Modeling of Structural Adjustment Processes of Farming Enterprises: The Need for Implementation of Cooperation and Collaboration Strategies

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Abstract

The research objective is to shed light on the structural adjustment process of farming enterprises in Switzerland. To this end, an analytical tool is developed which allows us to identify the most important influencing factors and to estimate in advance their effects on the structural adjustment process. The resulting structures will be compared with the relevant goals of the (agricultural) policy in order to draw conclusions about the effectiveness of the adjustment process. Using scenario techniques combined with an agent-based simulation, the influencing factors are varied to investigate alternative options like cooperation and collaboration strategies for improving the effectiveness with respect to the social, ecological and economic goals.

Key words

Agent-based simulation, structural change, cooperation strategies, collaboration

JEL classification: C61, Q12, Q15

Introduction

One of the main objectives of the reorientation of the Swiss as well as the European agricultural policy is the liberalization of agricultural markets. As a consequence, prices for agricultural products drop and farmers have to reduce their production costs or will lose income. In addition, social acceptance of structural change is increasingly important in the agricultural policy and became part of the Swiss agricultural law (LwG, 1998, Art. 2). Several studies in Switzerland have shown that different policy goals and measures increase the conflicts between economically essential structural adjustments and their social, and ecological impacts (Hofer, 2002, Koch und Rieder, 2001, Lehmann et al., 2002).

The objective of this research is to improve the understanding of the structural adjustment processes in a locality and on farm level. Therefore we search for the best modeling method and create an agent-based simulation tool, with which it is possible to identify important factors of influence and to estimate in advance their effects on structural change. The resulting structures will be compared with the relevant goals of the agricultural and regional policy in order to draw conclusions about the effectiveness of the adjustment process. To specify the options open to action, the modifiable influencing factors will be varied to generate a better effectiveness of social, ecological and economic goals.

Furthermore several case studies (Balmann et al., 2002, Freeman, 2005, Rouchier et al., 2001) have shown that structural adjustment processes on farm level depend not only on economic forces, but also on social and psychological factors. Farmers manage not only rationally and maximize their income, in reality they act upon guidelines like fairness, solidarity, confidence and altruism. Therefore, it is necessary to implement these social and psychological principles as endogenous variables in the model and not as restrictions only.

The Modeling Method and the computational approach

To analyze structural adjustment processes as an evolutionary process, we have chosen an agent-based simulation. Recent economic studies of land use change and path dependence pointed out the necessity that the modeled farmers act autonomously in order to maximize their expected individual household income (Balmann, 1999, Happe et al., 2004, Mann, 2003). For analyzing social and ecological goals, we have to replace the income target function by a benefit target function. With this approach, we can implement a more realistic behavior of the modeled farmers, like the sunk cost trap (von Nitzsch, 2002). This means that farmers often reinvest in their low cost-effective production systems. They do this, for example, to enhance their prestige although the opportunity costs are higher.

One main advantage of the agent-based approach is that it facilitates the consideration of inter-farm linkages and of linkages between farms and environment. It allows us to model dynamic processes, in which each farmer is an individual agent, who negotiates with the other farmers in the region and thereby maximizes his/her own net benefit or family income. With this negotiating mechanism limited production resources like farm land are efficiently allocated among the modeled agents. An additional advantage of the evolutionary simulation concept in general, and of an agent-based simulation in particular, is the combination of hard factors, like environmental legislation, and soft factors, like social decision making processes. For this reason, social and psychological principles are implemented as endogenous variables.

The possibility of implementing a high heterogeneity of agents is another important reason for choosing an agent-based simulation. This approach is in sharp contrast to the general assumption of a homogenous population required for traditional farm-level models (Freeman, 2005). And Freeman (2005) adds in his conclusions that “the highly flexible nature of agent-based models, due to their focus on a building system from the ‘ground up’, allows the researcher/policymaker an improved understanding of the interplay between aggregate level behavior and patterns and the underlying characteristics of the individuals that constitute the system of study”.

The agent-based approach allows us to integrate these issues in a multi level model. The first level is the farm level which describes the individual farmers and their different production costs, income possibilities and knowledge. The second level is the local level where the spatial production resources are located, and in addition the social network is defined. The national level is the third level, where the relevant markets and policy measurements are implemented.

For analyzing the effectiveness of relevant social, ecological and economic goals, we vary influencing factors like production costs or production structures as well as policy measurements in different scenarios. At the same time, we also analyze the efficiency ratio of the varied measurements.

For the computation approach of the model we use the software AnyLogic^{TM} developed by XJ Technologies, St. Petersburg, Russia. AnyLogic^{TM} is a multi-paradigm tool based on the programming language Java, and allows us to combine agent-based simulation with System Dynamics and Discrete Event Simulation. Borshchev and Fillippov (2004) have shown the advantages and the limits of combining the three simulation methods. By using AnyLogic^{TM} for modeling, we can implement the individual behavior of the farmers with the agent-based approach, and for the ecological part, the software allows us to use System Dynamics Models with stocks and flows for the ecological part of the simulation.

Farm management strategies to change structure

As Hofer (2002) has shown, farm land markets became smaller in Switzerland since decoupled direct payments on farmland were introduced in the first half of the nineties. Therefore, we have to understand structural change in a larger context, not only as the expansion of farm land or the disappearance of farms. In our model we implement eight assumed strategies farmers can choose to change structure. Figure 1 presents an overview. Most of the farmers combine the first seven strategies to get a situation with the best benefit.

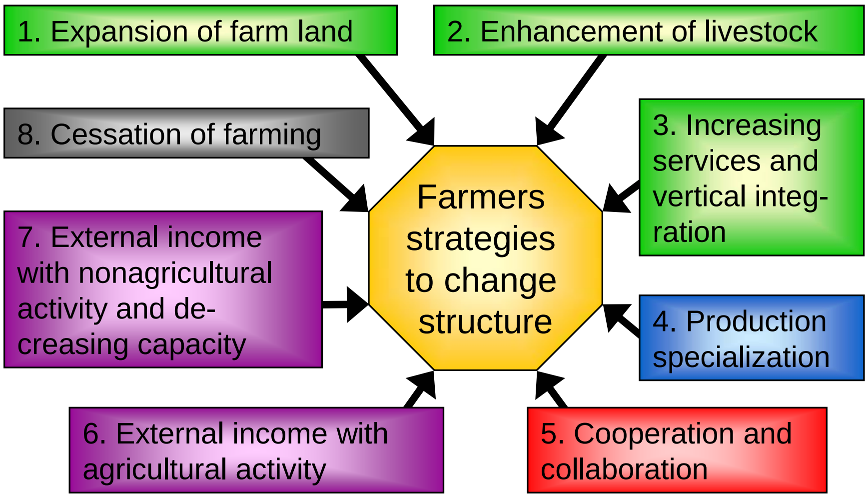

Figure 1: Several farm strategies to change structure

The first six strategies in Figure 1 attempt to use scale effects by reducing the production costs. The first strategy is expansion of farm land and the second is enhancement of livestock. The third strategy increases farm services by vertical integration. The fourth strategy is decreasing of production costs through specialization. Strategy five is a reduction of production costs by cooperation and collaboration with other farmers. The sixth strategy contains external income with agricultural activity, like wage work for other farmers. The seventh strategy is the reduction of activities on the farm and increasing the income outside of agriculture. The last strategy is the cessation of farming, which farmers choose when the other strategies do not generate the same high benefit. This is the only strategy farmers cannot combine with the other seven strategies in our model.

The cooperation problem and the advantages and costs of cooperation

For implementing cooperation and collaboration strategies in a structural adjustment simulation the modeled farmers must can interact. They decide simultaneously without knowing the decision of the other farmers. Hendrikse (2003) characterizes this situation as the cooperation problem where various Nash equilibria are possible by a lack of information. Hendrikse (2003) describes several ways to solve this problem: first, to get additional information; second, to change the payoffs; third, to reduce the number of players to one; and the fourth, to decrease the possibilities of choice. The best way to reduce the several equilibria to one is to minimize the lack of information within the modeled farmers. Therefore the modeled farmers must communicate with each other to share their information about their best individual strategies.

In fact, we can also observe this situation in reality, but the farmers have hidden costs for communication and administration. So they have higher costs for management on the one hand and on the other, their production costs can be lowered with cooperation and collaboration by scale effects. For example they can pool their fields to get greater land area for reducing their work time or machine costs per hectare. Or they can share a stable together and minimize the investment costs per livestock unit or free up time.

Validation and the limit of prediction

Jager and Janssen (2002) warn against using agent-based simulation models for policy development and support without improving the validity of the behavioral dynamics that is based on empirical findings. To validate our model, we use several approaches. First, we started the model with a historical situation from 1995 and compare the modeled results for the year 2005 with the actual situation. Using this approach the modeled environmental and market rules can be validated. Second, we will conduct a survey with the farmers from the modeled area to explain the differences between the model results and current situation. Third, we will use the model results as an input in a role playing game with other farmers. With these behavioral experiments, the modeled behavioral patterns of the agents can be compared with the observed behavior of the farmers.

Another approach for validation is to compare this model with other agent-based simulation models in related field of research. Because it uses object oriented programming, the model can be easily adapted for new market or policy rules as well as other local attributes. Thus, it is applicable for several country situations as well.

Conclusions

The agent-based simulation approach integrates various advantages for modeling structural adjustment processes. First, the limited resources like farmland are allocated in a mutually beneficial way by negotiating. Second, the integration of path dependence allows us to model structural adjustment as a strongly dynamic process. So the farmers in the model cannot revoke their decisions already made without sunk costs and thus they have to share information about their preferences for cooperation and collaboration. And third, the multi-level design and the object programming language facilitate the adaptation of the model for new policy or cost scenarios or for other regions.

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