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Evaluation of political control instruments for the Swiss alpine region

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Abstract

This paper analyses different direct payments system for the Swiss alpine region based on the multi-agent model SWISSland. Moreover, the future demand and management of the alpine pastures are simulated under different scenarios until 2020. In the model, agents are representing existing summer farms and are able to interact with each other. The results imply that the current direct payment system for the Swiss alpine region is effective and able to maintain a stable development until 2020. Since the land management in the alpine region is the activity that provides public goods, it would be reasonable to enforce payments that maximize the area of summered land. A change to contributions coupled to the surfaces could achieve the desired management of the alpine pastures meaning, at the same time, a need of proper monitoring systems.

Keywords: multi-agent models; policy analysis; simulation; alpine region

JEL classification: C16; Q18.

1. INTRODUCTION

Alpine grazing fulfils several functions for society as biodiversity protection, touristic attraction, traditional landscape and regional economy. Although in the last years contributions for the alpine region had increased, the alpine land use is in decline. In order to maintain the management of the Swiss alpine dairy farming, animal-referred direct payments will need to be provided also in the future (Mack et. al., 2008). Optimization models are used in order to simulate agricultural systems since a long time. Multi-agents models, where several agents are optimized independently, represent a new frontier as modelling method and are increasingly being developed replacing the use of the sector models, in which regional farms are optimised as a whole (Möhring et. al, 2010). This type of models allows the analysis of political instruments not only on the sector- but also on the farm-level. In 2006, Lauber developed the spatially explicit empirical agent-based model SULAPS for predicting structural changes in the agricultural sector for all existing farms of two case study regions in the mountain area of Eastern Switzerland (Lauber, 2006).

With the SWISSland Alpmodel we aim at forecast future developments of the whole Swiss alpine region based on a multi-agent model were the agents are representing the summer farms. What should we expect if no political intervention was made until 2020? What would happen if the direct payments coupled to the summered animals were increased? What consequences would involve the change to direct payments coupled to the managed surfaces instead of coupled to the summered animals?

The paper is intended to outline the SWISSland Alpmodel which is being used to support the decision making on the next development of the direct payment system for the Swiss alpine region[1]. Moreover, the approach used for the definition of the agents' population and the integration of qualitative factors in the data set is explained. Three scenarios had been simulated in order to analyze the effects of policy change. Other scenarios will be simulated afterwards.

In the next paragraph an introduction to the relevant theoretical background is presented. Model's general structure, objective function and data sources are explained afterwards. Further, scenarios and results are presented and discussed.

2. METHODOLOGICAL APPROACH

2.1. Overview and theoretical background

Optimization models belong to the case toolbox of agricultural economists since a long time and are an important tool for agricultural policy analysis. Agent-based simulation models (ABM) are increasingly being used to aid decision-making in agricultural policy designs (Happe, 2005). This is reflected not only in the high demand for scientific policy support, but also in a large number of projects explicitly involving the use of optimization models and the amount of financial resources going into model development and applications (Happe and Balmann, 2008). This type of models, where several agents are being optimized independently, offers several advantages respect to more conventional approaches as the sector models. Specific advantages include their ability to model individual decision-making entities and their interactions, to incorporate social processes and non-monetary influences on decision-making, and to dynamically link social and environmental processes (Matthews et al., 2007). Usually, an agent-based model is composed of a number of individually acting decision units (agents) which are able to interact with each other and with the environment where they are located. Agents are defined as "decision units „because they are able to choose or change their activities between a given range of possibilities and they might even decide between different investments alternatives. Agents' properties are not fixed in advance, but are subject to ongoing change, which might be triggered by interaction with other agents or through learning mechanisms (LeBaron et al., 2008). This type of models are flexible with respect to the way they are implemented since the modeller is free to base individual agents' behaviour on theory, empirical observations, or ad-hoc assumptions (Happe and Balmann, 2008) and are similar to the ways in which stakeholders generally think about actions and interactions between decision makers (Matthews et al., 2007). When applied to agriculture, agent based models can simulate, at the micro-level, the behaviour of individual farmers, without the need of aggregating them in "representative" agents, and then generate the macro (aggregate)-evidence (Lobianco and Esposti, 2010). As the other types of models, also the multi-agent models are based on a number

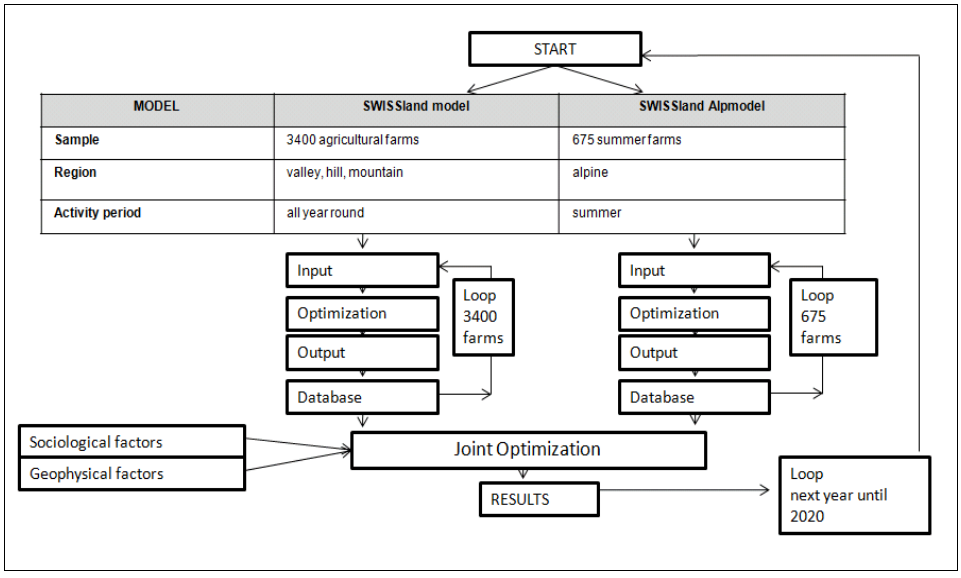
1 The project was supported by the Swiss Federal Office for Agriculture (FOAG) and is the part of the joint-project AlpFUTUR

of assumptions. Explicit assumptions are required to define the model and to limit the complexity of the model for modelling and computation sake. Nevertheless, in general one cannot exclude the fact that simplification decisively influences the model's results (Hamilton et al., 1985). Examples of recent European multi-agent optimization models are: SWISSland (Möhring et. al, 2010) and SULAPS in Switzerland (Lauber, 2006), AgriPoliS in Germany (Happe et. al., 2004), and RegMAS in Italy (Lobianco and Esposti, 2010).

2.2. The SWISSland model

The SWISSland (Swiss Agriculture Structural Change Information System) model 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 behaviours, with the aim of improving the simulation and forecasting of structural change. As in most agent-based models in the agricultural sector, also in this model each agent is representing an existing agricultural farm. Since SWISSland is meant to represent the whole of Swiss agriculture, the agent population must reflect the heterogeneous structural and socio-economic characteristics and behaviours as realistically as possible. The location, farm type, resource endowment and cost structure of the agents are based on the FADN data while socio-economic characteristics were obtained through questionnaire (Möhring et. al, 2010). The part of the SWISSland model concerning the alpine region is defined as: "SWISSland Alpmodel". Following graph shows the SWISSland general framework.

Figure 1. SWISSland model general framework



Source: own elaboration

2.3. The SWISSland Alpmodel

The SWISSland Alpmodel is based on mathematical programming methods. The high heterogeneity between summer farms is one of the reasons why a farm-based multi-agent

approach is the most appropriate choice in order to simulate the effects of policy interventions. The model optimizes each single summer farm independently through recursive non-linear programming. The agents are simulating repeatedly 675 currently (2008) existing Swiss agricultural summer farms. The time horizon studied ranges from 2008 to 2020, with 2008 as reference year. Main output is the value of the agricultural income of the summer farms. It is necessary to define the agents in the reference year regarding natural and human resource endowments, grassland production, products' factor markets, primary and processed products and agricultural policies. Most of these inputs become, after the reference year calculations, outputs. Further, an overview of the main inputs and outputs variables of the SWISSland Alpmodel is provided.

Table 1: Overview of the optimization model

<table>
<tr><td></td><td></td><td>Financing</td><td>Animal husbandry</td><td>Grassland</td><td>RHS</td></tr>
<tr><td></td><td>Household income</td><td colspan="3">Objective-function coefficients</td><td>Max.</td></tr>
<tr><td rowspan="3">Factor Capacities</td><td>Surface devoted to livestock (ha)</td><td rowspan="4" colspan="3">Technical coefficients</td><td rowspan="4">Capacities</td></tr>
<tr><td>Manpower hours (Employed)</td></tr>
<tr><td>Manpower hours (Family member)</td></tr>
<tr><td>Ecological Restrictions</td><td>Cantonal restrictions (max. animal units)</td></tr>
</table>

Source: own elaboration

The livestock held at the summer farm is probably the most influencing input variable of the SWISSland Alpmodel. The maximal livestock capacity is exogenously restricted. For each summer farm, the cantonal administration determinates the maximal number of animals for three categories (dairy animals, non-dairy sheep and other non-dairy animals) based on the length of the summering, the available pastoral surfaces and the potential erosion damages. However, as long as the number of the livestock does not go below 75% or over 110% of the maximal allowed amount (=100%), the alpine farm manager receives 100% of the public direct payments. Other constraints are represented by the labour and the fodder availability. Specifically, for each summer farm and period, the total amount of livestock cannot exceed the total supply through grassland production and present manpower. As long as all these restrictions are fulfilled, the farmer have a choice between different animal categories (dairy-cows, dairy-sheep, dairy-goats, mother-cows, young cattle, cattle over 2 years old, horses, pigs, non-dairy sheep and non-dairy goats).

In the alpine region, limits to increase the agricultural production arise not only from technologies or labour but also from the pastures' availability which may be limited in certain areas. Since data of the pastures' spatial structure and extension of the modelled summer farms are not available, we always refer to the used surfaces. In the reference year, we calculate the minimal available pastures' surfaces of the summer farm based on the number of summered animals, their forage needs, length of the summering period, the altitude and the quality of the pastures. The demand of the grass is given exogenously as daily average need for each livestock category. Moreover we estimate the total minimal surface available based on the capacity utilization of the summer farm, which can be calculated. For example, if the summer farm capacity utilization is 60% it means that at least another 40% of the pastures is still available. As constraints, for each summer farm a minimal of 0.5 hectare (as determined by the government) and a maximal of 1.3 hectare grassland extension per livestock unit are determined.

Labour supply is differentiated in two classes. The first is the labour supply provided by the farm's family members. Furthermore, summer farms can hire each year additional employees in order to accomplish the minimal requested labour supply determined by the length of the summering, the number and categories of summered livestock and the extension of the pastures to be managed.

In the SWISSland Alpmodel, production activities are essentially represented by livestock production (e.g. dairy-cows, cattle, fattening pigs, etc.) and plant production (grassland). Most of the activities consist of the production of marketable animal products except for the grassland activity which is exclusively realized as intermediate product for the livestock production. The labour activity is needed to balance capacities. Each agent, while being simulated, has the opportunity to manage his set of livestock categories responding to the market changes. Dairy products are milk, cheese and butter. The production systems can be distinguished in: none dairy production, cheese transformed at the summer farm, industrial milk production, milk transformed in a nearby village. Under different scenarios, product prices may change in response to market developments and this factor may influence the farmers' decision process.

As subsidies, direct payments based on the number of animals and the length in the alpine region as well as contributions for each kg milk transformed in cheese are considered, according to the current Swiss Agricultural Policy 2011. Finally, in order to simulate scenarios until 2020, costs and price functions are multiplied by a factor which takes into account future expected developments.

2.4. Objective function and calibration

One of the main assumptions of the model is that the manager's overall objective is to maximize its household income. This is realized solving an objective function which maximizes the summer farm total agricultural household income and which is limited by farm factor endowments and production activities (e.g. grassland, labour and fixed assets). Solving the objective function, the SWISSland Alpmodel finds the optimal level for all its endogenous variables in order to maximize the income, subject to the feasibility region determined by the

constraint functions. The objective function maximizing the household income may be reported as follows:

$$Max\ Z_t = \sum_i p_{it}y_{it} + \sum_j dp_{jt}x_{jt} - \sum_i v_{it}x_{it} - \sum_g s_{gt}l_{gt} - \sum_j \alpha_{jt}x_{jt} - 0.5\sum_j \beta_{jt}x_{jt}^2$$
$$\text{s.t. } m_n\left(x_{t=1,j=1},..., X_{t=T,j=J}\right) \leq 0$$

where, *Z* represent the household income*; i* represent buying and selling activities index; *y* the vector of the expected yield; *p* the vector of the expected price; *j* the production activities index; *t* time index; *dp* the vector of the financial contribution; *x* the vector of the animal activities; *v* the vector of the costs; s the vector of the salary for labour; *l* the vector of the employed labour; *g* the labour activities index; m_n the restrictions of all decision variables with n different equations; α the vector with parameters of the linear term (Positive mathematical programming); β the matrix with parameters of the quadratic term (Positive mathematical programming).

Even with a constraint structure and parameters that are theoretically correct, it is highly unlikely that a model will calibrate closely to the reference year data. This is inherent in the process of abstracting and simplifying a real system in which the model loses information and needs to be verified against actual behaviour (Howitt, 2002). With pure linear programming models problems of overspecialization usually occur and the Positive Mathematical Programming (PMP) was developed to overcome this problem and obtain more plausible solutions. Models calibrated with the PMP methodology yield smooth responses to exogenous changes (Howitt, 1995). The PMP approach works adding a number of non-linear relationships to the objective function of the model to calibrate the model exactly to the reference year data using the information contained in the data set (Howitt, 1995). This approach is currently applied in the SWISSland Alpmodel and, for what concerns the alpine region the observed allocations of livestock are used to derive nonlinear cost functions that calibrate the model without adding unrealistic constraints. However, it is important to recognize that this approach cannot be fully validated since the use of the quadratic cost function only represents an assumption.

2.5. Modelling the summer farms' spatial structure and traditional behaviour

The SWISSland Alpmodel is not spatially explicit defined. This means that spatial representations regarding inputs and outcomes are not implemented. Main consequence is that the model is stationary in space which is not a very limiting factor since no land exchange is considered for the alpine region. However, the spatial structure and accessibility are taken into account in a certain level influencing transportation costs and determining the agent's interaction possibilities not only for the use of the pastures but also for several other resources.

While most of the livestock is transferred during the summer period to summer farms within the same canton of the home-farm, some alpine pastures are traditionally receiving cattle from different cantons. Such traditional systems are respected in the model trough the application of restrictions.

Traditional behaviour plays a major role in determining the future of a summer farm and to model the behaviour of the farmers, several assumptions needed to be made regarding personal goals and expectations. While the whole single-farm optimization is realized with the mathematical programming software (GAMS), a JAVA platform allows the combination of the sociological and geophysical factors with the economic outputs of the optimization. The combination of all these aspects (sociological, geophysical and economic) determines the future management or the eventual abandonment of a summer farm and its pastures.

2.6. Data sources

The large amount of data needed for a multi-agent model demands the use of several databases which implied some difficulties. In order to get a complete and robust dataset, an intense data organization and assumptions were necessary. The data set used in the model can be divided into three main groups. First, single farm level data for production coefficients form the core of the optimization model, second, soft-factors obtained through a survey of the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), define the agents in a qualitative way, and third, regional and national data for production and prices are needed for the simulation in the whole time frame. The modelled summer farms sample matches the sample surveyed by the WSL (von Felten, 2011) and it correspond to 9.5% (N=675) of the total number of summer farm currently existing in Switzerland. These qualitative single farm-level data were then combined with the quantitative data extracted from the Swiss agricultural information system (AGIS).

3. SCENARIOS

The SWISSland Alpmodel allows the forecast of local response at the application of different agricultural policies for the alpine region. Based on the most probable future development of the alpine management, scenarios were planned and simulated in order to test some alternatives. In the simulated scenarios, some parameters are constantly applied while others are scenario-specific. In following table an overview of tested scenarios is provided.

Table 2. Scenarios overview

	Architecture of Direct Payments System	**Direct payments for the alpine region**	**Direct payments for the farmland regions**
I: AP2011	Unchanged (as 2008)	Unchanged (as 2008)	Unchanged (as 2008)
II: DPA	Unchanged (as 2008)	+ 50%	Unchanged (as 2008)
III: ECODP	Contribution coupled to pastures	400 CHF/hectare and no direct payments coupled to animals	Unchanged (as 2008)

AP2011: Agricultural Policy 2011
DPA: Increase of the direct payments to the alpine region
ECODP: Agri-environmental direct payments coupled to pastoral surface

Source: own elaboration

3.1. Agricultural Policy 2011 (AP2011)

In this scenario future developments of the alpine region are estimated assuming that the structure of the milk market in Switzerland and in the EU will not change substantially until 2020. Therefore, in the model current market condition as the abolition of milk quota regulations (2009), the free trade with EU of cheese market (2007) and the market support limited to the price supplement for milk transformed in cheese are considered. Milk prices decreased about 20 % in the years following the abolition of milk quota and it is possible to identify the effects on the summer farms income between 2008 and 2012. The financial crisis of 2009/2010 enhanced this trend. However, the abolition of milk price control and the removal of the milk quota regulation are expected to improve the economic efficiency of the sector in the mid/long-term. In this scenario, no change in the current direct payments system is made.

3.2. Increase of the direct payments to the alpine region (DPA)

Direct payments play a major role for the alpine region economy. In order to evaluate the importance of these contributions, some modifications in the direct payments system for roughage-consuming animals spending the summer at the alpine pastures were tested. Mack and Flury estimated in 2008 that to ensure the level of the alpine management, a substantial increase in payments would be necessary (Mack and Flury, 2008). Therefore, in this scenario, an increase of the current direct payments of 50% in respect to 2008 is simulated. No other modifications were done in this scenario.

3.3. Agri-environmental direct payments coupled to pastoral surface (ECODP)

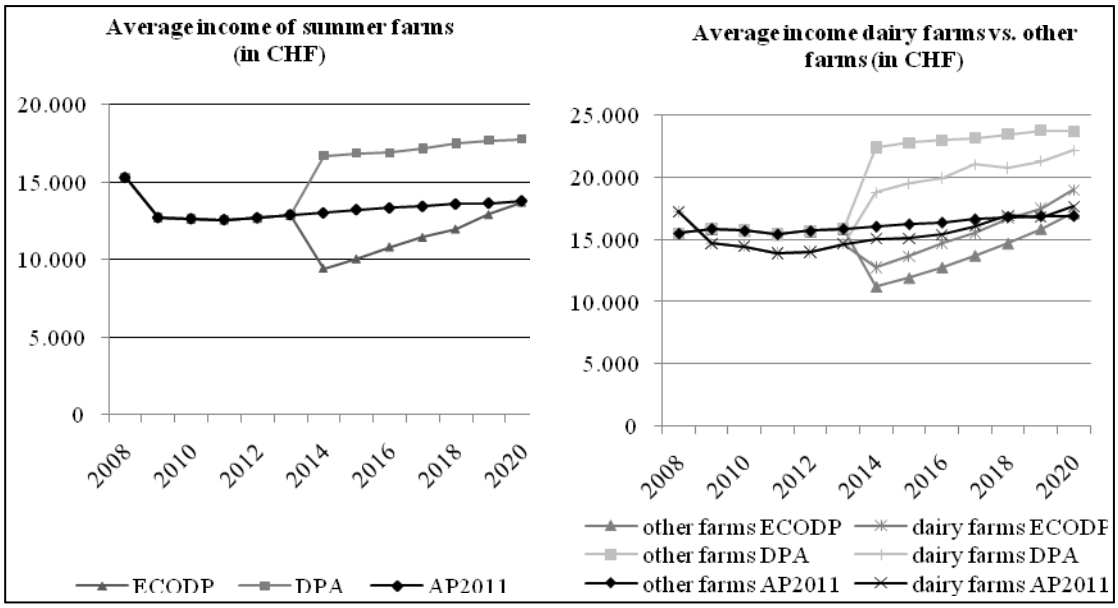
A major challenge for the coming decades will be at the local level, to establish appropriate management practices for semi-natural lands resulting from those rural practices

that are least likely to be continued for production purposes (Ostermann, 1998). Therefore, the effects of direct payments coupled not to the summered animal but to the pasture's management is one of the simulated scenarios. With the SWISSland Alpmodel an estimation of the use of the pastures as well as their land use intensity is possible. Main goal of this scenario is to find a system which should help to avoid land use polarization and to ensure the maintenance of the alpine meadows flora and fauna biodiversity. In this scenario, the model forecasts the effects of the provision of direct payments coupled to an extensive use and management of the alpine pastures. The amount of the contribution was settled at 400 CHF pro hectare based on the work of Greif and Riemerth (2006) who estimated the economic importance of alpine grazing in Austria in terms of benefit for farmers, forestry and tourism at around EUR 300 per hectare of alpine pasture.

4. SELECTED MODEL'S RESULTS

A decrease of the *agricultural income* between 2008 and 2011 is mainly due to the abolishment of milk quotas and to the decrease of the milk price. Starting in 2014, in the scenario DPA, an increase of 50% (in respect to 2009) of the direct payments per unit of summered livestock is simulated. Positive effects on the summer farms' agricultural income are observable and correspond to the increase of the direct payments and of the summered livestock. In the scenario ECODP, starting in 2014, an abolishment of the direct payments coupled to the summered livestock is compensated by the provision of 400 CHF contributions per hectare of managed pastoral surface. Here, a positive effect on the agricultural income can be observed in the long term and relies on the contributions and on the more extensive pastoral management since the number of livestock actually decreases strongly.

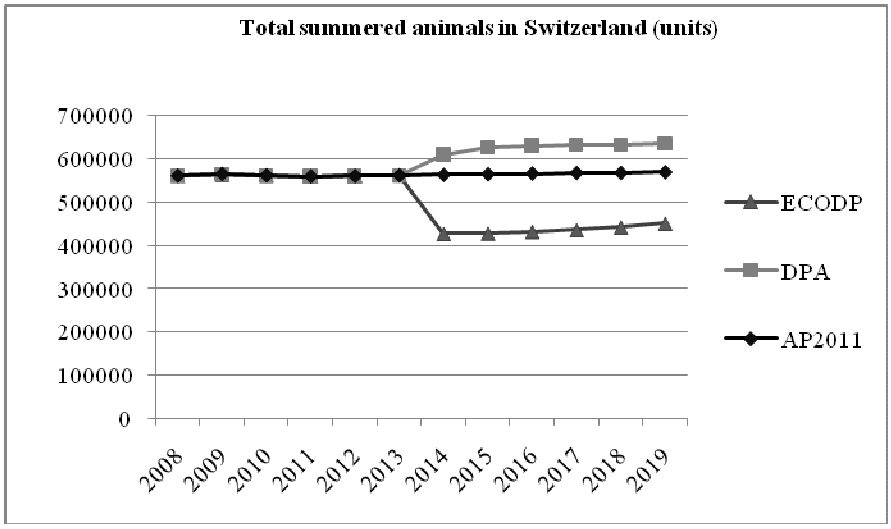
Figure 2. Average income of Swiss summer farms under the three simulated scenarios



Source: own elaboration

Different developments in the management of pastoral surfaces under the simulated scenarios show the strong impact that agricultural policies changes might have on the alpine region. Scenario AP2011 shows a relatively constant number of *summered livestock*. The observable decrease of summered animals until 2013 corresponds to the decrease of the dairy cows and relies on the price trends. If in 2014, the contributions for the alpine region were increased by 50% (scenario DPA) the total number of summered livestock would tend to increase in following years as well. However, limits in the increase of the number of summered animals could be represented by the available pastoral surface. A change in the direct payments system with contributions coupled to the pastoral management (scenario: ECODP) would lead to a more extensive use of the pastures, partially due to the drop of the total number of summered livestock happening right after the application of the policy change. With the time we can see how the number of summered animals tends to increase back but still, with this policy, the density of the animals per hectare will certainly be held at the minimal level possible.

Figure 3. Total summered animals in Switzerland under the three simulated scenarios



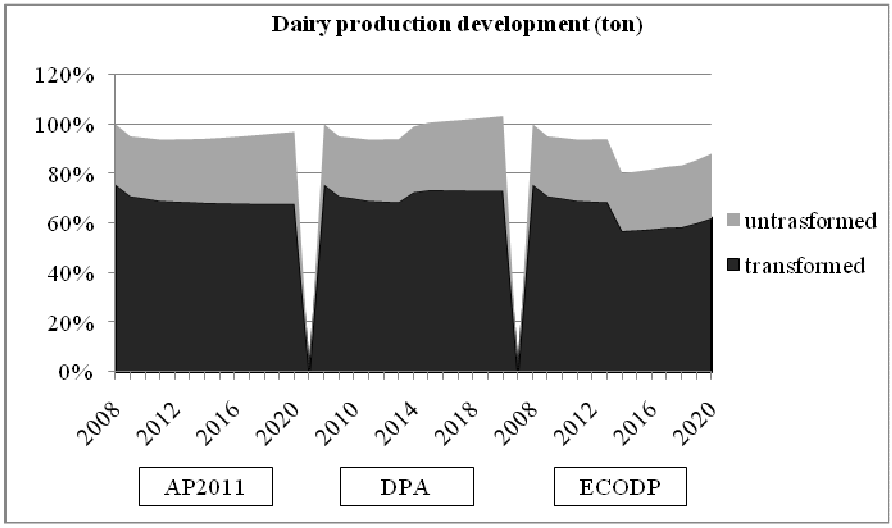
Source: own elaboration

The development of the *dairy production* in the alpine region is clearly connected with the trends of the summered dairy animals. Moreover, other factors determine the production of these valuable products as the availability of experienced labour force as well as the price of the milk. In the following figure the trend of the dairy production under the simulated scenarios is provided differentiated by transformed (cheeses, butter) and untransformed milk.

In all scenarios, the dairy production decreases until 2012 due to the milk price trends and tends to stabilize afterwards. Under scenario AP2011, the production of untransformed milk seems to remain quite stable and actually increases at the end of the time frame while cheese production shows a constant declining trend. In scenario DPA, the dairy production increases after 2014 essentially as a consequence of the increased number of summered livestock units. Dairy production drops in the ECODP scenario because of the decrease of summered dairy

livestock and even if it tends to increase afterwards, it remains way below production of 2008. Since with this policy contribution are provided depending from the managed surfaces and there is no actual distinction between the summered animals' categories, this trend is plausible.

Figure 4. Development of the dairy production in the alpine region (expressed in % respect to 2008) under scenarios AP2011, DPA and ECODP (100% = 72973 ton milk)

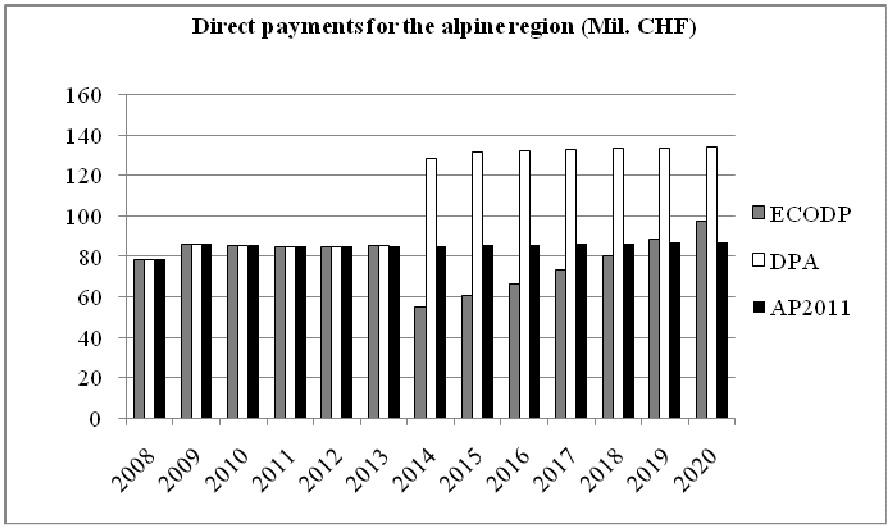


Source: own elaboration

The trend of the total expenditure for the *direct payments* in the simulated scenarios is illustrated in the following figure. As we can see, under AP2011, the amount of contribution for the alpine region would remain relatively constant until 2020. Obviously, under scenario DPA, the direct payments total costs would substantially increase. More interesting is probably to observe the costs of the contribution coupled to the pastoral surfaces. Under scenario ECODP, the total costs in terms of contributions for the alpine region would drop right after the policy application and would then increase back.

The *labour* market of the alpine region is expected to develop as it is shown in the following figure under the simulated scenarios.

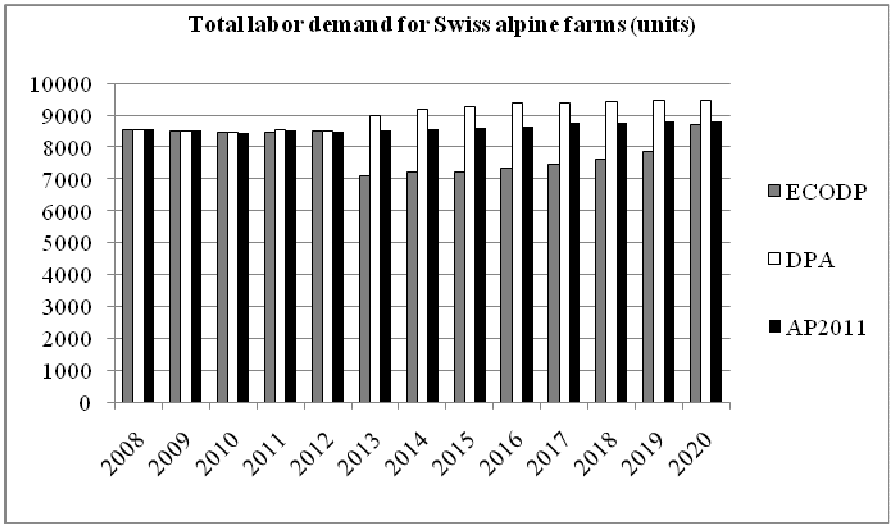
Figure 5. Total expected yearly expenses for contributions to the alpine region.



Source: own elaboration

Under scenario AP2011, the demand remains relatively constant although fluctuations are observed and referable to several factors including price trends and milk quota abolishment. In scenario DPA, the increase of the summered livestock causes a growth in the demand of the manpower demand. Although the observed growth is not very strong, problems could occur in case of an increase in the labour demand which is always less likely to be fulfilled because of the low availability of experienced labour force and limiting costs. Under scenario ECODP, a drop in the demand of labour follows the drop of summered animals. However, in a few years the trend reaches back the demand of the other two scenarios.

Figure 6. Total labour demand (expressed in number of employee working full time) for the alpine region under scenarios AP2011, DPA and ECODP.



Source: own elaboration

5. CONCLUSIONS

This paper describes the mathematical structure of the SWISSland Alpmodel. The model has been developed to assess the economic impacts of agricultural policies changes in the alpine region. Therefore, the model intends to support policy analysis especially regarding the evaluation of the direct payment system for the alpine region. The scenario AP2011 shows the expectable trends if the agricultural policy systems remains unchanged. According to the results, if no political intervention is made, the development of the alpine region would maintain its current trend without many changes. Under scenario DPA, direct payments coupled to the summered livestock units would be increased of 50%. In this scenario, a higher amount of animals would spend the summer at the alpine farm and main consequence is an increase in the managed pastoral surfaces or a more intensive use of the pastoral surfaces. Under this scenario, difficulties regarding the labour availability and possible cases of overuse of the pastoral surfaces should be foreseen. Always less experienced people are working at the summer farms and an increase in the demand is unlikely to be easily fulfilled. For this same reason and also for the high workload at these farms an over use of the pastoral surfaces is possible as well. A correct management of the pastures, the control of the reforestation as well as the proper installation of the fences demands well prepared farmers and represent costs as well. Moreover the total expenditure in terms of direct payments would increase strongly under this scenario. Scenario ECODP shows the effects of direct payments coupled to the managed surfaces instead of coupled to the summered livestock. Positive effects in the maintenance of the pastoral management are observable. However, after the policy change, the number of the summered livestock decreases strongly and recuperates a few years afterwards. Since land management in the alpine region is the activity that provides public goods, it would be plausible to enforce payments that maximize the area of summered land as the observed scenario with area based payments obviously does. However, in this case there would be a strong need for monitoring systems that control which areas in the alpine regions show signs of agricultural over use to avoid opportunistic overstatements of grazed areas. Moreover, way more detailed data about the pastures' borders and ownership should be collected.

Limits of this project are relying on the data quality and on the limits of the modelling method itself. The scarce availability of data regarding the summer farms and the consequent use of normal data decreases the capability of this model in providing accurate results on the single farm level. However, in any moment, more detailed data can be integrated in the database improving the results. Moreover, limits derive from the structure of models as well, which are by definition simplified abstractions of the real systems.

The results imply that the optimal policy strategy for alpine farming depends on the objective in this area. The direct payment system for the Swiss alpine region is effective and an increase of the contributions could increase the use of the alpine pastures. A change to contributions coupled to the surfaces could attain the desired management of the pastures meaning, at the same, time the need of proper monitoring systems.

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