Towards a cost-benefit assessment of farm structural change in European mountain regions

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Abstract

Farm structural change increases the productivity and efficiency of farming. In the policy debate, however, there is still a strong attachment to a highly fragmented structure of family farms, especially in countries with high support for the agricultural sector. In these regions, the somewhat "romantic" attachment to small family farms in the policy debate may also be interpreted as a public preference for concomitant non-use values of agricultural production. As a consequence, a cost-benefit analysis including the economic gains from farm structural change as well as the non-use values of small-scale, traditional agriculture may give a new perspective on this policy debate. We here combine results from a discrete choice experiment in a Swiss mountain region with simulation results from an agent-based farm model in the same case study region. We compare the willingness to pay of local people for farm survival with the reduced average income that results from impeded structural change. Results imply that on average WTP is higher than the opportunity costs. However, the differentiation into farm types shows that productive full-time farmers would have to bear the highest opportunity costs that exceed the average WTP by far. We discuss this result with respect to the policy debate and further research.

1. Background

In most European regions, agriculture is undergoing a progressive structural change with a decline in the number of farms (e.g. Zimmermann and Heckelei, 2012). This farm structural change increases the productivity and efficiency of farming through the re-distribution of land and labour and the realization of economies of scale. While the economic benefits from farm structural change are indisputable, there is still a strong attachment to a highly fragmented structure of family farms in the policy debate and there seem to be little consensus about how much restructuring, rationalisation and consequent decline in smaller farm employment is acceptable (Buckwell, 2015).

The debate is of particular importance in mountain regions where natural production conditions constrain farm growth and national policies often focus on the support of multifunctional rather than on competitive and efficient farms (Flury, Huber and Tasser, 2013, Pinter and Kirner, 2014). In these regions, the somewhat "romantic" attachment to small family farms in the policy debate may also be interpreted as a public preference for concomitant non-use values of agricultural production. Indeed, economic valuation studies exemplify preferences for 'rural' multifunctionality such as residential or leisure functions (e.g. Gómez-Limón, Vera-Toscano and Rico-González, 2012) or traditional agricultural practices (e.g. Mazzocchi and Sali, 2016). Current research, however, does usually not consider such public preferences in the assessment of farm structural change.

To address this gap, we here combine results from a choice experiment in a Swiss mountain region with simulation results from an agent-based farm model in the same case study region. We compare the willingness to pay of local people for farm survival with the reduced average income that results from impeded structural change. Such a novel approach represents a step towards a cost-benefit analysis of farm structural change in mountain regions. Considering costs *and* benefits in structural change provides information for policy makers on the level of structural change that might be more acceptable and thus support the policy debate on multifunctional agriculture in rural regions.

2. Methods and Data

2.1. Choice experiment

We use the results from a discrete choice experiment (DCE) in the inner-alpine region of Visp for the quantification of the benefits associated with farm survival (for details see Brunner, Huber and Grêt-Regamey, 2016, Rewitzer, Huber, Grêt-Regamey and Barkmann, submitted). DCEs have frequently been used for the economic valuation of landscape-related changes. They are consistent with random utility theory and can be used to elicit passive use values. The method provides an opportunity to identify marginal values of attributes and has the potential to explore the entire WTP distributions including individual WTP values (Schläpfer, 2015). Key challenges are the hypothetical nature of respondent responses, differences in WTP and WTA as well the often complex nature of the experimental design, and the selection of appropriate attributes and attribute levels (e.g. Hausman, 2012). Recent applications of DCEs, however, have shown that state-of-the-art approaches and careful designs may address these challenges in a reasonable manner.

The experiment in our case study region focused on cultural ecosystem services (CES) and covered agricultural heritage, the existence value of biodiversity, and scenic beauty. Additionally, protection against natural hazards typical for mountain areas was included. The attribute on scenic beauty was operationalized via computer-generated visualizations. The visualizations differ with respect to sub-attributes on the visual impact of changes in forest area, grassland management, and settlement expansion. For the following analysis, only the attribute of agricultural heritage and the monetary attribute are used.

The DCE was divided in four sections. First, respondents were briefly introduced to landscape change in the Swiss Alps as a result of external environmental processes, market forces, political decisions, and individual action. Next, we asked respondents attitudinal questions with respect to the attributes which also served to acquaint respondents with the concepts behind the indicators before introducing and explaining the (C)ES attributes of landscape change. With respect to the farms, we asked the respondents whether they buy and if yes what their motivation is to buy local products. The third part of the questionnaire covered the DCE itself. Finally, socio-demographic standard questions were asked. The importance of agriculture to local traditions, regional identity and sense of place became evident during the qualitative interviews as well as in the questionnaire. Thus, agriculture is an essential part of the region's cultural heritage and the number of farms was chosen as the most suitable indicator to reflect this preference.

The monetary attribute was operationalized as changes to the yearly personal income tax bill (five levels from +6% to -6%). By adapting the cost attribute to the individual tax burden, the credibility of the cost attribute can be increased (Schläpfer, Schmitt and Roschewitz, 2008). We included willingness-to-pay (WTP) as well as willingness-to-accept compensation (WTA) levels to reflect the fact that improvements as well as impairments of the cultural landscape are depicted in the DCE. To convert fractions of the tax bill to absolute amounts, a closed format question was used in the survey that asks for a rough quantification of the annual tax bill (7 multiple choice categories ranging from less than 2,000 to more than 12,000 CHF). Respondents who did not indicate their annual tax bill (n=54) were assigned the mean value of the sample.

The attribute cultural heritage i.e., change in the number of farms and the monetary attribute had three and four levels, respectively (Tab. 1). We assumed an additive utility function linear in parameters with respect to the attribute levels as coded in Table 1 and used nested Logit models to estimate the parameters. To estimate the WTP, we calculated the negative ratio of the cultural heritage coefficient and the coefficient of the cost attribute.

Table 1: Selected DCE attributes on CES in the Visp area (Swiss Alps)

Attribute	Indicator	Levels (Coding)
Agricultural heritage	(change in) number of farms	-50; -25; -10; 0 [SQ: 173 farms]
(…)		
Income change	changes in tax statement [%/year/person]	-6; -3; 0; +3; +6

Note: (…) Other CES attributes are not shown.

The general results of the choice experiments show that respondents would voluntarily pay a mean of 0.076% more income tax if one of the next farms to disappear was saved. The pre-studies had already indicated that agriculture is an important part of regional identity (see Box 1). The stated motive why respondents buy local products influences the economic appreciation of agricultural heritage. This can be interpreted as a sign that the chosen indicator represents quite well the meaning of agricultural heritage for the respondents. On average, respondents indicated that they were paying 3’603 CHF of taxes per year. Multiplying this amount with the estimated mean WTP of 0.076%, this results in total amount of 2.8 CHF every household would be willing to pay for the prevention of one farm exiting the sector. With 5’832 households in our case study region, the total amount of benefit associated with structural change not taking place amounts to 16’061 CHF per year and farm. Unfortunately, the estimation of the parameters for the three attribute levels (dummy coded) was not significant. Thus, we used the mean WTP as indicator for the benefit loss within the levels of the DCE.

2.2. Agent-based modelling

The purpose of ALUAM-AB is to simulate future land-use and structural changes, triggered by the combined effects of climate, market and policy changes and giving due consideration to the individual decision-making of the farmers. The model is defined by interconnected human and environmental/agronomic subsystems. Agents represent groups of farms. An agent has (1) its own state (i.e., land endowment, animal housing capacity, etc.) which is updated after every simulation period of one year and (2) decision-making mechanisms for managing farm resources (i.e., a constraint income maximization based on mathematical programming techniques). The state of the agent includes variables for household composition and available resources (land, capital and labor) and a specific type of decision-making based on opportunity costs of labor and a threshold for minimum income and other characteristics. The agent characterization i.e., the typology of decision-making is derived from a cluster analysis based on a survey (n = 111 out of 215 farmers in the whole region in 2012), interviews (n = 15) and administrative structural data.

Methodologically, the agent typology generation followed four steps: Firstly, we performed a principal component analysis (PCA) on 19 questionnaire items relating to farming objectives and attitudes based on the farm survey. Secondly, PCA regression coefficients were clustered by applying kmeans clustering. Silhouette statistics were employed to select the number of clusters for further analysis. Thirdly, the typology was refined by describing the resulting clusters with respect to additional survey data on farm structure and management (labor use, household income, age, intentions for future management) and farm census data (land-use, livestock types, parcel characteristics, participation in agri-environment schemes). Fourthly, the characteristics of the actor types were translated into modeling constraints and guidelines for initial allocation of the decision-making types to model agents i.e., opportunity costs, minimum income etc.

This procedure resulted in five different farm types in our case study region (Brändle, Langendijk, Peter, Brunner and Huber, 2015). *Production-oriented farmers* attaches great importance to generating an adequate income, high yields and innovative products from their farming activities. *Ecological and landscape stewards* place a stronger emphasis on the social, ecological and landscape aspects of their farming activities than on the achievement of high yields or profits. They consider extensive land-use and the provision of ecological services to be both an adequate source of income and an effective measure to increase biodiversity. *Part-time or leisure-oriented breeders* share a strong interest in being recognized as "good" farmers or breeders within their respective (farming) communities and to share their farming passion by participating in exhibitions, competitions, or cow fights. *Traditionalist leisure farmers* undertake small-scale farming as a way to maintain local traditions. Compared to type 3, they do not aim for such a strong involvement in breeding, competitions and local decision- making, and show much higher stated opportunity costs. *Leisure-oriented farmers* place a high importance mainly on being involved in local decisions and village life. They are significantly less focused on achieving high income and yields than the other clusters but do not place a strong focus on ecological or competition objectives either. All of the farmers work out-side of agriculture and, with an average of 2.8 hours, labor invested in agricultural activities is very low. The combination of these five decision types with the farm structural data resulted in 14 different agent types. In the following analysis, we group these 14 types into fulltime farmers (n=10); part-time farmers (n=141) and leisure farmers (n=100).

The environmental/agronomic subsystem is characterized by the agricultural production cycle in the case study area. Agronomic variables include plant nutrient requirements (N, P), manure production and production coefficients such as fodder intake, growth, birth, deaths of animals and labor requirements that are based on national average data and are the same as in the aggregated model presented by Briner et al. (2012). In the modeled farm decision process (income optimization), the environmental variables are considered as material (fodder and nutrients) balances that link land-use activities with livestock activities. As a result, land-use intensities can be defined in a spatially explicit manner. Crop rotation requirements and a labor balance are additional constraints that link the human and environmental/agronomic subsystems.

Structural change is modeled using a land market sub-model. The model identifies land units that are no longer cultivated under the existing farm structure. There are three reasons why fields are attributed to the land market in the model: i) units generate a land rent below zero, ii) the corresponding agent does not reach the minimum wage level, therefore the farm is abandoned and all the assigned land enters the land market or iii) the farmer retires in the simulation year and has no successor. The land market sub-model randomly assigns the land units to one of the other agents. It is then checked to confirm that this agent shows the two following characteristics: the agent receiving the land unit must want to expand his cultivated area (stated willingness to grow) and his shadow price for the land unit must be positive. If these conditions are not met, the land unit is re-turned to the land market and assigned randomly to another farm. Once again it is checked to verify that this agent fulfils the conditions for the assignment of land. This procedure is repeated until all land units are assigned to a farm or none of the farms is willing to take the land units left on the market. Land units that are not transferred to other farms are defined as abandoned and natural vegetation dynamics get under way on these parcels (modeled in the vegetation model LandClim (see Briner, Elkin and Huber, 2013 for details)). If land-use allocation is optimal, farm-land capacities and livestock are updated and the next annual time step is initialized using the parameters (prices, costs, direct payments) of the following year.

For the simulation of structural change, the probability of having a successor after the retirement of the farmer is critically driving the number of farms in ALUAM-AB. For the following analysis, we performed a sensitivity analysis of this probability. The standard model coding represents farm succession as a linear combination of farm type and farm size. We use different succession rates for farm types based on the survey in which farmers revealed whether they have a successor or not (if they were older than 40 in 2011). In addition, we used past changes in the numbers of farms for each cluster to derive the probability within three size clusters (<5 ha, 5-15 ha, >15 ha). For fulltime farms with a farm size bigger than 15 hectares, for instance, this resulted in a succession probability of 80%. We used random numbers to simulate the probability of farm exit for each of the linear combination of farm types and size. Since the farm structural data included the age of every individual farmer in the case study region, we could assign the number of farmers that are retired for every farm type and year and then assign a succession probability to the corresponding farm. Farm entry is not considered in ALUAM-AB. Farm structural change in Switzerland is highly regulated trough the federal law on peasant land markets (Huber, Flury and Finger, 2015) which actually prevent the entry of new farmers in the sector. The agent-based model is fully described in Brändle et al. (2015) using the ODD protocol.

2.3. Integration of choice and farm structural modelling

To assess costs and benefits from farm structural change, we use the average WTP over all households in the case study for the prevention of one farm (i.e., 16’061 CHF per year). This value is used to represent the benefit from slower structural change in our case study region. Second, we run the agent-based model under different scenarios varying the probability of farm succession. We used two climate and socio-economic scenarios, respectively, to test for the effects of lower farm exit levels. Within the four scenarios, we calculated the effect of eight different changes in the succession probability (-0.2, -0.15, -0.1, -0.05, +0.05, +0.1, +0.15, +0.2) over a period of 15 years (model runs 2020-2035). We use a “business as usual” and a more liberalized scenario to include the effect of alternative boundary conditions on the results (see Huber, Briner, Bugmann, Elkin, Hirschi, Seidl, Snell and Rigling, 2014 for details). Third, we calculate the average income reduction per farm, since lower structural change impedes the shift of land to more productive farms, and the increase in direct payments compared to a reference scenario without any changes in exit probabilities. Finally, the reduction in income per farm (including changes in direct payments) can be compared to the average benefit per farm. As long as the reduction of the farm income is smaller than the amount of 16'061 CHF, the benefit from policy measures that reduce the decline in farms is higher than the corresponding costs.

3. Results

Lower succession probabilities lead to a decrease in the number of farms in our simulations and as a consequence to an increase in the average income of the farms (Fig. 1).

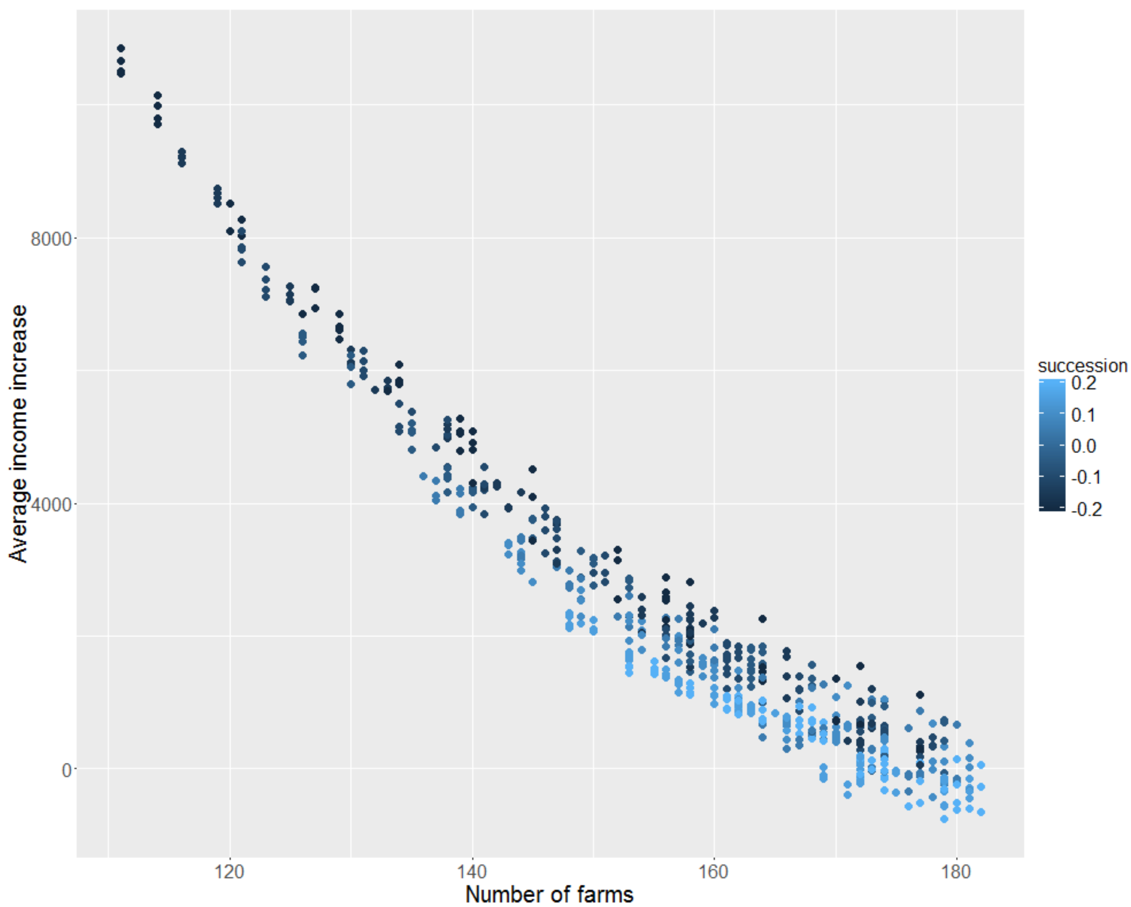

Figure 1. Simulated average income increase in CHF of all farms with varying succession probabilities between the years 2020 and 2035. Negative succession rates imply that less farms are taken over after the farmer's retirement. Positive values of the variable "succession" imply that structural change is slowed down and more farms remain in the sector. Income increase is calculated as the difference between the average incomes after structural change taking place minus the average income with the initial number of farms.

This represents the economic gains from structural change i.e., the re-allocation of land and labor to more productive farm types. Preventing structural change by keeping farms in the sector would imply that these economic gains would not occur and thus can be interpreted as opportunity costs of maintaining farm structures. Compared to the average WTP 16’061 CHF which was calculated for a reduction of 50 farms, opportunity costs are always lower than the stated benefit people would obtain from structural change not taking place.

The economic gains from farm structural change, however, varies substantially between the different farm types and the time scale considered in our simulation. For full-time farmers, the average income increase in certain scenarios exceeded the mean WTP by far (Fig. 2). Whereas in the first years the opportunity costs of full-time farmers is driven by the scenario parameters and not by the succession rate, lower succession probabilities which reduce the number of full-time farms by 30% in 2035, lead to high opportunity costs in the longer run. Please note that the average income changes in the simulations result from changes in the succession probabilities of all farms simultaneously.

Figure 2. Simulated average income increase of fulltime farms with varying succession probabilities. Size of the pixel illustrate the number of farms.

For the part-time farmers, the effect of different succession rates on average income is more pronounced (Fig. 3). The change in income with lower succession probabilities is already early visible in the simulation results and there is a much clearer divergence of increasing and decreasing rates. However, the overall level of the income change is much lower than for full-time farms and do not exceed an amount of 9’000 CHF. Since there are much more part-time than full-time farmers in our case study region, this has a considerable effect on the change in average income (Fig. 1).

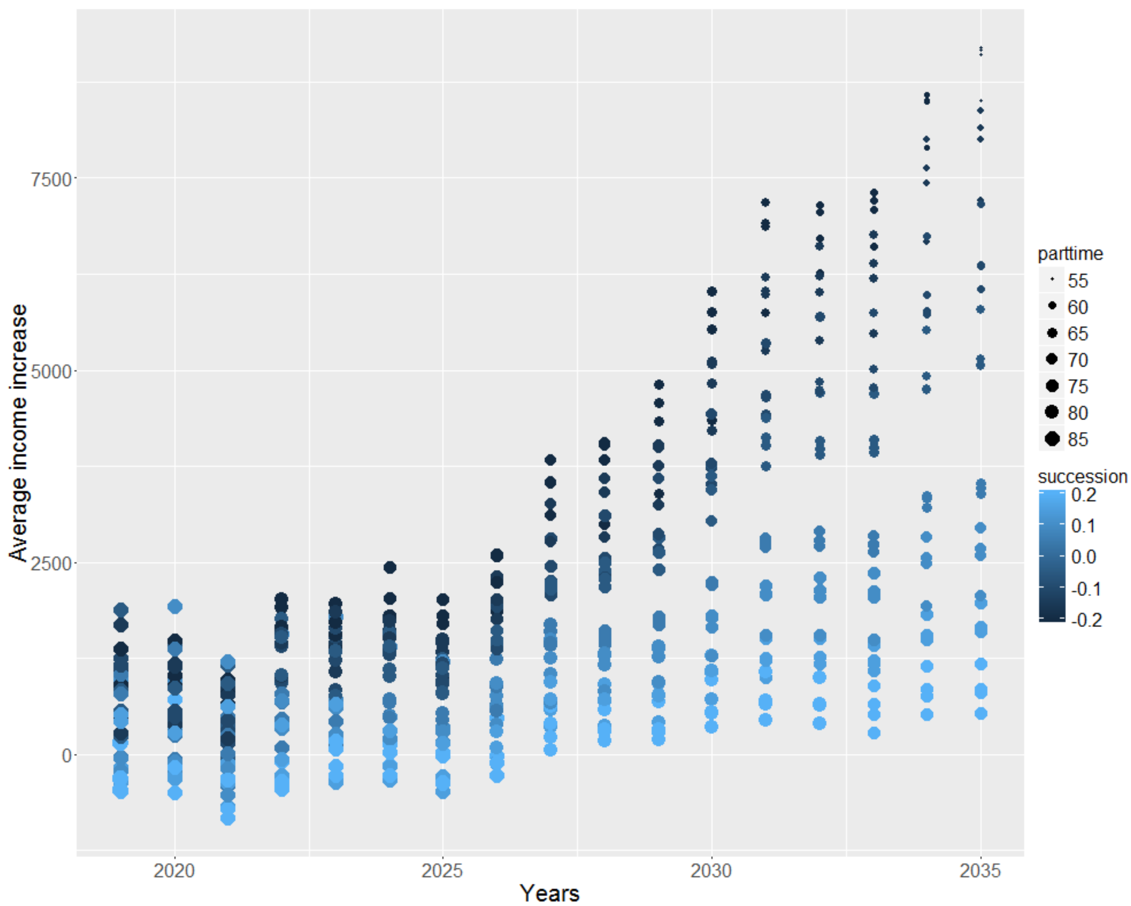

Figure 3. Simulated average income increase of part-time farms with varying succession probabilities. Size of the pixel illustrate the number of farms.

This effect is even more pronounced if also leisure farmers are considered since the opportunity costs of farm structural change not taking place are even lower. Even with a reduction in the succession rate of 20%, the increase in income does not exceed 3'000 CHF. On the one hand, this reflects the small farm sizes of these leisure farmers cultivating less than 6 ha of land on average and the fact that these farms cannot grow in our simulation model. Limited labor availability and stated farmers preferences clearly reduce the potential of farm structural change to increase the productivity of these farms. Since roughly 40% of the farms belong to this category of leisure farmers, this has a substantial impact on the average income.

Overall the simulation results imply that the average gain from farm structural change in terms of increased income is lower than the mean WTP resulting from our DCE in the case study region. There are, however, substantial differences between different farm types. While part-time and leisure farmers have low opportunity costs, the foregone income of productive and more efficient farms exceeds the average WTP by far.

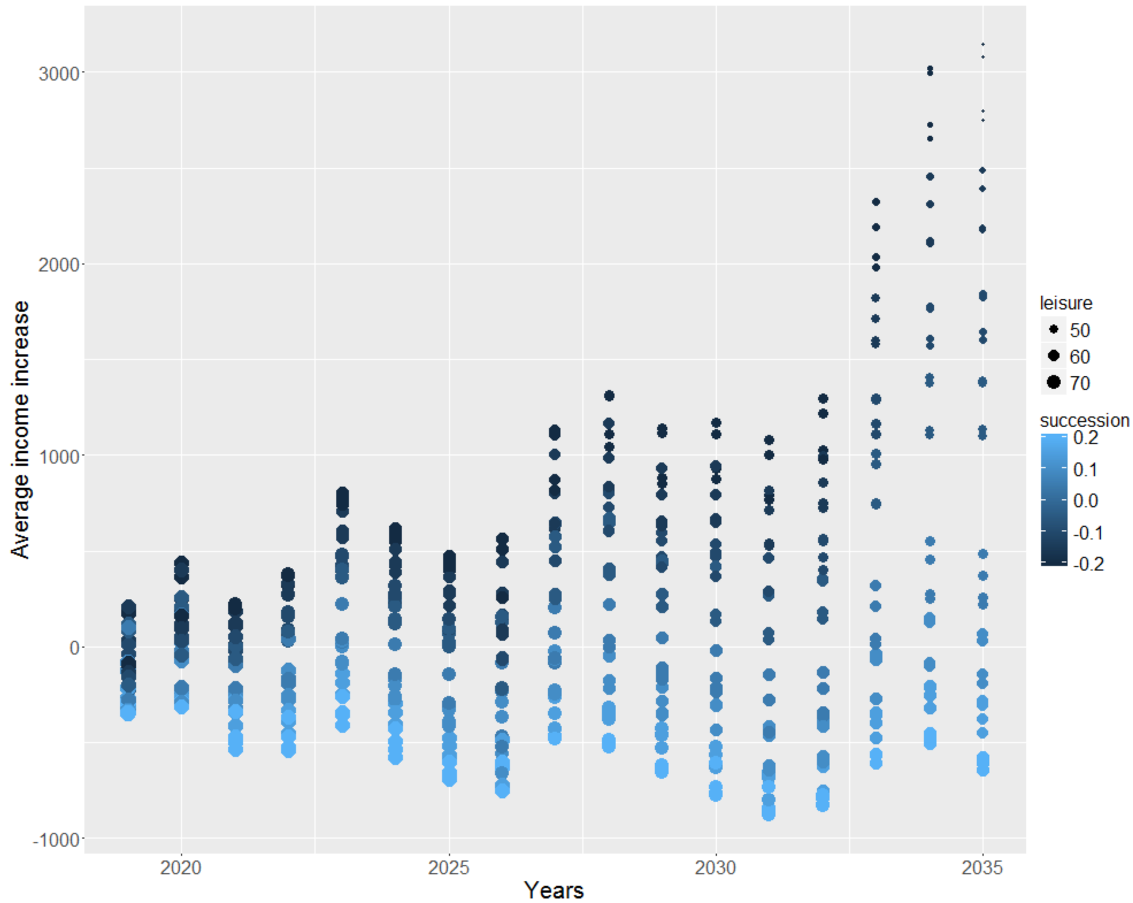

Figure 4. Simulated average income increase of leisure farms with varying succession probabilities. Size of the pixel illustrate the number of farms.

4. Discussion

This study presents a first and preliminary attempt towards a cost-benefit analysis of farm structural change in a mountain region. The combination of a DCE, monetarizing the non-use values local people attach to the existing of farms, and the simulation of different farm structural change scenarios in an agent-based model allowed to compare the famer's opportunity costs of reduced structural change with a mean WTP i.e., the benefit local people associate with a higher number of farms.

Results imply that, in fact, WTP is higher than opportunity costs which would offer room for the support of farm structures in these regions. Indeed, our DCE and the interviews revealed a strong attachment of the respondents with the farmer community in our case study region. Ignoring such preferences in policy debates may undermine the long term credibility of the sectoral policy and could – at least in Switzerland – result in referenda that could reverse policy strategies aiming towards a more competitive farm sector[1].

The comparison must, however, be interpreted with care. We did not simulate the effect of a policy change on farm exit. We performed a sensitivity analysis of the succession

[1] There is actually a referendum in the near future which would impose more protective measures on the Swiss agricultural policy: http://www.ernaehrungssicherheit.ch/de/

rate in the agent-based model ALUAM and compared the change in income with stated WTP estimates for the same case study region. This represents a rather weak link between the two methodologies. It remains open, how and to what extent a certain policy with a budget limit in the size of the mean WTP would actually increase or decrease the farm succession rate within different farm types. The two results - mean WTP and change in income - were treated as independent components of a cost-benefit analysis and thus no efficiency consideration with respect to the governmental budget are made. Further studies would have to integrate and model specific policy measures to actually link the WTP of the local people to the opportunity costs of the farmer i.e., the foregone income of reduced structural change and not only to provide a sensitivity analysis over a set of succession probabilities. Moreover, other agent-based models are depicting succession probabilities in much more detail considering, for instance, also social household characteristics (e.g. Troost and Berger, 2016). The advantage of ALUAM-AB in this context is the empirical basis (past changes and stated intentions) of the succession rate in the simulation.

In addition, the DCE was not designed to actually monetarize the value of cultural heritage i.e., the number of farms, only. Since the choice of attributes and the framing of the DCE have a direct impact on the estimation results (Schläpfer, 2015), the absolute value of the mean WTP has to also be interpreted with care. Our results imply that studies using stated preference methods to value traditional farming structures or practices (e.g. Gómez-Limón, Vera-Toscano and Rico-González, 2012, Bernués, Rodríguez-Ortega, Alfnes, Clemetsen and Eik, 2015, García-Llorente, Martín-López, Nunes, Castro and Montes, 2012) should explicitly take into account the different farm types within their case study region and link it to concrete policy measures. In our DCE it remains open what kind of farm type the local people had in mind when they were choosing between the different scenarios. Not considering farm types may result in a mismatch between what services or characteristics people value and what type of farmers actually bear the costs of these services.

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