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**Farm entry policy and its impact on structural change analysed by an
agent-based sector model**

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FARM ENTRY POLICY AND ITS IMPACT ON STRUCTURAL CHANGE ANALYSED BY AN AGENT-BASED SECTOR MODEL

ABSTRACT

The Swiss agent-based model (SWISSland) claims to depict as realistically as possible the 50 000 family farms comprising the whole of Swiss agriculture in all their heterogeneity as regards farm and cost structures as well as farm decision-making behaviour and interactions, with the aim of improving the simulation and forecasting of structural change in agriculture. With the linking of different methods and recorded data, there is a marked increase in the quality of the assessment of policy consequences. Simulations are shown for policy measures which affect only farm entry by cutting socially motivated direct payments for young operators.

KEYWORDS: agent-based model, sector model, farm entry, structural change

1. INTRODUCTION

In order to analyse structural change for specific regions taking into account agricultural policy or market changes, agent-based models (ABMs) are an appropriate methodology. MATTHEWS et al. (2007, p.1447) summarize the advantages of agent-based models as follows: “The specific advantages of agent-based models include their ability to model individual decision making entities and their interactions, to incorporate social processes and non-monetary influence on decision making, and to dynamically link social and environmental processes”. Since regional peculiarities are decisive for the use of agricultural land, agent-based models have been used for some time now, predominantly on a regional scale (BALMANN 2000; HAPPE 2004; SCHREINEMACHERS 2006; VALBUENA 2009). However, when using the model in policy decision support, the impact of policy changes on cost-effectiveness and structures, sectoral scale also needs to be evaluated to allow forecasts on the trend in the number of farms and the growth of those farms remaining in the agricultural sector.

The agent-based model for Switzerland (SWISSland) (SWISSland=German acronym for “Structural Change Information System Switzerland”) is characterised not only by the fact that it models individual, clear-cut regions, but also that it provides the opportunity of mapping a whole country without forfeiting the validity of smaller spatial units. Even though Switzerland is obviously a relatively small country, the consequence of a national model scale is the necessity to process potentially extremely large amounts of data. This increases the pressure to abstract when defining agents. At the same time, however, the wealth of heterogeneity must not be lost, for in actual fact modelling this heterogeneity quite simply means that consideration has been given to the different action strategies of farmers and the many possible agricultural technologies which, in turn, arise from the need to adapt to different landscape structures and soil qualities. In addition, the time span modelled for forecast calculations is between 10 and 20 years, there also being a need for the individual modelling of the adaptive responses of individual agents and their behaviour when interacting with other agents throughout this period. The model must also include a spatial dimension to allow for the mapping of neighbour relationships in agent interaction. Structural change in agriculture and the diverse forces driving it must be seen not only from the perspective of the farmer exercising rational business behaviour, but also from the individual perspective of each member of the farming family. Preferences relating to farm transfer and exit from

agriculture, farm orientation and strategy, farm growth and investment should therefore be taken into account, as should technical progress, agricultural policy measures and opportunities for part-time farming.

The aim of this contribution is to show the design and the implications of an agent-based model for the Swiss agricultural sector which relies on the total national FADN farm sample (about 3400 data records). Finally, simulations are shown for policy measures which affect only farm entry by cutting socially motivated direct payments for young operators. These measures are currently being discussed in Switzerland in order to guarantee social sustainability for older farmers, while farm entry is not eligible for these payments. Forecasts for structural change in Swiss agriculture are then presented and discussed.

2. MODEL DESIGN AND DATABASE

2.2 OVERVIEW OF THE DESIGN OF EXISTING AGRICULTURAL AGENT-BASED MODELS

The model design of an agent-based model is defined by the structure of the agent population, the degree of generalization and the data base. Previous approaches used various methods for defining agents and generating the agent population (Tab.1).

Table 1: Structure of the agent population in existing agent-based models

Sample Model	LAUBER (2006)	BALMANN (2000); HAPPE (2004)	BERGER (2001); SCHREINEMACHERS (2006)	VALBUENA et al. (2008)
Data Basis	Structured interviews with all farms in mountain valley: Survey of structural, economic and spatial features as well as behaviours and decision making	FADN data, planning data, expert knowledge for deriving the typical production technology	Data from a household survey, planning data, qualitative information from field observations	FADN data, planning data, survey and spatial data
Agent Population	Total population Agents = existing farms	Total population Clones of typical farms	Total population Multiplication of the reference farms by means of the Monte Carlo Simulation	Sample Agents = sample (selection of typical agents)

Those approaches which model all the existing farms in a region as agent populations are usually based on extensive surveys, and the agents generally possess an explicit spatial reference. Owing to the high degree of effort associated with data collection, however, only small regions with up to 100 agents can usually be included (LAUBER, 2006). The results of such case studies, however, can only be generalised to a limited extent. The concept of the definition of typical farms (BALMANN, 2000; HAPPE, 2004) generally employs a small selected sample of FADN farms as a data basis for the agents. Through identical multiplication ('cloning') of the farms – as a function of their occurrence in the population – an agent population is generated which corresponds to the actual size of the region. Economically rational behaviour is imputed to the agents based on the maximisation of profit. The cost functions based on planning data are simply modified by means of randomly assigned correction coefficients for different management skills. In order to establish the spatial reference, the authors have divided the space to be modelled into grid cells. This approach simplifies the treatment, but does not take into account the varied shapes, sizes and ownership structures of the units of area. The more sophisticated approach carried out by BERGER (2001) and SCHREINEMACHERS (2006) uses so-called reference farms forming a

representative sample of all the farms of a region to define the agents. Based on the reference farms, a Monte Carlo simulation produces further model agents corresponding to the number of farms in the total population. VALBUENA et al. (2008 and 2009) adopt a different approach. Rather than modelling the total number of farms in a region, the authors work with a selection of typical agents. In comparison to the work of BALMANN and HAPPE, however, more information on features such as intentions, perceptions, attitudes and the decision-making behaviour of the players is used here. Special importance is placed on as realistic a depiction of the spatial distribution of the agent types as possible.

2.2 SELECTION OF AGENTS TO DEFINE THE POPULATION IN THE SWISSLAND MODEL

The SWISSland agent-based model claims to depict as realistically as possible around 55 000 family farms throughout Swiss agriculture in all their heterogeneity with regard to operating and cost structures as well as modes of social behaviour. The Swiss agent-based sector model selected the non-representative FADN farm sample from 3400 actual existing family farms as data source to define the agents. On the one hand, this approach ensures detailed individual farm records for modelling the agents' production resources (land use, livestock, family and non-family labour, financial values), production costs, prices and direct payments for each production activity, the geographical location and biographical data of the farm operator). In addition, from a technical point of view it is easier to handle 3400 agents rather than 55 000 agents, and modelling individual behaviour gets easier. However, this approach poses various challenges regarding the sectoral representativeness and extrapolation of the sample to the sectoral scale, the modelling of empirical observed production decisions and potential future changes, the modelling of interactions among neighbouring farms, and finally the modelling of farm entry and exit decisions.

2.3 IMPROVING THE REPRESENTATIVENESS OF THE FADN FARM SAMPLE FOR EXTRAPOLATION

The FADN data pool aims to constitute a representative sample of Swiss farms. Nevertheless, a linear extrapolation leads to significant deviations from sectoral figures. An improved quality of fit could be obtained by assigning different weightings to the individual farms. However, this would lead to inconsistencies with respect to the modelled relationships between the farms: a land deal between farms to which differing extrapolation factors are assigned would yield a change in the overall modelled area. Representativeness is therefore improved before the model applications by adjusting the sample (MÖHRING et al. 2010). Over-represented farms are deleted from the sample, underrepresented farms are multiplied. The determination of the farms to be deleted or multiplied is effected by an optimisation process which minimizes the sum of the squared deviations between the extrapolated figures of the farms and the extent of these figures in the basic population.

Minimization:

$$\sum_m \left(\sum_b \frac{w_b * M_{mb} * HF}{MCH_m} - 1 \right)^2 * MF_m \rightarrow \min$$

Sum of the squared deviations

where:

- w_b : Sought-after weighting of FADN farm b (Integer-variable, standard value: 1)
- M_{mb} : Extent of feature m on FADN farm b
- HF: Extrapolation factor between the SWISSland agent population and the farms throughout Switzerland
- MCH_m : Optimum mapped extent of the feature m in Swiss agriculture
- MF_m : Feature-weighting factor of feature m
(Relative weighting of the features observed)

The list of figures considered in this optimisation process contains important characteristics such as farm size, regional location, organic farm management and the sizes of particular land and animal categories. The resulting agent population enables linear extrapolation of model outcomes.

2.4 MODELLING EMPIRICAL OBSERVED PRODUCTION DECISIONS AND POTENTIAL FUTURE CHANGES

The agents' production and investment decisions are carried out by a recursive farm optimisation model, which is predefined by a set of alternative production decision variables. In addition the model includes various biophysical and economic constraints (Table 2). Let us denote alternative production decisions by a nonnegative variable block $X_{t,a,i}$, where $t = \{1, \dots, T\}$ denotes the set of time periods, $a = \{1, \dots, A\}$ the set of agents, and $i = \{1, \dots, ii, \dots, I\}$ the set of production activities, where production activities from 1 to ii are the statistical observed activities in the base year (2008) and those from ii to I are potential new production activities. Annual variations of land use and livestock are not taken into account. For that reason the average of three years (2006-2008) is used as base year.

Table 2: Overview of the farm optimization model

			Crop cultivation			Livestock rearing				Labour				Investment					RHS				
			Area	Leasing	Crop rotation	Livestock produced	Livestock purchase	Livestock's sale	Reproduction	RLU eligible	Family MPU	External MPU (base)	External MPU (new)	Part-time work	Tractor-base	Tractor-new	Trailer-new	Housing places-base		Housing places-new	Housing places previous year	Financing	
			c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c			
	Household income	CHF	Objective-function coefficients																			Max	
Factor capacities	Land usage	ha	■	■	■																	↑	
	Basic fodder	DM	■			■																	↑
	Animals / reproduction	no.				■	■	■	■														↑
	RCLU	LU	■							■													↑
	Labour	NAT	■								■	■	■	■									↑
	Housing places	places				■										■	■	■	■	■			↑
	Technology	ha	■											■	■	■						■	↑
Biological restrictions	Crop rotation	ha	■	■																		↑	
	Nutrient balance (N,P)	kg	■			■																↑	
	Water pollution control	LU	■			■																↑	
	Extensive areas	ha	■																			↑	
	Grassland	ha	■																			↑	
	Ecological compensation area	ha	■																			↑	

RHS: Right Hand Side

One of the main assumptions of the model is that the manager's overall objective is to maximize its household income (Z).

This objective function is:

$$\begin{aligned}
 \text{Max } Z_{t,a} = & \sum_i \delta_t r_{t,a,i} X_{t,a,i} + \sum_i p_{t,a,i} X_{t,a,i} + - \sum_i v_{t,a,i} X_{t,a,i} \sum_j w_{t,a,j} N_{t,a,j} - \sum_g s_{t,a,g} L_{t,a,g} \\
 & - \sum_h q_{t,a,h} Y_{t,a,h} - \sum_i \alpha_{a,i} X_{t,a,i} - 0.5 \sum_i \beta_{a,i} X_{t,a,i}^2
 \end{aligned}$$

The total revenue of the land use and livestock activities is the product of revenue coefficients r_i , a time period specific discount factor δ_t , and the activity level $X_{t,a,i}$. The vector of the direct payments is represented by p and the vector of purchased activities by v . The off-farm income

is the product of off-farm wages w and off-farm activities N_j . The vector of the labour cost for employees is s while L is the hired labour. The costs for investments in machinery and buildings are calculated as a product of cost coefficients q_h and investment activities Y_h .

Even with a constraint structure and parameters that are theoretically correct for an agent, it is highly unlikely that a pure linear programming model will calibrate closely to the base year data of the FADN farm. For that reason the decision process for plant and animal production activities is carried out according to the standard Positive Mathematical Programming (PMP) approach (HOWITT, 1995). The PMP approach is an appropriate method of overcoming this problem and obtaining more plausible solutions. In addition, PMP-based models yield smooth responses to exogenous changes (HOWITT 1995).

The FADN farms implemented a certain production program in the base year. For this observed production program PMP terms α and β were estimated based on their individual variable production costs. For the estimation exogenous elasticities were applied (Gocht, 2005), which in the absence of the exact values for Swiss agriculture were defined as unity. However, normally farms are not fully able to realize all potential production lines which are predominant in a region due to scarce production resources, management reasons or market or agricultural policy conditions. Marginal cost functions for potential new productions lines were estimated based on the observed farm-type specific average values. These average values were increased by an exogenous factor in order to take account of the fact that these production lines were not realized in the base year. Prices, direct payments and yields were estimated for all non- existing production activities by estimating averages and standard deviations. Based on these averages and stand deviations random values for all coefficients were used in the model.

Marginal cost functions (MCs) for observed production activities ($X_{1..ii}$):

$$MC(X)_{ai} = \alpha_{ai} + \beta_{ai}X_{ai} \quad \text{for } i = 1..ii$$

Marginal cost functions (MCs) for potential new production activities ($X_{ii..I}$) where $\bar{\alpha}$ and $\bar{\beta}$ are the average of the observed values of similar farms. Those groups include farms in the

$$MC(X)_j = \bar{\alpha}_i + 1.5(\bar{\beta}_i X_i) \quad \text{for } i = ii..I$$

same regions with similar farm types.

2.5 MODELLING OF SPATIALLY ADJACENT AGENTS

The 3400 FADN reference farms are located all over Switzerland and usually bear no neighbourly relationship to each other. As a rule interactions between agents (agricultural trade between farms) only take place between neighbouring farms or farms within a municipality. Municipalities with a typical spatial structure were selected in order to introduce a spatial dimension into the agent-based model. These reference municipalities were chosen in a two-step procedure. Firstly, a municipal typology was built, taking into consideration the distribution of farms and their utilized agricultural area in different elevation classes. Ten municipal types then reflected the different topographical structure of farm activities. Secondly, taking the representativeness of farm type and size into consideration, one municipality per class was chosen and specific geographical data (topology of the parcels cultivated by each farm, location of the farm buildings) were determined for each farm present in the municipality. Data were processed in a GIS in order to generate information on distances from the farm buildings to the parcels, neighbourhoods, parcel size and type of cultivation. The individual reference municipalities of representative types of region served as a source of information for the characterisation of the model agents in terms of spatial and

topographic properties. This was done by assigning each FADN farm to a matching location in a reference municipality.

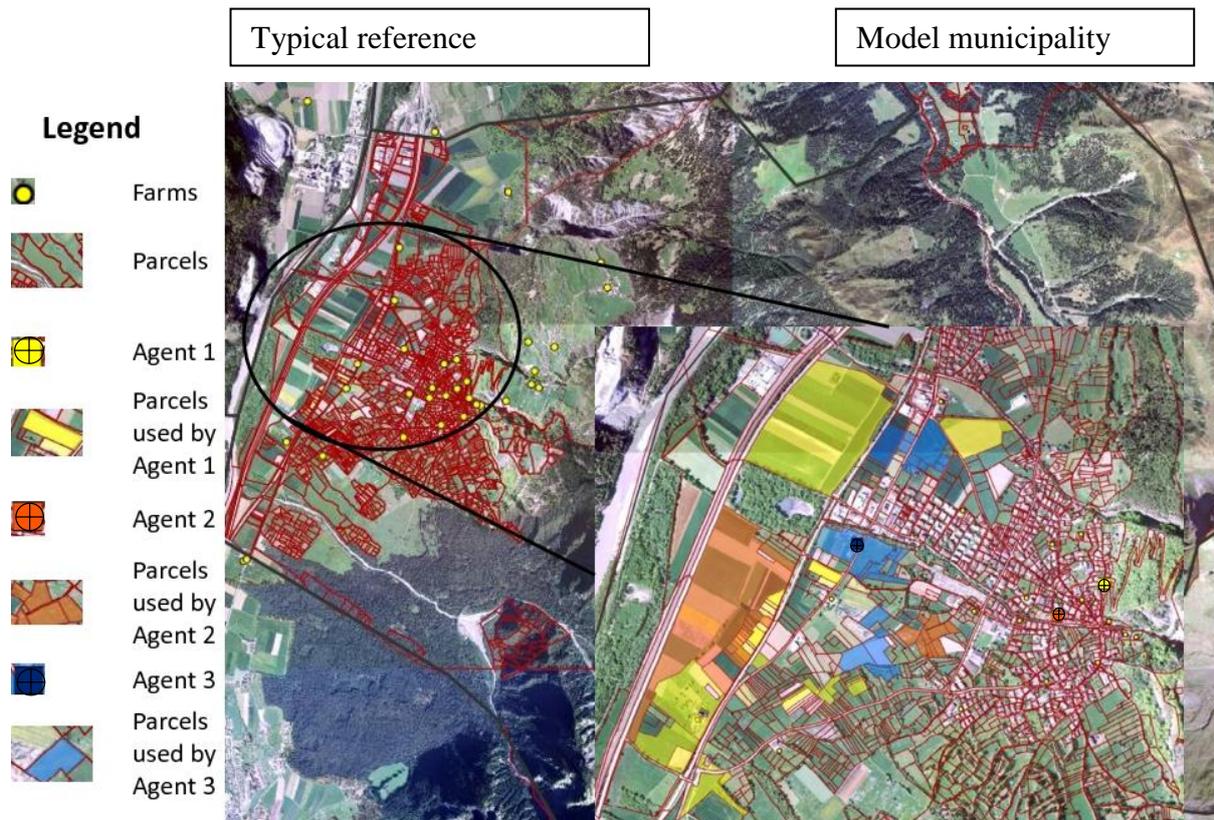


Figure 1: Assigning a typical spatial structure of a reference municipality to the SWISSland agents

The principal criteria for the allocation of farms to reference municipalities were important key farm indicators which were present in both data sets, particularly farm area (ha UAA, ha grassland, ha arable land), the altitude (m a.s.l.) and the zones to which they belonged (valley zone to mountain zone 4). Because the number of Swissland agents was significantly higher than the number of farms in the reference municipalities, a first step was to quadruple those reference municipalities which were underrepresented in respect of these allocation features. This was done by minimising the sum of the squared deviations between the features of the FADN sample and the reference municipalities.

In a second step each agent was assigned to a matching farm from the reference municipalities. This was done by way of a loop formulation¹ in which each agent was successively assigned to the best matching farm still vacant in the reference municipalities. Each best matching farm corresponded to the one with the fewest differences in the assignment features².

¹ This assignment could also be formulated as an optimization problem. The binary solution variable of such a system, however, would be a matrix in the dimension of "number of agents x number of farms in the reference municipalities", which overtaxes the available solver capacity.

² In the event of assignment characteristics being unequally represented, this procedure could result in there being no suitable farm left in the reference municipalities for the last agents to be assigned. For this reason the assignment features of both the agents and the farms in the reference municipalities are transformed beforehand into rank values. This way an acceptable assignment result is achieved, also because there is still a choice of several farms in the reference municipalities for the last FADN farm to be assigned.

Finally, the parcels of land in the reference municipalities were corrected so that the farm area exactly matched that of the associated agent in Switzerland. All the agents were thus given a spatial characteristic (farm coordinates, number of parcels with grassland and arable land, parcel coordinates and their field/farm distance) and neighbouring agents whose parcels were adjacent to those of other agents.

2.6 MODELLING FARM ENTRY AND EXIT DECISIONS

The exit from farming in Switzerland is shaped primarily by the life cycle of the farm manager. As a rule a farm closes down or is transferred to a successor on payment of the state pension at the age of 65 and the lapse of rights to direct payments (MEIER et al., 2009). Under the present framework conditions farms are only very seldom given up before pensionable age is reached (ROSSIER et al, 2006). This is also reflected in the fact that only in less than 10 % of all cases are Swiss farm managers older than the statutory retirement age of 65. In an empirical study ROSSIER et al. (2006) found that in Switzerland the decision on farm succession bears a significant relationship to the number of sons, the location (valley, hill or mountain region), the size and type of farm and farm direct payments and income potential. In Switzerland these findings on farm transfer are implemented in a two-stage decision-making process. In a first step the agents without successors and those with a potential transfer candidate are stochastically determined on the basis of the farm transfer probabilities arising from the number of sons, location, farm size and farm type (Tab. 3) based on the findings of ROSSIER et al. (2008). The probabilities represent a so-called minimum farm transfer. In a second step the income criterion for farm transfer is implemented in that the attainable household income of a potential successor in the transfer year must be higher than the exogenously determined minimum income. A definitive farm transfer takes place only when this criterion is met.

Table 3: Probability of farm transfer by region, farm type and farm size

Region	Farm type	Farm size	Farm size	Farm size
		0 – 10 ha	10- 20 ha	> 20 ha
Valley	Non-dairy farmer	31 %	48 %	68 %
Valley	Dairy farmer	44 %	69 %	91 %
Hill	Non-dairy farmer	45 %	12 %	50 %
Hill	Dairy farmer	67 %	70 %	75 %
Mountain	Non-dairy farmer	40 %	23 %	73 %
Mountain	Dairy farmer	65 %	72 %	88 %

Source: ROSSIER et al., 2006

Farm entry and exit is therefore determined by both the rate of exit of farmers reaching pensionable age and the share of successful takeovers which is dependent on income trends. If the farms have no successor the land is put up for lease.

2.7 MODELLING RULES FOR LAND RENTING DECISIONS AND INTERACTIONS AMONG AGENTS

Interactions between agents in the form of land exchange are based on the rules below, which follow the same order every year:

1. If agent A exits, agent A's first vacant parcel p1 available for leasing is stochastically determined.
2. Five potential agents (agents N1-5) interested in leasing are sought for p1. Agents N1-5 must be neighbours of A and not have come close to retirement age (< 60 years).

3. The agents N1-5 calculate their potential income growth on rental of p1 by means of single-farm optimisation.
4. Agent N, who achieves the highest income growth with p1, obtains p1, the rent being derived from the FADN data on an individual farm basis and exogenously defined.
5. If no neighbour N achieves income growth with p1, 3 further neighbouring agents N6-8 with an interest in leasing are ascertained.
6. If an interested party is still not found, p1 is offered for lease again the following year.
7. Neighbouring farms with an interest in leasing are sought for agent A's second available vacant parcel p2. N1-5 could also be interested in p2.

2.8 TECHNICAL IMPLEMENTATION OF MODEL DESIGN AND DATA FLOW

The SWISSland agent-based model comprises three software components: a MySQL database in which are filed all input data and model results (Figure 2). A JAVA-based control platform starts the model's initialisation phase and assigns modes of behaviour to the model agents. It also contains the algorithms for land market interactions and controls communication and data exchange between optimisation model and data base.

Special Gams models for the agents optimise the production program. Figure 2 shows an overview of the model procedure. In the initialisation phase data are read and processed, the requisite calculations for the definition of model agents are carried out and the PMP calibration is prepared.

The JAVA platform is used to assign both rational and non-rational behaviour to the model agents. The GAMS model then starts the optimisation of all agents for the base year. Parcel demand and supply is determined on the basis of the criteria described above. The individual farm model optimises five neighbouring agents per parcel and, based on production program modifications in the event of land lease, calculates their income achievement potential. The vacant parcel for lease is allocated to the agent who can achieve the highest income growth. In the following forecast year this agent can then farm this leased parcel. The results of each forecast year are written back into the database and serve as the starting point for the following year's optimisation.

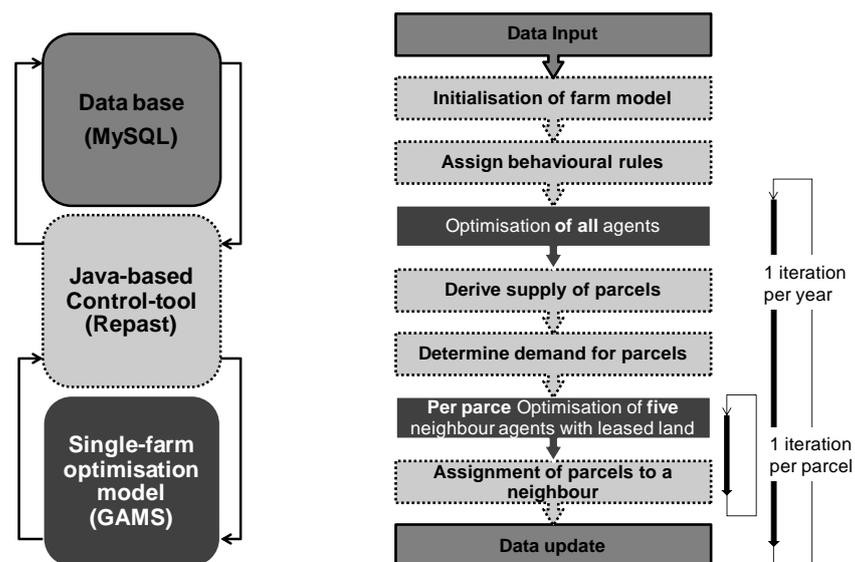


Figure 2: Technical design and data flow of the SWISSland model

3. ANALYSING FARM ENTRY AND THE IMPACT ON STRUCTURAL CHANGE

3.1 MODEL SCENARIOS

As the model was developed as a decision support system for policy makers, model results are presented for some policy scenarios actually discussed in Swiss agricultural policy. At the moment Swiss agricultural policy is in the process of reforming the direct payment system, which has been in existence since 1998. Animal-related subsidies for roughage consumers are to be abolished with the exception of ethological contributions, and area contributions will be strictly linked to societal goals such as self sufficiency and ecological performance. The overhaul of the direct payment system will cut direct payments by 20-30 %, depending on farm type. Direct payments make a major contribution towards Swiss farming incomes, however, so this policy would also result in steep drops in income, to be cushioned by so-called socially motivated adjustment contributions for farm managers.

Against the background of target-oriented agricultural policy, these adjustment contributions will probably not be paid to new entrants taking over a farm after reform becomes effective. This will be investigated further, as exemplified by the Swissland model for a 12 year period from 2009 to 2020.

The following options will be examined:

- (1) All farmers, even new entrants, are compensated for direct payment reductions (reference scenario: Scenario 1).
- (2) For social reasons present-day farmers are compensated for direct payment reductions by means of adjustment contributions, whereas new entrants are awarded no compensation. (Scenario 2: entry more difficult). This aims at accelerating a socially acceptable structural change and decreasing of expenditures for the Swiss agriculture. However it should not lead to social hardships for single farms and should maintain or increase the economical competitiveness of Swiss agriculture.

3.2 RESULTS

The contribution of socially motivated direct payments to the household income of Swiss farms varies widely depending on the farm size, the region and the agricultural production of the farms (Figure 3). Consequently farms are very differently affected by a cut of these payments. While those with a high share of household income suffer from a serious income loss, others are hardly affected. According to the empirical findings that young farmers will only take over the farm from its predecessor if the household income exceeds a minimum wage, cutting the socially motivated direct payments for the successor has a significant influence on farm transfer and farm exit (Figure 4).

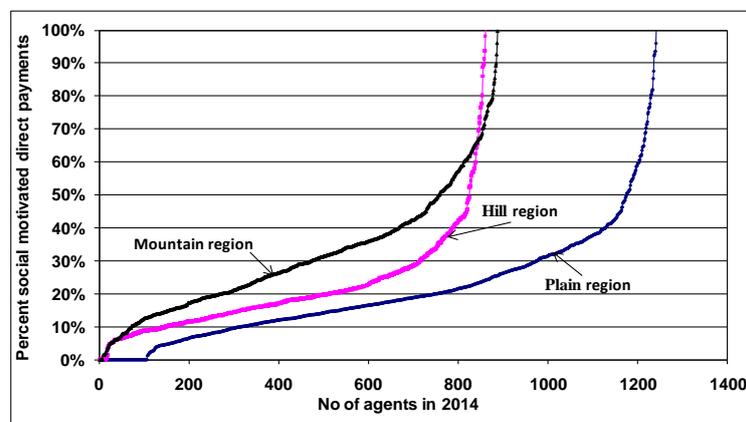


Figure 3: Socially motivated direct payments (share of household income) in the plain, hill and mountain region at the beginning of the reform for scenario 1

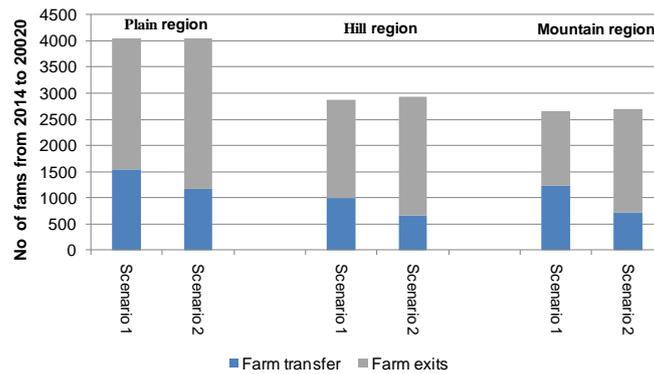


Figure 4: Total number of farm exits and farm transfers in Scenario 1 (with socially motivated direct payments for farm entries) and Scenario 2 (without socially motivated direct payments) from 2014 to 2020

In all regions farm transfers decrease because young farmers decide against farming due to the lower income perspective. Those farms, which are transferred to the next generation, are larger farms, which have a low share of social motivated direct payments to their household income. The increased number of farm exits has an impact on farm growth and on the increase of farm size during the time horizon (Figure 5). While in scenario 1 with socially motivated direct payments the average increase of farm size is 1.34 ha from 2014 to 2020, in scenario 2 (without socially motivated direct payments) the average farm size goes up by 1.83 ha. Additionally for more than half of the agents a further increase in farm size is observed when cutting socially motivated direct payments (Figure 5). On the other hand, due to the cut of socially motivated direct payments the average household income in scenario 2 is lower than in scenario 1. But on average the difference is slight due to the higher farm exits and accelerated farm growth. Assessing the impact of scenario 2 the results show, that the average reduction of direct-payments is higher than the average income loss (Figure 6). Consequently a high share of the direct payment cuts can be compensated by the effects of structural change.

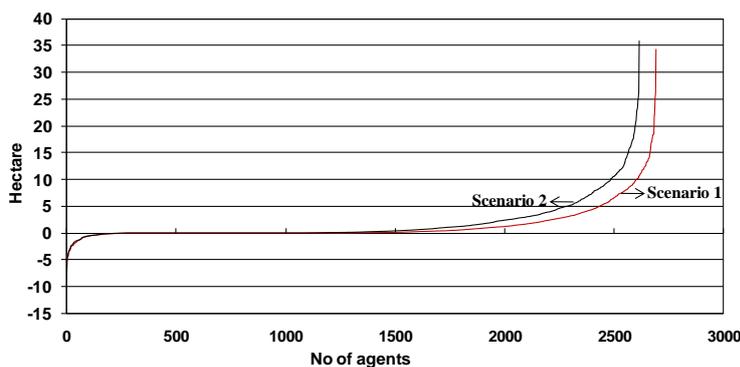


Figure 5: Change of farm size (in hectare) in Scenario 1 (with socially motivated direct payments for farm entries) and Scenario 2 (without socially motivated direct payments) from 2014 to 2020

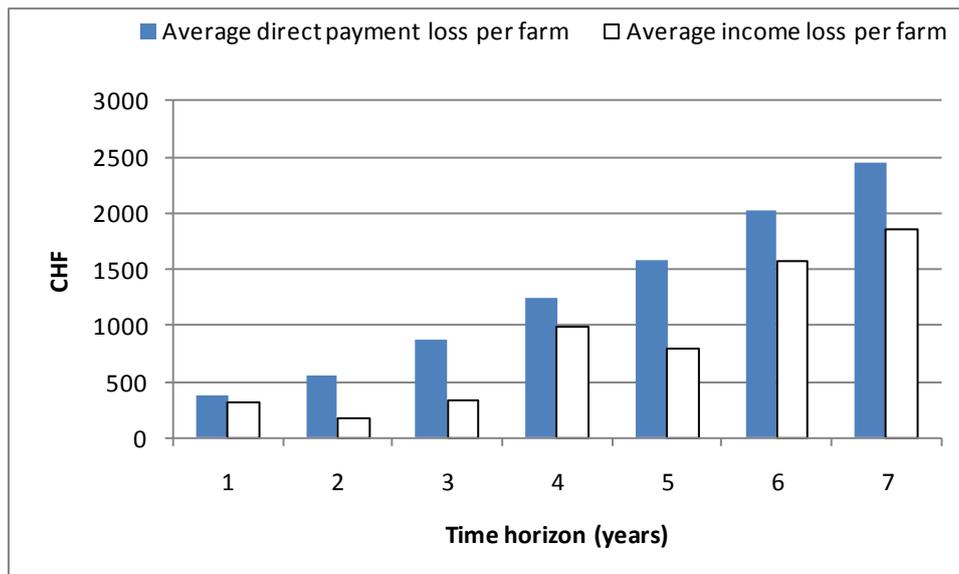


Figure 6: Average annually direct payment reduction per farm and average income loss per farm due to the cut of socially motivated direct payments (scenario 2).

4. DISCUSSION

The larger the agent population to be modelled in an agent model, the less detailed the design of the individual-farm optimisation models or agents generally is. SWISSland aims to model both a large agent population and the individual agent as realistically as necessary, for which complex individual-farm optimisation models are, however, essential. This entails several difficulties. Besides technical capacity problems, a high degree of detail harbours the risk of problems with model validation and the interpretation of the model results. Communication with policy decision-makers becomes more difficult if the modelled connections are not sufficiently comprehensible (HAPPE and KELLERMANN, 2007). Finding a reasonable balance between complexity and simplification will therefore be a criterion of success in the modelling of SWISSland.

Here, the fact that not only a manageably sized region but an entire country is to be modelled is of importance. Although Switzerland, as is known, is one of the smaller nations, the goal of a national model standard demands the processing of potentially extremely large quantities of data. This reinforces the pressure to abstract in certain places, without unnecessarily restricting the wealth of single-farm individuality.

All in all, it appears that multi-agent models are in fact in a considerably better position to model complex reality than old-style aggregated sector models. Through the deliberate use of suitable selected documents and with the assistance of different disciplines, modelling can home in on the mechanisms, and above all the heterogeneity, of human behaviour. In this way, we continue to bear in mind the aim of realistically appraising policy consequences.

REFERENCES

- Balmann, A. (2000). Modeling Land Use with Multi-Agent Systems. Perspectives for the Analysis of Agricultural Policies. Proceedings of the IIFET 2000: Microbehavior and Macroresults.
- Berger, T. (2001). "Agent-based Spatial Models Applied to Agriculture: A Simulation Tool for Technology Diffusion, Resource Use Changes and Policy Analysis." *Agricultural Economics*. 25(2): 1-16.

- Gocht, A. (2005). Assessment of simulation behavior of different mathematical programming approaches. 89. EAAE Seminar: Modeling Agricultural Policies: State of the Art and new Challenges. Parma.
- Happe, K. (2004). Agricultural policies and farm structures. Agent-based modelling and application to EU-policy reform. Studies on the Agricultural Food Sector in Central and Eastern Europe. Halle, Institute of Agricultural Development in Central and Eastern Europe (IAMO). 30: 298.
- Howitt, R. E. (1995). "Positive Mathematical Programming." American Journal of Agricultural Economics. 77: 229-342.
- Lauber, S. (2006). Agrarstrukturwandel im Berggebiet. Ein agentenbasiertes, räumlich explizites Agrarstruktur- und Landnutzungsmodell für zwei Regionen Mittelbündens. Tänikon, Eidgenössische Forschungsanstalt Agroscope Reckenholz-Tänikon ART.
- Matthews, R. B., N. G. Gilbert, et al. (2007). "Agent-based land-use models: a review of applications." Landscape Ecology. 22(10): 1447-1459.
- Meier, B., G. Giuliani, et al. (2009). Flächentransfers und Agrarstrukturentwicklung. Studie im Auftrag des Bundesamtes für Landwirtschaft. Schlussbericht. Winterthur und Zürich.
- Möhring, A., A. Zimmermann, et al. (2010). "Multidisziplinäre Agentendefinitionen für Optimierungsmodelle." Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaus e.V. 45: 329-340.
- Rossier, R. (2008). Einstellung der Junglandwirte bezüglich Hofübernahme. Agrarbericht 2008. Bundesamt für Landwirtschaft (BLW). Bern.
- Rossier, R. and B. Wyss (2006). "Determinanten der Hofnachfolge." Agrarforschung. 13(4): 144-149.
- Schreinemachers, P. (2006). The (Ir)relevance of the Crop Yield Gap Concept to Food Security in Developing Countries with an Application of Multi Agent Modeling to Farming Systems in Uganda. Bonn, Uni Bonn: 222.
- Valbuena, D., P. H. Verburg, et al. (2008). "A method to define a typology for agent-based analysis in regional land-use research." Agriculture, Ecosystems & Environment. 128(1-2): 27-36.
- Valbuena, D., P.H. Verburg, et al. (2009). "An agent-based approach to model land-use change at a regional scale." Landscape Ecology. 24: 149-155.