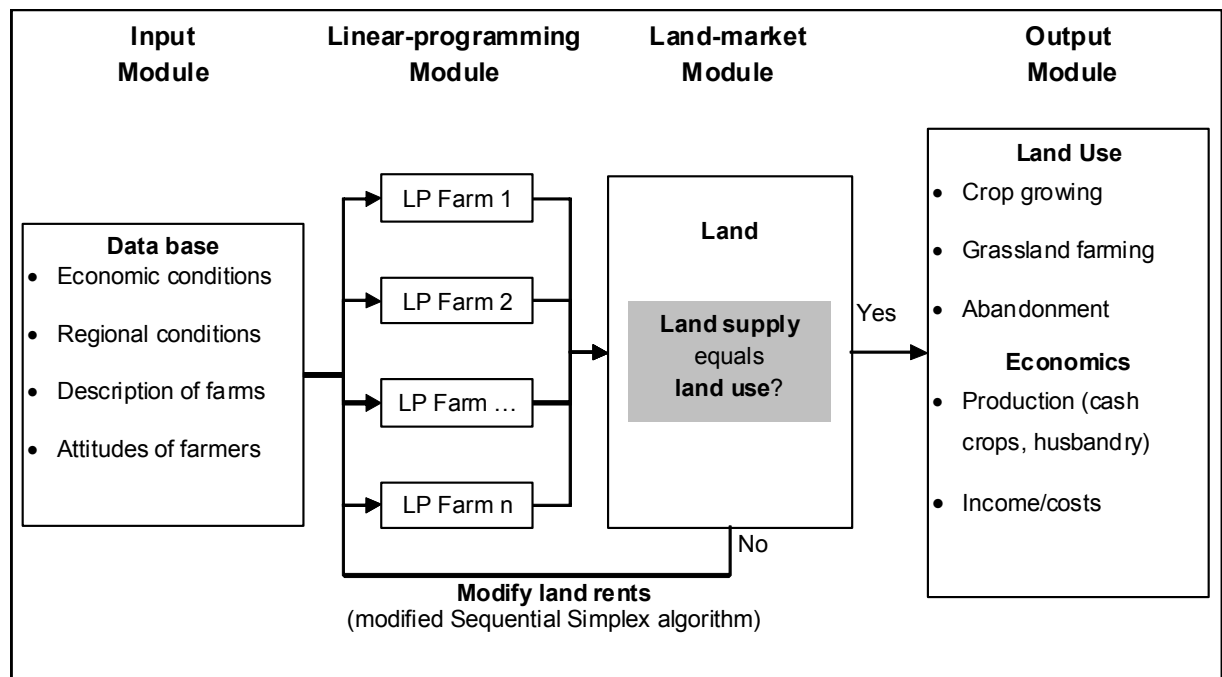
## **2 THE MODEL**

### **1.1 Structure of the model**

The model was developed against the background of the high heterogeneity present in Bavaria’s agriculture. This heterogeneity concerns the natural conditions as well as the agrarian structure. An undulated topography and varying soil conditions induce shifts from absolute grassland sites to pure cereal stands within a distance of a few

kilometres. Regarding the agrarian structure, full-time farms often alternate with part-time farms. In the same region there are farms specialised on global markets and others concentrating on local niche markets. In order to include all relevant competitors in a certain region, the model is capable of considering about thirty farms. Based on this number, the spatial scale of the model ranges from 500 to 2,500 ha of agricultural land. This area corresponds to the size of a rural village and may include a variety of different site qualities. Consequently the model allows for the distinction of different classes of productivity, accessibility, plot size and slope, in addition to the differentiation into grassland and arable land.

A time horizon of five to ten years is chosen that allows farmers to take fundamental investment decisions and model calculations are limited to a comparative-static analysis. One primary target of the model is to study the effects of farmers' attitudes and social settings on individual farms and land use. Therefore the model considers decisive attitudes of farmers such as farmers' personal planning horizon, farm income, leisure demand and wages. On the other hand personal risk assessment is not considered. In contrast to Happe and Balmann (2002) it is assumed that all farmers have equal capabilities and all agents have perfect information. Regarding the technical structure, the model basically combines linear programming (LP) and market modelling. All in all the model consists of an input module, a linear-programming module allowing the calculation of optimal farm organisation, a land-market module deriving land rents and distribution of land among the farmers, and an output module (fig. 1).



**Figure 1:** Structure of the land-use model

The *input module* contains all exogenous data that influences agriculture in the study region. One of the most important attributes on farm level is the farmer who is characterised by his personal attitude and the amount of labour he is prepared to devote to farming. Each farm is in possession of various types of agricultural land and production rights such as milk quota. Further important features of farms are their endowment with technical equipment consisting of buildings and machinery. Data on a

regional level is valid for all farms. These data sets include production methods, investment alternatives and the amount of available agricultural land in the study region. Production methods are described by various variables such as potential yields, costs, demands on labour and machinery. But some of this data also depends on other data sets. For instance, the potential yield in cropping is site dependent and the labour demand is subject to the individual farm mechanisation. Farmers, of course, can only conduct certain production methods if they own the appropriate technical equipment. For instance, in order to produce milk a farmer must be in possession of a grassland mechanisation and a dairy-cattle stable. Stables and mechanisations are defined in four size classes that differ with respect to costs, type and extent of provided capacities. A combination of stables and mechanisations is called a farm type. Changing the farm type induces costs that depend on the new farm type as well as on the situation before the investment.

The determination of the production methods and the derivation of farm organisation take place in the *linear-programming module*. In this module all farms are simulated individually; they act independently of each other and maximise their individual utility by adjusting the organisation of their farm. The farms react to incentives such as changes of prices and subsidy levels. These reactions lead to a change of the land use on a regional level (cf. Rounsevell et al., 2003). Since farms are modelled individually, they can be conceived as individual agents.

The results of the linear programming module are merged in the *land market module*. Land market is modelled as an equilibrium market in which all land qualities (e.g. grassland, arable land) have to be compiled as an own land market resulting in individual land rents. In a first step the market module takes up the land demand of the different farms calculated in the linear-programming module. In this first step the initial land rents for all land qualities are assumed arbitrarily. In the next step the demand is added up on a regional level. If the aggregated demand for any land quality is unequal to the supply in the region, the land-market module recalculates a new set of land rents. These prices are given back to the linear-programming module and the demand of land is recalculated. This process is repeated until demand equals supply in all land quality classes.

In this context it is necessary to mention that land rents are contingent on one another. For instance a high rent on grassland increases the demand on arable land which can be used for forage production. This results in higher rents on arable land. The consequence of this interdependency is that the market calculation has to be carried out simultaneously for all land qualities. Since the number of thinkable land-rent combinations increases exponentially with the number of markets, the determination of the equilibrium land rents by trial and error will result in an unreasonably high calculation effort. Therefore the Sequential Simplex Optimisation (SSO) is applied. The SSO is an evolutionary operation method that is widely applied in process optimisation (Walters et. al 1999; p.6). It aims to find an optimal combination of different variables. In our case the optimum is achieved when, for all considered land qualities, the demand equals the supply.

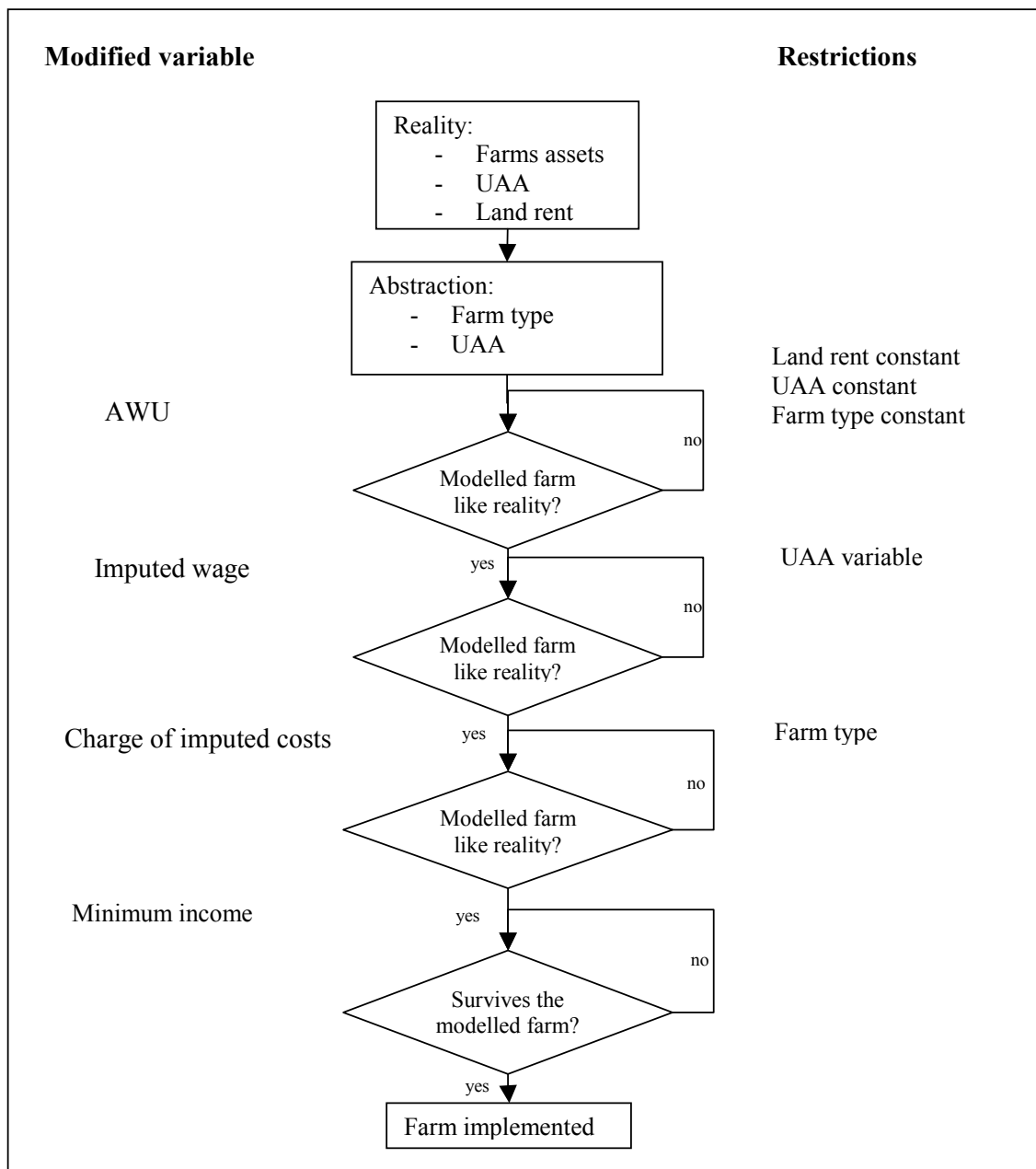
Finally, the function of the *output module* is the conditioning and the analysis of the model results. The results are transmitted to a database that edits and analyses the data on a farm and regional level. The aim is to provide an overview of agriculture and land use in the studied region. The results on the farm level as well as the regional level

include key economic, ecological and social figures. On the farm level, the output data focuses on land use and animal husbandry. In addition, the analysis of a single farm's investments allows the quantification of socio-economic criteria on this level, such as the transition from full-time to part-time farming or vice versa. On the regional level, social and ecological questions are of main concern. In this context it is important to mention that the region is conceived as the aggregate of the modelled farms. The objective at the regional level is the analyses of the effects of certain policy measures. In addition to land use developments, changes in socio-economic criteria can also be shown. For instance, it is possible to identify possible concentration processes or the danger of land abandonment.

## **1.2 Calibration of the model**

Land use models must be calibrated in order to achieve reasonable results. In general it is tried to reproduce the current situation and compare model results with reality. If the average land rent as well as the resulting land use correspond to reality, the model is assumed to work with sufficient accuracy. In this context personal attitudes of farmers are of particular importance. They influence model results significantly, but data quality about these factors is not satisfactory (comp. Kantelhardt et al. 2005a and 2005b). In this paper, farmer's attitudes are used to calibrate the land use model. It is assumed that all farms in the current situation are operating optimally and the farmer is realizing all his personal aims without any external restrictions being in force.

In order to implement the 'real' farms with the farmer's attitudes in the model, every farm is optimised independently several times without using the market module (fig. 2). In the first calibration step, farm type and utilized agricultural acreage (UAA) are fixed for all farms on the level observed in reality. This also applies to land rents which are derived from real data and kept constant. The labour input of the farm is derived with these restrictions; it is fixed in a way that the model farm has a realistic combination of production methods. In a second step, the imputed wage is calibrated in a similar way. In a third step, the level of imputed costs, more precisely the charged percentage of the standard imputed costs of the given farm type, is set in a way that insures that the farm is neither investing nor disinvesting. In the last calibration step, the minimum income required by the respective farmer is calculated. The level is chosen in a way that ensures that the farm would continue to operate under the settings derived in the prior steps. Finally, a safety supplement of twenty percent of the cash flow of the respective farm is added to the minimum income since we assume that farmers would accept this income reduction before giving up farming.



<sup>1)</sup> UAA: utilised agricultural acreage

<sup>2)</sup> AWU: 1 AWU (agricultural working unit): 2,380 working hours

**Figure 2:** Scheme for the implementation of farms in the model

### 1.3. Impact of the calibration on the agents' behaviour

Since we use an LP to derive the optimal farm organisation, the adaptation of the farm organisation occurs stepwise. The chosen organisation remains constant as long as certain thresholds for the respective variables (imputed wage, charge of imputed costs, minimum income) are not exceeded. Consequently, more than one combination of these variables will correctly initialise an agent. In the next chapter we show how this feature allows incorporating behavioural differences among farmers. The focus of this section will be on two questions, which will be briefly sketched here; a more detailed discussion can be found in Roeder (2007):

(1) How does the specification of one variable influence the range of feasible options for the other variables used in the calibration process?

(2) Which consequences have modifications of the variable's level on the agent's behaviour in the simulation runs?

First of all we will have a look on the interrelation between the four calibration variables. In principle, the minimum income is a residual variable. It is calculated by deducting the imputed wage and the charged imputed costs for buildings, machinery and other stocks from the farm's total gross margin. Consequently, if for the imputed wage and/or the other imputed costs high values are chosen, the minimum income and safety supplement will result comparatively low (tab. 1). In contrast to the other variables of the calibration process the demanded minimum income induce a fixed lower threshold level that must be earned in any case in order to allow the survival of the agent, whereas the costs induce by the other variables are variable.

**Tab. 1:** Consequences of different settings for the imputed wage and charge of imputed costs on the minimum required profit (under the condition of a given farm type and a constant total gross margin)

		Charge of imputed costs	
		High	low
Imputed wage	High	Minimum income low	Minimum income average
	low	Minimum income average	Minimum income high

For the analyses of the impact of the selection of real values on the agents' behaviour we first have to look on the impact of the relation between the imputed wage and the minimum profit (labour demand and imputed costs are kept constant for this analysis). Let us assume that an agent can be correctly initialised with two settings: In the first, the imputed wage is comparatively high and consequently the minimum income is set at a low level ( $w_h$ ) and in the second, the wage is comparative low and the income high ( $w_l$ ). In the model runs, the agent has in the first setting the opportunity to save costs by saving labour, however the expansion of labour is rather costly. Consequently, a large share of his total imputed costs is variable. In the other setting the behavioural incentives have switched. This means that if economic conditions become adverse an agent initialised by  $w_h$  is more flexible in downscaling his farm. In contrast an agent represented by  $w_l$  will either enlarge or cease farming due to his low imputed wage the demanded minimum income is comparatively high.

The next pair of variables is the imputed costs and the minimum profit (labour demand and imputed wage are kept constant). We select a high value for the charged imputed cost and consequently a low one for the minimum income. In this case the comparative cost advantage of existing farm type compared to another farm type is fairly low. Therefore, an agent initialised in this way, will very likely respond to a changing business environment by an adaptation of his farm type.

Finally, we analyse the relation between the level of imputed wage and the charge of imputed costs (in this case the minimum income is kept constant). In the model the level of the charge of imputed costs depends on the difference in the economic excellence between the best and the second best farm type. These two variables are only linked if these two farm types differ in their respective labour demand. If the labour demand of the most excellent farm type is lower than the one of the second best, an increase in the imputed wage will enlarge the difference. Consequently higher

values for the charge of imputed costs can be chosen without impacting the ranking of the farm types. In case the most excellent farm type has the higher labour demand the difference between the two farm types decreases with increase imputed wage. Consequently, only lower values for charged imputed costs leave the order of farm types unaffected.

Table 2 summarizes the impact of different parameterisations of the charge of imputed costs and imputed wage on the agent’s behaviour. Agents with low values for both (charge of imputed costs and imputed wages) will react to changing conditions by abandoning farming or continuing with their old farm type. Such an agent can hardly save money by reducing his labour force or by downscaling his enterprise. On the other hand the low charge of imputed costs induces a cost advantage of the existing farm types and limits the likelihood of additional investments. In any case he must earn a fairly high minimum income in order to stay in business. Agents with low values for the charge of imputed costs and high imputed wages will only in rare events change their farm type. In addition to the effect of the low value of the charge of imputed costs the labour input is limited by the high imputed wage. An agent with a low imputed wage and a high charge of imputed costs will react to small changes by enlarging his enterprise, since both (the costs induced by the additional labour and the cost advantage of the existing farm type) are small. Lastly, an agent which claims high imputed costs and a high imputed wage will react to fairly small changes in the business environment by downscaling his business since it can save both imputed labour and capital costs.

**Tab. 2:** Impact of different parameterisations for the charge of imputed costs and imputed wage on the agents’ behaviour (under the condition of a given profitability of the farm)

	Charge of imputed costs on existing investment good			
	high		low	
	Imputed wage		Imputed wage	
	high	low	high	low
<b>Willingness to enlarge the farm</b>	average	high	low	average
<b>Willingness to reduce farm size</b>	high	average	average	low
<b>Willingness to abandon farming</b>	low	average	average	high

### 3 CASE STUDY “GARMISCH”

The conditions for agriculture in the municipality of Garmisch-Partenkirchen are comparatively unfavourable. The municipality is located at 700 m.a.s.l. and receives an annual precipitation of approximately 1’300 mm at an average temperature of 6.7 °C (DWD, 2006). The agricultural area is exclusively used as grassland. While the areas in the valley floor are cut up to three times a year, the areas at the flanks and at higher altitude are used as rough pastures for heifers and sheep. The stock is consists of low yielding dairy cattle and their replacement, suckler cows and sheep (BayLStaD, 2006).

In Garmisch Partenkirchen operate more than 100 farms (BayLStaD, 2006). The overwhelming majority is run part time. The average farm size is just below 9 ha and over 75 % of the farms are smaller than 10 ha. An important feature of the agricultural structure in the area is the importance of cooperatively managed rough pastures (cf. Gueydon et al., 2007). At present there are three cooperatives in Garmisch which manage nearly 1000 ha; this is roughly the equivalent of the agricultural area managed by the farms individually (Hinterstoißer, 2005). Due to unfavourable site conditions



farms receive high levels of compensatory payments (180 EUR per ha; Deutscher Bundestag, 2004) and often participate in the Bavarian agri-environmental scheme (KuLaP; Roeder, 2007).

### 3.1 Data base and farms

In 2004 we surveyed 25 farms within the EU-research project LACOPE. These farms manage on average 8 ha of grassland and keep 11 LU and consequently represent fairly well the figure for the whole municipality. In the model we include only 20 of the farms surveyed since five farms keep less than one livestock unit and manage at the same time less than 2 ha. Regarding the privately managed acreage and the stock size, the farms covered in the model are a little larger than the municipality average (tab. 3). The survey furthermore shows that the majority of the household income is derived off-farm. Especially, for the smaller farms the economic importance of agriculture is often negligible.

**Tab. 3:** Key figures for the year 2004 of the farms depicted in the model (n = 20)

	Minimum	25 % Quantil	Average	75 % Quantil	Maximum
Stock per farm (LU)	2	4.1	10.7	16.8	33
Farm size (ha)	2.3	5.3	11.3	15.7	41.1
Stocking rate (LU/ha) <sup>1)</sup>	0.38	0.80	0.90	1.16	1.56

Roughly half of the stock of the depicted farms are suckler cows and fattening heifers, a third are low yielding dairy cattle while the rest consists of sheep and horses. An indication of the low intensity of dairy farming in the area are the low milk yields per capita (below 4.300 kg per head) and per ha (roughly 1.100 kg per ha). Most privately managed pastures are cut twice a year. For roughly 150 days during the summer period sheep, heifers and cows graze on cooperatively managed rough pastures.

In the model the “agents” (respectively farms) can select one of 18 farm types, they can choose among more than 500 livestock activities and 100 activities to manage their grassland (for detailed description see Roeder, 2007). The farm types can be distinguished according to the following features: size, type of stable (loose housing or tied stable) and whether or not the grassland management is more or less completely outsourced. The livestock activities are differentiated according to the type of animal production (suckler cow, heifer fattening and dairy cattle), the yield level, the labour demand, the fed ration, and the utilization of rough pastures. The different grassland management activities reflect the differences in yield, the type and quality of the forage produced (hay, silage, cut fresh grass, or pastured grass), the labour demand due to differences in the size of the plots and machinery and the eligibility for agri-environmental measures.

### 3.2 Szenarios

In order to assess the impact of the implementation of different farming styles and the different degrees of decoupling we calculate two policy scenarios with two different setting for the farmer’s attitude each. Each of the different setting for the farmer’s attitude is capable to replicate the initial farm structure under the conditions prior to the Fischler Reform (*REF*); in the first set up the parameters were chosen in a way which gives the farmers more flexibility (*active*) while in the other the farmers behave

quite conservatively (*passive*). In both policy scenarios a hectare of privately managed grassland can receive up to 500 EUR. This amount is roughly equivalent to the level of payments which the farms in the region received prior to the Fischler reform and it is approximately 200 EUR per ha below the level which would result from the combination of the current regional payment in Bavarian and the current support via the second pillar.

The two policy scenarios differ with regard to how these payments are allocated between the first and the second pillar. In the first policy scenario we implemented a situation which reflects the full implementation of the German regional model of the Fischler reform, i. e. from 2013 on each hectare will receive the same level of payments and all first pillar payments are fully decoupled. To claim these payments it is necessary to maintain the land in GAEC (good agricultural and ecological conditions), i. e. mulching the grassland once a year is sufficient (*PE*). In the second scenario, more funds are allocated to the second pillar (*AEM*). In order to receive funds of the second pillar the farms must follow certain prescribed management regimes. The critical aspect in the context of Garmisch is that farms must maintain a minimum stocking density of 0.5 LU per ha in order to receive the payment.

**Tab. 4:** Overview of the prices and premiums in the different scenarios

Scenario	Premium	Prices
<b>REF</b>	As at 2004 (vgl. BayStMLF, 2004; RegMfR, 2003; Deutscher Bundestag, 2004)	Milk: LfL (2006a) Avg. value of 1998-2003 Price of milk quota: 60 ct / kg (LfL, 2006b) Beef prices: LfL (2006a) Avg. value of 1998-2003
<b>PE</b>	200 EUR / ha (Compensatory payment & agri-environment); (linked to the compliance with designated minimum stocking levels) 300 EUR / ha payment entitlements (not linked to stocking) 360 EUR / ha rough grazing	Milk: BLW (Avg. 2005/06) Price of milk quota: 49 ct / kg (ZMP, 2006) Beef prices: BLW (Avg. value 2005/06)
<b>AEM</b>	400 EUR / ha (Compensatory payment & agri-environment); (linked to the compliance with designated minimum stocking levels) 100 EUR / ha payment entitlements (not linked to stocking) 360 EUR / ha rough grazing <sup>1)</sup>	

1) This roughly the payment level in 2006.

The assumptions and coefficients in the economic model reflect a time horizon of 5 to 10 years, since for this period political and technical developments can be assessed with some confidence and some adaptations with regard to fixed assets are likely to occur on the farm level. For further details on the implementation of the technological coefficients see Roeder (2007).

## 4 RESULTS

The results show that the choice of the farmers' attitude has a larger impact on farm structure and land use intensity than the policy scenario. However, the level of tenure is largely determined by the policy scenario. The detailed analyses we focus on five aspects: the tenure, the emerging farm structure, the intensity of land use, the type and level of production and the labour demand.

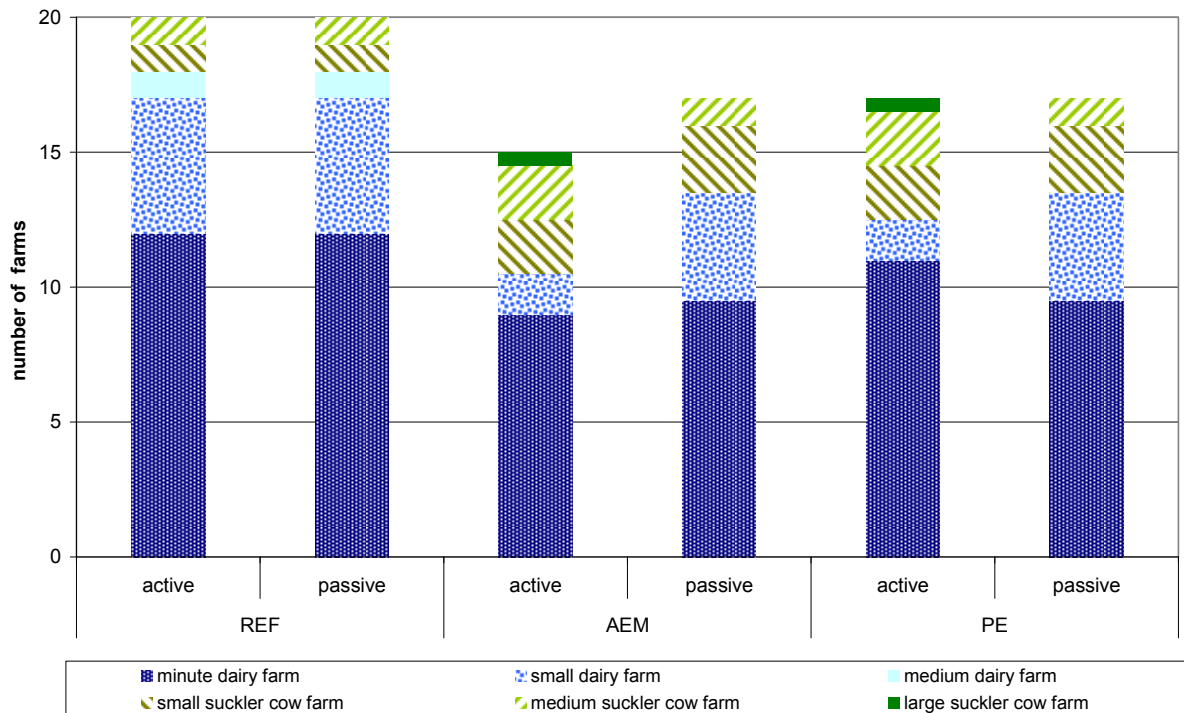
Looking on the tenure, one can conclude that the higher the degree of decoupled payments the higher is the tenure (tab. 5). The decoupling of the animal payments leads to significantly higher tenure. The high tenure in the two decoupled scenarios is due to the fact that for most farmers the market revenues do not cover the variable costs of production. Therefore especially the smaller farms reduce their stocking to a level which still enables them to receive all agri-environmental payments. While the decoupling has a large impact on tenure the higher degree of „unconditional“ first pillar payments in *PE* compared to *AUM* has hardly any additional impact. This is due to the fact that even with the reduced level of second pillar payments, the additional revenues justify for most agents the continuation of livestock production. If a passive set up is chosen the average tenure for all agricultural even declines since less land is changing ownership in *PE* compared to *AUM*.

**Tab. 5:** Tenure for newly rented land in dependence of the chosen scenario and set up for the farmer's attitude (in EUR / ha)

Scenario	Farmer's attitude	
	active	passive
<b>REF</b>	34 (32) <sup>1</sup>	30 (28)
<b>PE</b>	278 (159)	275 (137)
<b>AUM</b>	245 (149)	244 (139)

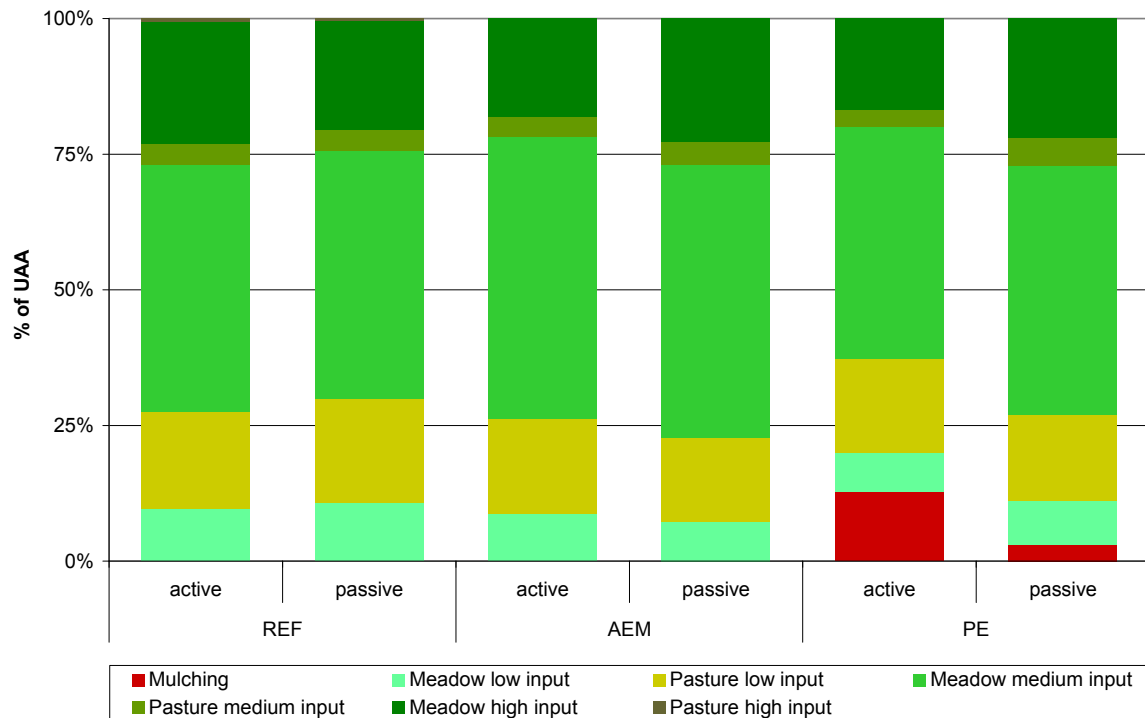
1) in brackets weighted mean of new, old rental contracts and imputed costs for owned farm land

If a passive set up for the farmer's attitude is chosen, the rate of structural change is a little bit lower than under an active setting (fig. 3). With an active setting structural change affects mainly the small and medium sized dairy farms (with 15 – 25 cows). From six small or medium sized farms in the initial situation only 1.5 continue. The remaining farms abandon agriculture or shift to suckler cow farming. With a passive setting only two of the small and medium sized farms dairy farms modify their farm type. Independently of the chosen scenario and set up for the farmer's attitude roughly one quarter of the minute dairy farms (5 cows) leave the sector. In all scenarios the number and size of the suckler cow farms increase. The shift towards suckler cow farming is more pronounced in an active setting than in passive one. Only with an active set up of the farmer's attitude farm sizes beyond the initial level can be observed.



**Fig. 3:** Farm structure use in dependence of the chosen scenario and set up for the farmer's attitude

In the reference scenario nearly 30 % of the area is used at low intensity (permanent pasture or mown once a year) (fig. 4). Nearly half of the area is used at medium intensities (mown twice a year or low input rotational pasture) and only a fifth is used as “high input” meadows (mown three times a year). In *AUM* the share of low input uses drops with a passive initialisation by 7 %, while medium and high input forms gain in importance. With an active setting the medium input forms gain on the expense of both high and low input types. In *PE* more than 10 % of the study area is used by mulching. This share is much lower in a passive set up (roughly 3 %). The high share of mulched areas in an active setting is mainly on the expense of medium and high input meadows.



**Fig. 4:** Land use in dependence of the chosen scenario and set up for the farmer's attitude

Tab. 6 shows that the level of beef production is barely affected by the chosen policy scenario and the set up of the farmer's attitude. However, these two variables have some impact on the level of milk production. Choosing an active initialisation the milk production declines the more decoupled the payments are. This is due to the fact that small dairy farms give up farming or shift to suckler cow farming / heifer fattening. In a passive set up, due to the lower valuation of capital and especially labour the small dairy farms increase their milk production. However the level of milk production remains rather low.

**Tab. 6:** Milk and beef production per ha in dependence of the chosen scenario and set up for the farmer's attitude (in kg / ha)

Scenario	Farmer's attitude			
	active		passive	
	Milk (kg / ha)	Beef (kg sw / ha) <sup>1)</sup>	Milk (kg / ha)	Beef (kg sw / ha)
<b>REF</b>	1'232	137	1'007	132
<b>AUM</b>	925	140	1'471	145
<b>PE</b>	818	128	1'489	138

<sup>1)</sup> sw: slaughter weight

The respective developments of the farm structure have also implications on the labour demand per ha. In an active setting the decoupling of the payments induces a strong shift in the larger farms from dairy to beef (tab. 7). As the labour demand in beef production is smaller than in dairy, the total labour declines. In the passive setting the number of dairy farms is much less affected. As a result the labour demand does not change with increased decoupling.

**Tab. 7:** Avg. labour demand per ha of individually managed farm land in dependence of the chosen scenario and set up for the farmer's attitude (in Wh / ha)

Scenario	Farmers' attitude	
	Active	Passive
REF	104	92
PE	80	95
AUM	81	98

## 5 DISCUSSION AND CONCLUSION

Central result of the study is the increase of tenure with an increasing degree of decoupling. This result is in line with various other modelling exercises for Germany (cf. Weinmann *et al.*, 2006; Henning *et al.*, 2004, p. 169; Hüttel, 2005; Roeder *et al.*, 2006a), as well as with first empirical results (Kilian *et al.*, 2008). However it is questionable whether the increase will be as strong as predicted by the model. Several reasons would suppose a much weaker increase: First, rental contracts especially for grassland normally have a long duration (Henter, 2008). Second, most farmers in Garmisch are not able to adequately remunerate their capital and labour. Looking at the high labour demand of 70 to 100 Wh per ha an increase of the land rent of 200 EUR per ha would be compensated by a potential increase of the imputed wage by just 2 or 3 EUR per Wh. Third, most of the farmers cooperate already in the management of the summer pasture. It is therefore questionable how intensively these farms would compete on the land market for additional land.

With a higher rate of decoupling (**PE**) the rate of structural change is somewhat smaller than in a business environment with a higher degree of coupled payment (**AUM**). However, this holds only for an active initialisation of the farmer's attitude. This result is backed by Douarin *et al.* (2006) for Slovakia and Hennessy (2006, p. 195) for Irish beef farmers. However, Happe (2004, p. 195) could only show a very small effect in an intensive pig fattening region of Baden-Wurtemberg and Henningsen *et al.*, 2005 could not find any such effect in Schleswig Holstein.

While the abandonment of the minute farms is not very surprising regarding the comparatively small labour efficiency of these farms, it is at first site surprising that the small dairy farms (15 cows) in the sample are very sensitive with respect to the chosen scenario and farmer's attitude. In many scenarios the percentage of agents belonging to this group leaving the sector is higher than in the group of minute farms (5 cows). This "vulnerability" is due to two reasons: First, if these farms are run as dairy farms they nearly demand a full labour unit and therefore the combination is much more difficult than for the smaller farms. Second, the productivity of these farms is not sufficient to guarantee a sufficient family income. The high vulnerability of this group of farms is backed by empirical studies which confirm the low percentage of guaranteed generational farm hand over (Roeder, 2007; Weineisen, 2008). The analysis of Lauber (2006, p. 154) show for municipalities in the Swiss Alps similar result with respect to the relative stability of the smallest farms.

Several studies predict for Germany that decoupling will induce a declining level of cattle farming (e. g. Henning *et al.*, 2004, p. 140; Gay & Osterburg, 2005; K pker *et al.*, 2006). However, the area used by cattle will remain constant, implying a shift to lower intensity of agriculture. Also in Lauber's study (2006, p. 156 ff.) changes in the support policy resulted in comparatively small adjustments in the land use intensity and stocking level.

As demonstrated, individuality of farms is often of great importance for future land use. So it is to assume that even comparable farms will react to an identical change of the business environment differently and the adaptation process to the new conditions will depend to a large extent on the attitudes of the concerned agents (Jager et al., 2000). This applies in particular for small-structured regions with high heterogeneity with regard to farm structure and farmers' attitudes. With our approach we try to integrate elusive factors such as farmers' attitudes into a land-use model.

The integration of farmers' attitudes demands the modelling of individual farms trying to achieve their individual interests. In order to cope with this problem a multi-agent technique is the mean of choice. This technique allows for the consideration of individual farms. With our model we show a possibility to implement farmer's attitudes in land-use models in an indirect way. We assume that the present farm organisation is the result of an optimisation process realising the individual aims of farmers under current settings. This means that we consider farmers' attitudes as a black box, but farm organisation is an expression of these attitudes.

Most farmers in our study area could be attributed a comparatively passive farmer's attitude. Due to generally good economic conditions outside the agricultural sector most farmers, especially the ones managing the small and minute farms do not depend on the agricultural income. These farmers attribute a high intrinsic value to the continuation of farming. As a result they demand only a low remuneration of their labour and capital. In the study of Weineisen (2008) the owners of the small and minute farms stated that their decision to continue farming is more or less independent of the CAP and is more severely influenced by the general economic development of the area.

Of course this can be only a first attempt to integrate individuality in land-use models. Due to the fact that we consider farmers attitude as a black box, we avoided to survey personal aims very detailed. It is to assume that this way of implementing farmers' attitudes indirectly is not sufficient for describing farmers' decision making process. Even if this would be a valid way to explain previous developments, it is to question if this data can be extrapolated into future. This applies in particular for up to now unique occurrences like the decoupling process in the current CAP reform. In order to predict future developments it is not sufficient to change only the economic and policy framework but it is also necessary to estimate changes in farmers' attitudes. Otherwise model results tend to be trapped in historic situations. The most relevant change of attitudes takes place during the generational handover of farms.

To summarize it can be said that the model is suitable to derive land-use developments of smaller regions and helps to identify relevant factors influencing such development. The model may become especially important during the next decade when the European NATURA 2000 guidelines have to be implemented concerning in particular small- and medium-sized regions.

## **REFERENCES**

- BayStMLF (Bayerisches Staatsministerium für Landwirtschaft und Forsten) (2004): Maßnahmenübersicht KuLaP Teil A, Stand 11/2004. München: 1 p.
- BLW (Bayerisches Landwirtschaftliches Wochenblatt) (2007): Märkte und Preise. URL:<http://www.maerkteundpreise.de/> verschiedene Zugriffe. lastly accessed: 10.01.2007

- Deutscher Bundestag (2004): Unterrichtung durch die Bundesregierung - Rahmenplan der Gemeinschaftsaufgabe „Verbesserung der Agrarstruktur und des Küstenschutzes“ für den Zeitraum 2004 bis 2007; Drucksache 15/3151; Zugeleitet mit Schreiben des Bundesministeriums für Verbraucherschutz, Ernährung und Landwirtschaft vom 12. Mai 2004 gemäß Beschluss des Deutschen Bundestages vom 3. Mai 1984 (Drucksache 10/1250). 15. Wahlperiode 21. 05. 2004.
- Douarin, E., Bailey, A., Blaas, G., Bozik, M., Davidova, S. & Latruffe, L. (2006): Potential impact of the CAP Single Area Payment on the structural change in Slovakia. URL: <http://www.fat.admin.ch/eaee96/abstracts/s63.pdf>. paper presented at the 96th EAAE Seminar “Causes and impacts of agricultural structures” from the 10.-11.1.2006. Tänikon, Switzerland: 17 p.
- DWD (Deutscher Wetterdienst) (2006): Stationsmittelwerte der Periode 1961 bis 1990. URL: [http://www.dwd.de/de/Funde/Klima/KLIS/daten/online/nat/index\\_mittelwert\\_e.htm](http://www.dwd.de/de/Funde/Klima/KLIS/daten/online/nat/index_mittelwert_e.htm). last accessed: 16.12.2006.
- Gay, S. H. & Osterburg, B. (2005): Land use implications of the 2003 reform of the Common Agricultural Policy in the European Union. Paper presented at 45th congress of the GeWiSoLa from the 5.-7.10.2005. Göttingen: 13 p.
- Gueydon, A., Roeder, N. & Hoffmann, H. (2007): Les terres collectives en Allemagne: l'exemple des allmendes du sud de la Bavière. Leur intégration dans l'économie agricole. in Charbonnier, P., Couturier, P., Follainet, A. and Fournier P. (eds.). Les espaces collectives dans les campagnes XIe-XXIe SIÈCLE. Presses Universitaires Blaise-Pascal, Clermont Ferrand (F) : 453-469.
- Happe, K. & Balmann, A. (2002): Struktur-, Effizienz- und Einkommenswirkungen von Direktzahlungen. *Agrarwirtschaft* 51: 376-388.
- Happe, K. (2004): Agricultural policies and farm structures – Agent based modelling and application to EU-policy reform. Ph. D. Thesis at the Universität Hohenheim: 291 p.
- Hennessy, T. C. (2006): Modelling the effect of policy reform on structural change in Irish Farming. Ph. D. Thesis at the University of Reading: 283 p.
- Henning, C.H.C.A., Henningsen, A., Struve, C. & Mueller-Scheessel, J. (2004): Auswirkungen der Mid-Term-Review- Beschlüsse auf den Agrarsektor und das Agribusiness in Schleswig-Holstein und Mecklenburg-Vorpommern. Sonderheft der *Agrarwirtschaft* 178. Bergen/Dumme: 212 p.
- Henningsen, A., Henning, C.H.C.A., Struve, C. & Mueller-Scheessel, J. (2005): Economic impact of the Mid-Term Review on agricultural production, farm income and farm survival: A quantitative analysis for local sub-regions of Schleswig-Holstein in Germany. URL: [http://www.eaae2005.dk/CONTRIBUTED\\_PAPERS/S33\\_271\\_Henningsen\\_etal.pdf](http://www.eaae2005.dk/CONTRIBUTED_PAPERS/S33_271_Henningsen_etal.pdf). paper presented at the XIth International Congress of the EAAE from the 24-27.08.2005. Kopenhagen; 13 p.
- Henter, S. H. (2008): Darstellung aktueller Einflüsse auf den Pacht- & Kaufmarkt von landwirtschaftlichen Flächen. unpublished diploma thesis, TU München-Weihenstephan.
- Hinterstößer, M. (2005): CEO of the Society for alpine pastures in Upper Bavaria (almwirtschaftlicher Verein Oberbayern). personal communication. April 2005.



- Hüttel, S., Küpker, B., Gocht, A., Kleinhanß, W. & Offermann, F. (2005): Assessing the 2003 CAP reform impacts on German Agriculture. paper presented at 45. congress of the GeWiSoLa from the 5.-7.10.2005. Göttingen: 12 p.
- Jager, W., M.A. Janssen, H.J.M. De Vries, J. De Greef & C.A. Vlek (2000): Behaviour in commons dilemmas: Homo economicus and Homo psychologicus in an ecological-economic model. *Ecological Economics* 35: 357-379.
- Kantelhardt, J. (2003): Perspektiven für eine extensive Grünlandnutzung. *Sonderheft der Agrarwirtschaft* 176: 272 p.
- Kantelhardt, J., M. Kapfer & Roeder N. (2005a): A regional multi-agent model as a tool for modelling small structured agricultural land-use. in Arfini F. (ed.) *Modelling agricultural policies: state of the art and new challenges; Proceedings of the 89th EAAE Seminar from the 3. - 5.02.2005. Parma (Italy): 737-757.*
- Kantelhardt, J., M. Kapfer and Roeder N. (2005b): Heterogene Agenten in regionalen Agrarmodellen - Ein Ansatz zur standardisierten Implementierung. Poster presented at the 45th annual conference of the GeWiSoLa from 5.-7.10.2005. Göttingen.
- Kilian, S.; Anton, J.; Roeder, N. & Salhofer, K. (2008): Impacts of 2003 CAP reform on land prices: from theory to empirical results. Paper presented at the 109th Seminar, November 20-21, 2008. Viterbo, (Italy.): 17 p.
- Küpker, B., Hüttel, S. & Kleinhanß, S. & Offermann, F. (2006): Assessing impacts of CAP reform in France and Germany. *Agrarwirtschaft* 55 (5/6): 227-237.
- Lauber, S. (2006): Agrarstrukturwandel im Berggebiet – ein agentenbasiertes, räumlich explizites Agrarstruktur- und Landnutzungsmodell für zwei Regionen Mittelbündens. *Tänikon (Switzerland): 216 p.*
- LfL (Bayerische Landesanstalt für Landwirtschaft) (2006a): Landwirtschaftliche Erzeugerpreise in Bayern. Datensammlung für die Landwirtschaftsberatung; München: 88 p.
- LfL (Bayerische Landesanstalt für Landwirtschaft) (2006b): Milchquotenverkaufsstelle Bayern. URL: [http://www.lfl-neu.bayern.de/iem/milchboerse/14853/linkurl\\_0\\_3\\_0\\_10.pdf](http://www.lfl-neu.bayern.de/iem/milchboerse/14853/linkurl_0_3_0_10.pdf). lastly modified: 25.04.2006.
- RegMFr (Regierung von Mittelfranken) (2003): Deckungsbeiträge. Variable Kosten. AKh-Bedarf der wichtigsten landwirtschaftlichen Produktionsverfahren incl. Sonderkulturen. 13. edition. Ansbach: 202 p.
- Roeder, N., (2007). Entwicklung und Anwendung eines agentenbasierten Landnutzungsmodells unter besonderer Berücksichtigung der Betriebsleitereinstellung. Ph. D. Thesis at the TU-München. URL: <http://mediatum2.ub.tum.de/doc/624088/624088.pdf>. Freising: p. 227.
- Rounsevell, M. D. A., Annetts J. E., Audsley E., Mayr T., & Reginster, I.(2003): Modelling the spatial distribution of agricultural land use at the regional scale. *Agriculture, Ecosystems & Environment* 95: 465-479.
- Salhofer, K.; Röder N. & Kilian, S. (2007): Märkte für Zahlungsansprüche; unpublished intermediate report. 20.12.2007. Freising: p.29.
- Schemm, H. (2004): Konzeption eines Rechenmodells zur Analyse agrarpolitischer Szenarien in einer Kleinstregion. Ph. D. Thesis at the TU München-Weihenstephan. Freising.
- USDA (United States Department of Agriculture) (2006): EU-25 Livestock and Products Annual 2006.

URL: <http://www.fas.usda.gov/gainfiles/200607/146208314.pdf> lastly modified: 14.07.2006; GAIN Report Number: E36107; 16 S.

- Walters, F., Parker, L, Morgan, S. & Deming, S. (1991): Sequential Simplex Optimization. Boca Raton (USA). 403 p.
- Weineisen, M. (2008): Akzeptanz von Anpassungsstrategien an agrarpolitische Rahmenbedingunge bei landwirtschaftlichen Familienbetrieben im Alpenraum. unpublished diploma thesis. TU München-Weihenstephan.
- Weinmann, B. Schroers, J. O. & Sheridan, P. (2006): Simulating the effects of decoupled payments using the land use model ProLand. *Agrarwirtschaft* 55(5/6): 248-256.
- ZMP (Zentrale Markt- und Preisberichtsstelle) (2006): Milchquotenbörse, ZMP – Spezial (44); Bonn; 7 p.