Spatial expansion of farm types and neighborhood influence : conversions to suckler cow farms in Switzerland

Spatial expansion of farm types and neighborhood influence – conversions to suckler cow farms in Switzerland

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Abstract

Since the introduction of direct payments for non-dairy ruminants including suckler cows in 1999, the number of specialized suckler cow farms in Switzerland has seen a significant increase. This paper explains the farm conversions to accommodate suckler cows, specifically taking into account neighborhood influences in traditional and non-traditional suckler cow regions. In the interests of achieving a better understanding of the dynamics of production decisions, the analysis takes into account different time periods. As far as changes in production were concerned, a positive neighborhood influence could be confirmed only for the time periods soon after the political change and for regions where the production technologies were not well-established. The results provide evidence that, from a sociological point of view, neighborhood influence based on uncertainty plays a specific role. For all regions and cantons, a persistent neighborhood influence prior to the later adoption periods could not be verified, which indicates that economic advantages based on the agglomeration of infrastructure and services for suckler cow production were not developed. The results show that the main driving forces for production changes and for the spatial distribution of suckler cow farms were structural conditions at farm level.

Keywords: *Spatial expansion, neighborhood influence, production decisions, spatial econometrics, Swiss agriculture*

JEL classification: *QR12*

1. Introduction

From 2000 to 2007 the number of suckler cow farms increased by 85 % from 2393 to 4427 farms in Switzerland, while in the same period the total number of farms decreased by 12 % from 70494 to 61764 farms. An impact analysis by Mann et al. (2004) showed that the introduction of direct payments for non-dairy ruminants including suckler cows by the Swiss government in 1999 contributed to this remarkable increase. A further study by Schrade et al. (2006) for Switzerland concluded that determinants, such as giving up labor-intensive milk production, the transition to off-farm employment, the possibility of combining suckler cow production with labor-intensive activities in the fruit and vegetable sector or the conservation and cultivation of alpine areas boosted the number of suckler cows.

This paper explains the farm conversions to the suckler cow type of farm in Switzerland since the year 2000, specifically taking into account neighborhood influences in traditional and non-traditional suckler cow regions. It verifies the hypothesis that production decisions made by farmers are influenced by their neighboring peers.

From a sociological point of view, neighborhood influences may be explained by the presence of uncertainty as regards the consequences of a change. Sociologists argue that «between the time farmers become aware of a new technology and the time they accept or reject its use, the farmers must persuade themselves that the new technology is or is not suited to their needs. During this time the farmer is likely to seek conviction that his thinking is on the right path from peers by means of interpersonal communication channels» (Rogers and Shoemaker 1971, p. 109 in Case, 1992). As uncertainty caused by new technologies decreases over time it was assumed that neighborhood influence also declines over time. Case (1992) confirmed neighborhood influences on the adoption of new technologies empirically using spatial econometrics methods.

From an economic point of view, neighborhood influences may be explained by the existence of localization economies or agglomeration economies (Eberts and McMillen, 1999; Roe *et al.*, 2002). Agglomeration economies imply that the performance of one operation improves when there are other similar operations nearby. These spillovers are explained by the presence of adjacent operations which facilitate a specific infrastructure of services and information which enhances the performance of each operation through lower transaction costs. It could be assumed that economic advantages based on the agglomeration of infrastructure and services persist over a certain period of time. Agglomeration economies were confirmed by Roe *et al.* (2002) for hog inventories in the U.S. and by Bichler *et al.* (2004) and Schmidtner *et al.* (2011) for organic production in Germany and by Isik (2004) for dairy production in the U.S..

While such static analyses have shown some influence on production decisions on the part of peers, the dynamics of the conversions to the suckler cow type of farm are hard to understand without taking variations over time into account in detail. This paper therefore explains farmer's decision to start accommodating suckler cows at municipality level for different time periods. The detailed spatial resolution of this study enables neighborhood influences to be distinguished both in the immediate and in the distant neighborhood. Different time periods were taken into consideration in order to assess whether there was any likelihood of neighborhood influence, based on the existence of uncertainty or based on economic advantages due to the agglomeration of infrastructure and services. If neighborhood influences are only confirmed in the early phase following the reform and disappear in the later periods, it could be assumed that such influence is based on the presence of uncertainty, while agglomeration economies are irrelevant. On the other hand, if a neighborhood influence is confirmed also in the late conversion phase or persists for the whole phase, it could be assumed that economic advantages based on the agglomeration of infrastructure and services for suckler cow production are a key factor. This paper is structured as follows: Section 2.1 will present the database and the selected farm sample. Section 2.2 will describe the spatial econometrics model and the underlying variables. Section 3 will report and discuss the results.

2. Materials and methods

2.1 Database

Farm-level data based on the Swiss Agricultural Farm Census carried out by the Federal Statistical Office (FSO) in the years 2000, 2003, 2005 and 2007 was used. Suckler cow farms were defined according to the Swiss Census' farm type classification as farms where at least 25 % of the ruminants are suckler cows and 75 % of the animals are ruminants. In this study, conversions to suckler cow production are defined as farms which were changing their farm type to suckler cow production within a certain time period. The potential conversions include all farms with the exception of the former.

The expansion of suckler cow farms after the introduction of direct payments for non-dairy ruminants in 1999 was analyzed over three successive time periods: the first period from 2000 to 2003 representing the early conversion period, the second period from 2003 to 2005 representing the middle and the last one, from 2005 to 2007, the late conversion period. In order to track the changes in production made over these time periods, farm exits were excluded from the sample at the beginning of the respective exit period, while entries were not taken into account before a complete time period had started. Farm records showed that dairy and cattle fattening farms tended primarily to adopt suckler cows.

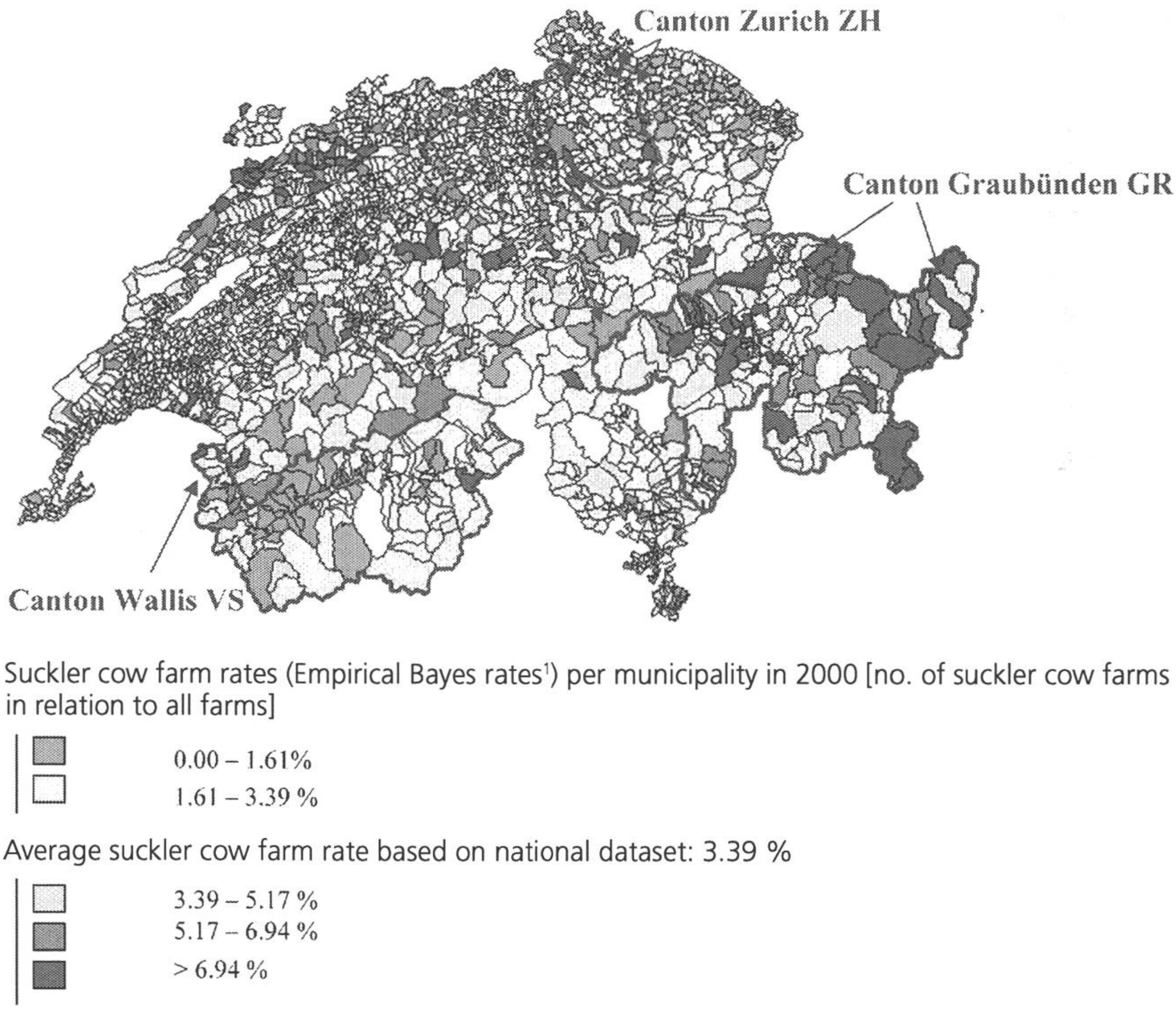
Spatial data for analyzing the changes in the number of suckler cow farms spatially explicit was not available at farm level. Therefore, the analysis was conducted at municipality level, this representing the smallest unit for which spatial data was provided. All municipalities incorporating at least one farm location during the whole of the period were considered.

2.2 Selected Regions

In order to analyze peer influence on new conversions and the spatial distribution of suckler cow farms, three different regions were taken into account: a traditional suckler cow region, a high-conversion region and a 'reluctant' region. Canton Graubünden [GR] in the south-east of Switzerland, which contains 184 municipalities, was selected as an example for a traditional suckler cow region. In 2000, when direct payments were introduced, the suckler cow farm rate in Graubünden (5.03 %) was already higher than the national average (Fig. 1).

Canton Zurich [ZH], which includes 171 municipalities, was chosen as a non-traditional suckler cow region with farm and expansion rates close to the national average for the year 2000. Finally, the Canton Wallis [VS] was selected as a non-traditional suckler cow region, with farm and expansion rates significantly below the national average (133 municipalities).

Fig. 1. Spatial distribution of suckler cow farms shortly after the introduction of direct payments for non-dairy ruminants in 2000 for Switzerland and the selected regions.



1 Empirical Bayes rates, to be explained in Section 2.3

2.3 Spatial econometric model

The ensuing hypothesis (H1) is that the spatial location of conversions to the suckler cow type of farm during a certain time period matters. Hypothesis (H2) postulates that the spatial location of suckler cow farms matters. For both a spatial lag model was used, taking into account spatial interactions among the dependent variable and among exogenous independent variables (see Pennerstorf, 2008 and Anselin, 1988). This type of model was chosen because it verifies explicitly the neighborhood influence caused by the dependent variable. It was assumed that the influence of space is different in the different regions, for that reason separate models for the selected regions Graubünden, Zurich and Wallis were estimated. It was also suspected that spatial dependence arises not only in the dependent variable but also in the error term, which indicates that residuals of adjacent municipalities may be correlated. Such correlations arise from omitted variables that are spatially correlated. For this reason a test for spatially correlated errors was carried out using a Lagrange multiplier test statistic. The spatial lag model based on maximum likelihood estimates and the tests were solved using the software GeoDA (Anselin, 2004).
The general model is given in equation 1 by:

$$Y_i = \rho W_{ij} * Y_j + \beta * X_i + \gamma W_{ij} * Z_j + \varepsilon \quad (1)$$

Where:

Y_i dependent variable for municipality i for a given time period;

For verifying H1 [the spatial location of conversions to the suckler cow type of farm during a certain time period matters]:

Y_i Vector of conversions (EB-rate in percent) to the suckler cow type of farm during a certain time period.
[no. of conversions to suckler cow type of farm in relation to all potential conversions for i municipalities during a certain time period]

For verifying H2 [the spatial location of suckler cow farms matters]:

Y_i Vector of suckler cow farms (EB-rate in percent) at the end of the time period.
[no. of suckler cow type of farms in relation to all farms for i municipalities at the end of a time period]

$W_{ij} * Y_j$ spatially lagged dependent variable;

W_{ij} standardized spatial weights matrix reflecting spatial neighborhood between the municipalities i and j;
The elements W_{ij} consist of

$$W_{ij} \begin{cases} = 0 & \text{if municipality } i=j \\ = 0 & \text{if municipality } i \neq j \text{ and j is not in the neighborhood of i} \\ > 0 & \text{if municipality } i \neq j \text{ and j is in the neighborhood of i} \end{cases}$$

X matrix containing for each municipality the independent explanatory variables, which will be described in the following section;

$W_{ij} * Z_j$ spatial interaction among the independent variables;

ε vector of normally distributed error terms;

ρ scalar spatial lag coefficient of the spatially lagged dependent variable to be estimated;

γ parameter vector of the regression coefficients for the spatial independent variables to be estimated;

β parameter vector of the regression coefficients for the independent variables to be estimated;

Several methods for generating the spatial weights matrix W_{ij} were examined (see Pennerstorf, 2008 and Anselin, 2005). Finally, a row-standardized first order contiguity spatial weights matrix was used, where the centroids of each municipality, which constitute a spatial unit, were converted to polygons by means of a Thiessen polygon tessellation. In the majority of cases this means that only the surrounding adjacent municipalities are defined as neighbors. The type of weights matrix was chosen because it showed the best fit for most of the regression indicators. The matrix W_{ij} was generated using the software GeoDa (Anselin, 2005).

All dependent variables were defined by rates because the total number of farms exhibits an extremely unequal distribution at municipality level. Fig. 2 shows the distribution of farms at municipality level, where significant variations are evident for all regions. Due to the high number of municipalities in Switzerland which have only a few farm locations, the raw rates of the dependent variables also display a wide variance (see Table 1). For this reason, all dependent variables were calculated applying an Empirical Bayes (EB) smoother (Bailey and Gatrell, 1995; Anselin et al., 2004). This approach uses Bayesian principles to guide the adjustment of the raw rate estimate by taking into account a prior distribution from the overall national dataset. The principle is referred to as «shrinkage», in the sense that the raw rate is moved towards an overall mean, as an inverse function of the inherent variance (see Bailey and Gatrell, 1995). According to Anselin (2004), the rates for municipalities with few farm locations tend to be adjusted considerably, whereas for the others the rates are barely changing.

Fig. 2. Number of farms per municipality for Switzerland and the selected regions

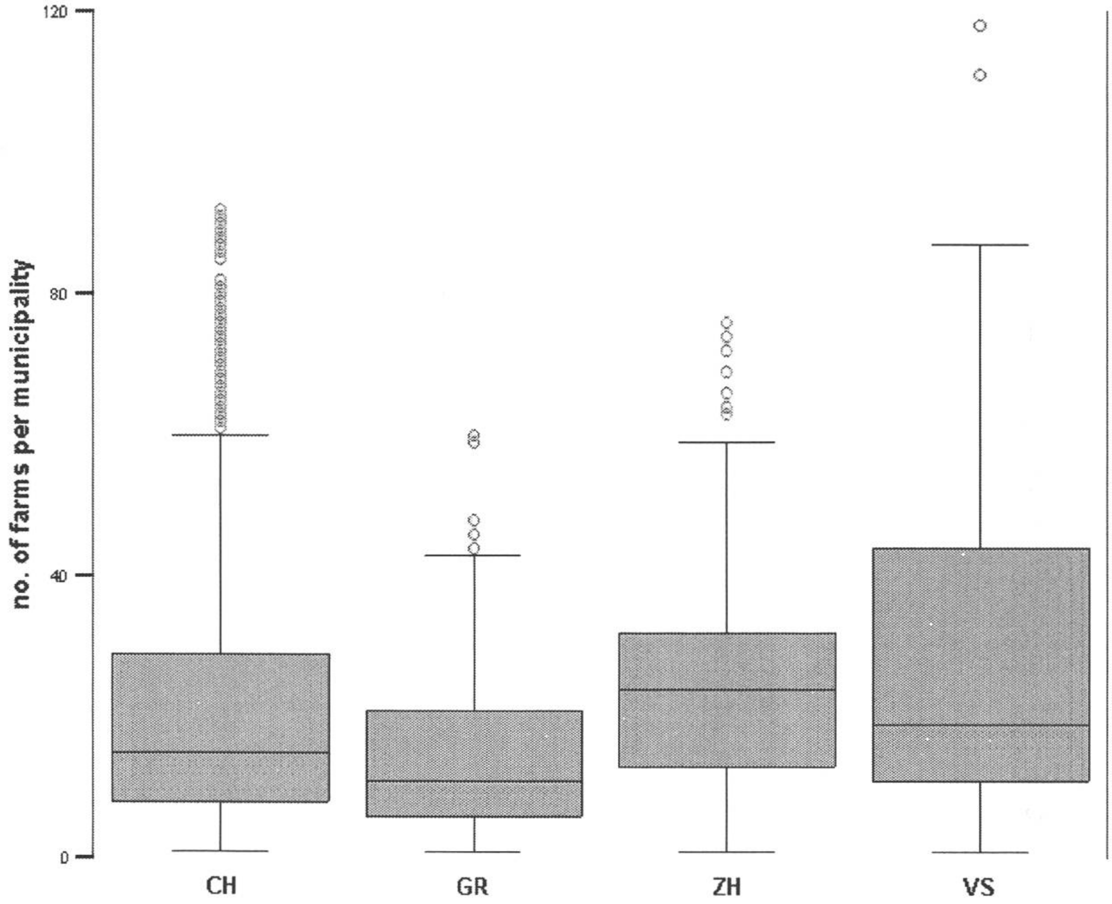


Table 1. Dependent variables (Raw Rates and Empirical Bayes (EB) Rates)

	Switzerland (CH)				ZH	GR	VS
Time Period	**Mean**	**Min**	**Max**	**Std. Dev**	**Mean**	**Mean**	**Mean**
	Model 1 Y= no. of conversions to suckler cow type of farm in relation to all potential conversions during the period						
	Raw Rate in percent						
Early (2000-2003)	*2.23*	*0.00*	*50.00*	*5.00*	*2,48*	*4,24*	*1,51*
Middle (2003-2005)	*1.70*	*0.00*	*100.00*	*4.89*	*1,84*	*2,69*	*1,15*
Late (2005-2007)	*1.83*	*0.00*	*50.00*	*4.66*	*1,40*	*3,49*	*0,73*
	Empirical Bayes (EB) Rate in percent						
Early (2000-2003)	*1.99*	*0.70*	*5.54*	*0.48*	*2,01*	*2,18*	*1,76*
Middle (2003-2005)	*1.55*	*0.58*	*4.09*	*0.39*	*1,58*	*1,67*	*1,35*
Late (2005-2007)	*1.64*	*0.70*	*3.60*	*0.34*	*1,63*	*1,72*	*1,50*
	Model 2 Y= no. of suckler cow type of farms in relation to all farms at the end of the period						
	Raw Rate in percent						
Early (2000-2003)	*5.42*	*0.00*	*60.00*	*9.74*	*5,56*	*12,82*	*3,70*
Middle (2003-2005)	*6.28*	*0.00*	*80.00*	*8.85*	*7,17*	*14,56*	*3,75*
Late (2005-2007)	*7.53*	*0.00*	*80.00*	*8.12*	*7,49*	*17,35*	*4,61*
	Empirical Bayes (EB) Rate in percent						
Early (2000-2003)	*5.10*	*0.67*	*23.78*	*2.17*	*5,13*	*7,17*	*3,94*
Middle (2003-2005)	*6.03*	*0.92*	*22.95*	*2.31*	*6,17*	*8,32*	*4,58*
Late (2005-2007)	*7.15*	*1.45*	*23.50*	*2.39*	*7,18*	*9,56*	*5,62*

2.4 Neighborhood influence variables

Model 1 considers neighborhood influence by the spatially lagged dependent variable ($\rho W_{ij*} Y_j$), which indicates that the rate of conversion to suckler cow production in municipality i is positively influenced by conversions in the adjacent municipalities j. In addition, neighborhood influence by traditional suckler cow farms, which had been already there before direct payments were introduced, is taken into account. The ensuing hypothesis is that the rate of conversion to suckler cow farms in municipality i is positively influenced by the number of traditional suckler cow farms in the neighborhood. The EB rates of suckler cow farms in the year 2000 ($SucklerFarm2000_i$) for municipality i is used as a proxy for traditional neighboring farms in the same municipality (*immediate neighborhood*). The rates for traditional suckler cow farms in adjacent municipalities j (W_{ij} * $SucklerFarm2000_j$) are used as a proxy for more distant neighbors (*distant neighborhood*). For avoiding endogeneity problems the independent variable «*SucklerFarm*» is related to the year 2000 for all time periods while the

dependent variable «*Conversions*» is referred to later time periods. For that reason it is impossible that the dependent variable «*Conversions*» influence the independent variable «*sucklerFarm2000*».
Model 2, which explains the suckler cow farm rate at the end of a given time period, considers neighborhood influence by the spatially lagged dependent variable. The hypothesis is that spatial concentration exists

2.5 Independent variables

Local geographical conditions

The cantons of Graubünden and Wallis are multi-lingual counties with French, German, Italian and Rhaeto-Romansch -speaking communities. It is assumed that conversion rates differ among the language communities due to different information channels (schools, extension services, technical journals). The language communities were considered through the medium of dummy variables (*FrenchCommunity, GermanCommunity, Rhaeto-RomanschCommunity, ItalianCommunity*). The altitude of the municipalities was taken into account on the basis of dummy variables for the mountain, hilly and valley region (*ValleyRegion, MountainRegion, HillRegion*).

Market access

In Switzerland small-scale milk processing factories with less than 50 full-time equivalents are widespread. According to a FOAG[2] database from 2011, there are 466 municipalities incorporating a local milk processing factory of this kind. It could be assumed that dairy farmers in municipalities or in adjacent municipalities with local milk processing where mainly cheese and other high priced specialties are produced, are not likely to convert to suckler cow production due to the regional market and higher milk prices. Hence it is suggested by way of a hypothesis that the presence of milk processing facilities has a negative influence on the number of farm conversions and the number of suckler cow farms. One dummy variable (*MilkProcessing in immediate neighborhood*) for milk processing facilities in the municipality under observation and another

2 FOAG: Federal Office for Agriculture

(*MilkProcessing in distant neighborhood*) for those in adjacent municipalities[3] were taken into consideration. The dummy variable for local milk processing factories was used as a proxy for milk prices above average.
Based on the urban-rural classification of the Swiss Federal Population Census 2000 urban municipalities were defined describing the proximity to urban agglomerations. The variables were used as a proxy for the possibility of carrying out off-farm work as well as a proxy for proximity to consumer markets (Dummy variables *UrbanMunicipality* and *UrbanNeighborhood*). The dummy variable *UrbanNeighborhood* was assigned 1 when more than 50 % of neighboring municipalities had an urban classification. Furthermore, based on the Swiss Federal Population Census 2000, a dummy variable for touristic municipalities (*TouristMunicipality*) was included as a proxy for the possibility of selling agricultural products directly to consumers.
It was suspected that a few dummy variables for local geographic conditions and market access (e.g. *ValleyRegion* and *UrbanMunicipality*, *TouristicMunicipality* and *MountainRegion*), are too correlated and provide insufficient separate information. For suggesting problems with the stability of the regression results the diagnostic multicollinearity condition number was used. In the case of a multicollinearity condition number over 30, which indicates too correlated exogenous variables, the dummy variables with the highest impact on the number were excluded (Anselin, 2005). Due to the fact that the dummy variables for local geographic conditions and market access were not necessary for specifying the model, dropping one of these does not lead to specification errors.

Farm-specific explanatory variables

In Switzerland it has in the past been observed that in particular family farms with an above-average agricultural area are more inclined to convert their production to suckler cows. Gerwig (2008) stated that Swiss suckler cow farms generate an adequate family income in cases where land resources are above Swiss average or family members work off-farm. For this reason it is hypothesized that farm size has a positive influence on the conversion rate and the suckler cow farm rates. The EB rates, based on the ratio of potential conversi-

3 One dairy processing unit for at least one neighboring municipality was assumed.

ons involving more than 25 hectares of farmland to the total number of potential conversions at the start of a given time period, were used as proxy for large farms (*LargeFarm*). The EB rates resulting from potential conversions with less than 1500 labor hours/year before the conversion were used as a proxy for off-farm work (*OffFarm*). Because the EB rates for this variable showed no difference at municipality level, (which means that inter-regional differences are purely stochastic), the variable was excluded from the sample. By contrast, according to the farm accountancy data network for Switzerland, after the introduction of direct payments for non-dairy ruminants, farms which were already specializing in fattening bulls or calves tended primarily to adopt suckler cow production because it meant a significant increase in their farm income. The number of potential conversions involving fattening cattle farms at the beginning of the respective time period in relation to the total number of potential conversions was used as proxy for cattle farms (*CattleFarm*).

The farm accountancy network also showed that combining organic standards with suckler cow production is highly profitable. For this reason, it is hypothesized that the higher the rates for organic farms at the beginning of a time period, the higher suckler cow adoption will be. The proxy for organic farms (*OrganicFarm*) is based on EB rates for potential conversions with organic farming at the start of a time period in relation to the total number of potential conversions.

Finally, farmers' milk quota per area is used to explain the conversion to suckler cows. It is hypothesized that farms with low milk quotas per hectare are more likely to give up milk production. The kilogram milk quota per hectare UA was used as proxy for milk quota (*MilkQuota*). In addition, the raw rates of arable land in relation to the total land per municipality (*ArableLand*), the rates for summer alpine pasture[4] per municipality (*AlpineLand*) and the rates for areas on hillsides (*AreaHillside*) were included in the models. It is assumed that a high share of arable land will have a negative influence on suckler cow production whilst a high hectarage proportion on slopes or alpine pasture will increase suckler cow production.

4 Land used for agriculture in higher regions of the Swiss Alps and Swiss Jura which can only be grazed in the summer for two to four months is referred to as summer alpine pasture.

Farm-specific independent variables aimed at explaining farmers' conversions to suckler cows are reported in Table 2.

It was suspected that the neighborhood influence variable traditional suckler cow farms for municipality i in the year 2000 ($SucklerFarm2000_i$) may be too correlated with the farm-specific variables. Particularly for the model verifying neighborhood influence during the early time period after introducing direct payments, problems due to multicollinearity were suspected because the independent farm-specific variables relate to the same base-year 2000. For models considering the middle and late period the neighborhood influence variable $SucklerFarm2000_i$ is suspected to cause problems with multicollinearity to a lesser extent because the independent farm specific variables are related to subsequent time periods. For all models the multicollinearity condition number will be displayed.

Table 2. Farm-specific independent variables aimed at explaining farmers' conversions to suckler cows

	Switzerland (CH)				ZH	GR	VS
Time Period	Mean	Min	Max	Std. Dev.	Mean	Mean	Mean
	LargeFarm EB rates (in percent) of potential conversions with more than 25 hectares agricultural land in relation to the total number of potential conversions at the start of a time period.						
Early (2000-2003)	*20.89*	*0.59*	*79.07*	*14.03*	*18,38*	*21,46*	*11.00*
Middle (2003-2005)	*23.17*	*0.73*	*78.84*	*14.13*	*20,63*	*24,85*	*12,57*
Late (2005-2007)	*24.24*	*0.83*	*77.45*	*13.87*	*21,98*	*25,90*	*14,19*
	CattleFarm EB rates (in percent) of potential conversions with cattle fattening farms in relation to the total number of potential conversions at the start of a time period.						
Early (2000-2003)	23.76	2.06	84.29	9.28	25,07	28,95	20,22
Middle (2003-2005)	24.09	2.83	82.59	8.14	26,22	28,44	20,72
Late (2005-2007)	25.49	4.90	81.15	7.67	27,36	29,37	21,99
	OrganicFarm EB rates (in percent) of potential conversions in organic production in relation to the total number of potential conversions at the start of a time period.						
Early (2000-2003)	6.35%	0.24%	71.59%	7.59%	5,69%	19,89%	4,69%
Middle (2003-2005)	8.47%	0.51%	77.63%	9.67%	7,12%	28,20%	6,69%
Late (2005-2007)	8.94%	0.56%	73.04%	9.82%	7,16%	29,47%	8,00%

3. Results and Discussion

The estimated models are reported in Tables 3 to 5. For all models the multicollinearity condition number is below 30, which indicates no problems with the stability of the results due to multicollinearity (Anselin, 2005). The pseudo R2 of the models range from 0.09 for the cantons of Zurich to 0.50 for the non-traditional suckler cow region Wallis. The models for this region show the best fit with pseudo R2 values from 0.37 to 0.50 (see Table 4). All models show a positive log-likelihood[5], which is caused by the small standard deviation of the Empirical Bayes transformation (see Table 3 to 5). For those models for which the test for spatial dependence in the dependent variables was confirmed, neighborhood influence in the error terms was also verified. The results indicate that spatial dependence due to omitted independent variables plays a certain role. But for those models, for which no neighborhood influence was verified, spatial dependence neither in the dependent variable nor in the error terms was confirmed.

3.1 Neighborhood influence

For the traditional suckler cow region of Graubünden, the results of both models show that no positive neighborhood influence can be confirmed (Table 3). On the contrary, in the early phases after the reforms, the neighboring conversions had a significantly negative impact on the conversion decisions of their peers (Model 1, Table 3). This indicates that, at the beginning of the reforms, local processing capacities for suckler cows (e.g. butcher, direct marketing) restrict accumulated new conversions in the neighborhood. The suckler cow type of farm rates at the end of the period (Model 2, Table 3) indicate a positive spatial interaction among neighbors, which cannot, however, be confirmed. Additionally, for the traditional region of Graubünden, the conversion rate is not positively influenced to any significant extent by former converters in the immediate or more distant neighborhood, while for the non-traditional region

5 The likelihood is the product of the density evaluated in the observations. Usually, the density takes values that are smaller than one, so its logarithm will be negative. However, this is not true for the density of a normal distribution with a small standard deviation (for example Std. Dev. = 0.1). This density will concentrate a large area around zero, and therefore will take large values around this point. Naturally, the logarithm of this value will be positive. (See http://blog.stata.com/tag/log-likelihood)

(canton Wallis) this hypothesis can be confirmed for the immediate and the more distant neighborhoods (Table 4, Model 1). This indicates that only those farmers who are not familiar with a technology like suckler cow production will seek advice from their more experienced peers for reducing uncertainty, while in the canton Graubünden there were already enough suckler cow farms which reduced uncertainty. As regards the non-traditional region of Wallis (Table 4, Model 2) the suckler cow farm rate shows a significantly positive spatial interaction in the first time period, while in the later periods this neighborly interdependence declines. These results show that, even when suckler cow farms were spreading in non-traditional suckler cow regions, spatial concentration could not be reported within the region, which consequently implies that agglomeration economies do not exist for suckler cow production (Roe et al., 2002). For canton Zurich the hypothesis of positive neighborhood influence and spatial concentration cannot be confirmed either.

3.2 Local geographical conditions

As regards Graubünden, directly after the introduction of the direct payments, the early adopters were among the German-speaking community (probably because most of the information was available in Switzerland's most widespread language only), while in the later periods this changed. For canton Wallis, there was no significant difference between the language communities. For the predominantly mountainous canton of Graubünden, the valley regions reflect a positive impact on conversion rate and spatial distribution which could not be confirmed overall. As regards canton Zurich, with its mix of hilly and flat land, suckler cow rates were significantly higher in the hilly regions.

3.3 Market access

For Graubünden and Wallis, which are basically agrarian cantons, proximity to urban municipalities had a positive influence on the conversion rate, something which was confirmed for canton Wallis as far the last two conversion periods were concerned (Table 4, Model 1). On the one hand, this could be an indicator that in agrarian cantons proximity to urban areas with off-farm employment possibilities increases the chances of conversion to suckler cow farms. On the other hand, it could indicate that proximity to local consumers (butchers, hotels) in more urban regions is of importance. However, the models show no evidence for the spatial concentration of suckler cow production in the urban neighborhood (Model 2). For canton Zurich, with its high percentage of urban municipalities, a significantly lower suckler cow concentration in the more touristic municipalities was confirmed, while a higher concentration was confirmed for the neighboring agrarian municipalities (Model 2, Table 5). The hypothesis of a negative impact of milk processing facilities in the immediate or more distant neighborhood on the conversion rate and suckler cow concentration could not be confirmed for canton Graubünden, while in the cantons of Wallis and Zurich this hypothesis was confirmed, albeit for the immediate neighborhood only. In contrast to canton Zurich, suckler cow concentration was significantly higher in municipalities with milk processing facilities in the more distant neighborhoods.

3.4 Farm-specific conditions

The results for all regions show that the main drivers for a conversion to suckler cow production and for spatial distribution of suckler cow farms were structural conditions at farm level. In the traditional suckler cow region, for the variables of cattle fattening farms, organic farms and milk quota, the hypothesis was confirmed for the majority of the models, while the other explanatory variables (market access and geographical conditions) had no significant impact on suckler cow rate and conversion rate. For this reason it may be concluded that conversion is driven mainly by micro-economic, farm-specific basic conditions in traditional regions.

For the non-traditional suckler cow regions, market access and the micro-economic status of the farms are also predominant factors. It is only in the 'reluctant' region of canton Wallis that conversion is driven not only by micro-economic drivers but also by socio-economic factors such as neighborhood influences and market access.

Table 3. Estimated spatial lag models for the traditional suckler cow region Graubünden (N=184 municipalities)

		Model 1: Y= Rate of conversions to suckler cows during the period (EB-rate)			Model 2: Y= Rate of suckler cow farms at the end of the period (EB-rate)		
Time Period	**Unit**	**Early**	**Middle**	**Late**	**Early**	**Middle**	**Late**
Spatial lag Variable		**Neighborhood Influence Variables**					
Conversions in neighborhood	*EB-rate*	*-0.2439***	*-0.253***	*-0.051*	-	-	-
SucklerFarm in neighborhood	*EB-rate*				*0.1154*	*0.0516*	0.0512
Independent Variable							
SucklerFarm2000							
Immediate neighborhood	*EB-rate*	-0.0010	*0.0071*	*0.0075*	-	-	-
Distant neighborhood	*EB-rate*	*-0.0025*	*0.0096*	*-0.0114*	-	-	-
		Local Geographical Conditions					
GermanCommunity	*Dummy*	*0.0031**	*-0.0013****	*-0.00012*	*0.0055*	*-0.0008*	*-0.0018*
Rhaeto-RomanschCommunity	*Dummy*	*0.00249****	*-0.0003*	*0.0008*	*-0.0044*	*-0.0139*	*-0.0108*
ValleyRegion	*Dummy*	*-0.0028*	*0.0024*	*-0.0014*	*-0.0279***	*0.0176*	*-0.019*
		Market Access					
UrbanNeighborhood	*Dummy*	*0.0007*	*0.0008*	*0.0006*	*-0.0005*	*0.0032*	*0.005*
UrbanMunicipality	*Dummy*	*0.0024*	*-0.00046*	*0.00013*	*0.0107*	*0.0075*	*0.0043*
Organicfarms in neighboring municipalities	*EB-rate*	*0.0043*	*0.0043*	*-0.0103**	*0.0633***	*0.074**	*0.0455****
MilkProcessing							
Immediate neighborhood	*Dummy*	*0.00043*	*0.00054*	*0.0001*	*-0.0002*	*0.0037*	*0.0035*
Distant neighborhood	*Dummy*	*0.0004*	*-0.00068*	*0.0002*	*-0.0051*	*-0.0071*	*-0.0049*
		Farm-Specific Conditions					
ArableLand	*Raw rate*	*-0.0006*	*0.0037*	*-0.0043*	*-0.0044*	*-0.0137*	*-0.019*
LargeFarm	*EB-rate*	*-0.0055***	*-0.0016*	*0.0061**	*-0.062**	*-0.081**	*-0.054**
CattleFarms	*EB-rate*	*0.0181**	*-0.0002*	*0.0030*	*0.1326**	*0.133**	*0.134**
OrganicFarms	*EB-rate*	*0.0033*	*0.0041***	*0.0069**	*0.0039*	*-0.0017*	*0.008*
MilkQuota	*Kg*	*-0.0001**	*0.0000*	*-0.0037*	*-0.027***	*0.0002*	*0.0001*
Constant		*0.01719**	*0.0187**	*0.0141**	*0.0207*	*0.0477**	*0.055**
		Regression diagnostics					
Pseudo-R^2		*0.254*	*0.123*	*0.175*	*0.294*	*0.231*	*0.194*
Log likelihood		*728*	*747*	*807*	*380*	*373*	*374*
Akaike info criterion		*-1422*	*-1461*	*-1580*	*-730*	*-716*	*-719*
Schwarz criterion		*-1367*	*-1407*	*-1526*	*-681*	*-668*	*-671*
Multicollinearity condition number		*19.7*	*21.16*	*21.97*	*16.5*	*18.34*	*19.37*
Spatial error Test[a)]		*4.62***	*5.16***	*0.83*	*2.26*	*0.32*	*0.23*
Spatial lag Test[b)]		*3.79***	*5.52***	*0.28*	*1.34*	*0.25*	*0.24*
Heteroskedastic Test[c)]		*39.56**	*15.06*	*31.41**	*13.37*	*18.17*	*18.13*
Morans' I[d)]		*-1.52*	*-1.65****	*1.74****	*2.29***	*1.31*	*1.22*

*, **, *** Statistical significance at levels 1, 5, and 10 % respectively

a) Lagrange multiplier tests (LM) for spatial error dependence tests the null hypothesis: the models residuals are not spatially autocorrelated.

b) Lagrange multiplier tests (LM) for spatial lag dependence tests the null hypothesis: the models dependent variables are not spatially autocorrelated.

c) Koenker-Bassett Test tests the null hypothesis: the models' errors are homoscedastic.

d) Morans' I tests the null hypothesis: the models' residuals are not spatially autocorrelated.

Table 4. Estimated spatial lag models for the reluctant region Wallis (N=133 municipalities)

		Model 1: Y= Rate of conversions to suckler cows during the period (EB-rate)			Model 2: Y= Rate of suckler cow farms at the end of the period (EB-rate)		
Time Period	**Unit**	**Early**	**Middle**	**Late**	**Early**	**Middle**	**Late**
Spatial lag Variable		**Neighborhood Influence Variables**					
Conversions in neighborhood	*EB-rate*	*-0.1436*	*-0.1072*	*-0.209*			
SucklerFarm in neighborhood	*EB-rate*				*0.327**	*0.22***	*0.166*
Independent Variable *SucklerFarm2000*							
Immediate neighborhood	*EB-rate*	*0.063**	*0.025*	*0.059**			
Distant neighborhood	*EB-rate*	*0.0802***	*0.075**	*-0.0068*			
		Local Geographical Conditions					
FrenchCommunity	*Dummy*	*-0.0006*	*0.0004**	*-0.0007*	*-0.0003*	*-0.0002*	*0.0040*
ValleyRegion	*Dummy*	*-0.0023***	*-0.0002*	*-0.0006-*	*- 0.0072****	*-0.0050*	*-0.0097***
		Market Access					
TouristMunicipality	*Dummy*	*-0.0011*	*-0.001*	*-0.0005*	*-0.0005*	*-0.0011*	*-0.0002*
UrbanNeighborhood	*Dummy*	*-0.0007*	*0.0009*	*0.0009*	*0.0051*	*0.0075***	*0.0062*
MilkProcessing							
Immediate neighborhood	*Dummy*	*-0.0013*	*-0.0011**	*-0.0013***	*-0.0025*	*-0.006****	*-0.013**
Distant neighborhood	*Dummy*	*0.00035*	*-0.0002*	*-0.0003*	*-0.00035*	*0.0011*	*-0.0064*
		Farm-specific Conditions					
ArableLand	*Raw rate*	*0.0015*	*-0.0032****	*0.006**	*0.0056*	*-0.0091*	*0.020*
LargeFarm	*EB-rate*	*0.0085***	*0.0054***	*0.0076**	*0.0454**	*0.065**	*0.074**
CattleFarms	*EB-rate*	*0.0121**	*0.0106**	*0.0047*	*0.0507**	*0.0658**	*0.071**
OrganicFarms	*EB-rate*	*0.0180***	*0.011**	*0.0047*	*0.081***	*0.074**	*0.062**
MilkQuota	*Kg*	*0.0000*	*0.0000*	*-0.0000*	*-0.0001*	*-0.0000*	*-0.0000*
Constant		*0.013**	*0.008**	*0.0138**	*0.0105****	*0.0096*	*0.017***
		Regression diagnostics					
Pseudo-R^2		*0.422*	*0.427*	*0.379*	*0.39*	*0.45*	*0.50*
Log likelihood		*572*	*633*	*608*	*380*	*382*	*371*
Akaike info criterion		*-1114*	*-1237*	*-1186*	*-735*	*-739*	*-716*
Schwarz criterion		*-1071*	*-1194*	*-1143*	*-697*	*-701*	*-679*
Multicollinearity condition number		*19.94*	*18.22*	*18.10*	*12.16*	*13.17*	*13.37*
Spatial error Test[a)]		*2.61*	*1.11*	*0.93*	*7.60**	*5.69***	*2.49*
Spatial lag Test[b)]		*1.25*	*0.66*	*1.84*	*9.54**	*4.74***	*2.87****
Heteroskedastic Test[c)]		*15.9*	*13.71*	*39.0**	*5.71*	*6.92*	*6.01*
Morans' I[d)]		*-1.045*	*-0.42*	*-0.32*	*3.60**	*3.22**	*2.31**

*, **, *** Statistical significance at levels 1, 5, and 10 % respectively
a) Lagrange multiplier tests (LM) for spatial error dependence tests the null hypothesis: the models residuals are not spatially autocorrelated.
b) Lagrange multiplier tests (LM) for spatial lag dependence tests the null hypothesis: the models dependent variables are not spatially autocorrelated.
c) Koenker-Bassett Test verifies the null hypothesis: the models' errors are homoscedastic.
d) Morans' I tests the null hypothesis: the models' residuals are not spatially autocorrelated.

Table 5. Estimated spatial lag models for the non-traditional suckler cow region Zurich (N=171 municipalities)

		Model 1: Y= Rate of conversions to suckler cows during the period (EB-rate)			**Model 2: Y= Rate of suckler cow farms at the end of the period (EB-rate)**		
Time Period	**Unit**	**Early**	**Middle**	**Late**	**Early**	**Middle**	**Late**
Spatial lag Variable		**Neighborhood Influence Variables**					
Conversions in neighborhood	*EB-rate*	*-0.0050*	*-0.040*	*-0.0106*	-	-	-
SucklerFarm in neighborhood	*EB-rate*				*-0.144*	*-0.144*	*-0.0272*
Independent Variable *SucklerFarm2000*							
Immediate neighborhood	*EB-rate*	*-0.0217*	*-0.0143*	*0.046***	-	-	-
Distant neighborhood	*EB-rate*	*0.0551*	*0.046*	*0.062****	-	-	-
		Local Geographical Conditions					
HillRegion	*Dummy*	*0.0034***	*0.0002*	*0.0019*	*0.0319**	*0.0337**	*0.0358**
		Market Access					
Non-UrbanNeighborhood	*Dummy*	*0.0071**	*0.0019*	*0.0013*	*0.026**	*0.0277**	*0.0279**
TouristMunicipality	*Dummy*	*-0.0004*		*0.0001*	*-0.0083***	*-0.0084***	*-0.0053*
MilkProcessing							
Immediate neighborhood	*Dummy*	*-0.0024****	*-0.0006*	*-0.0015*	*-0.010***	*-0.0142***	*-0.019**
Distant neighborhood	*Dummy*	*0.0019**	*0.0003*	*0.00044*	*0.0056****	*0.0054****	*0.0050*
		Farm-specific Conditions					
LargeFarm	*EB-rate*	*0.0066****	*0.0038*	*-0.0024*	*0.0262****	*0.028****	*0.019*
CattleFarms	*EB-rate*	*0.0059*	*0.0045*	*0.0063****	*0.042**	*0.0329****	*0.049**
OrganicFarms	*EB-rate*	*0.0068*	*0.0133****	*0.0150**	*0.025*	*0.056****	*0.042*
MilkQuota	*Kg*	*-0.0001****	*-0.0000*	*-0.0000*	*-0.0002**	*-0.0002**	*-0.0002**
Constant		*0.016**	*0.0133**	*0.010**	*0.046**	*0.057**	*0.053**
		Regression diagnostics					
Pseudo-R^2		*0.1815*	*0.094*	*0.195*	*0.310*	*0.294*	*0.306*
Log likelihood [1]		*694*	*692*	*735*	*470*	*449*	*450*
Akaike info criterion		*-1363*	*-1358*	*-1444*	*-918*	*-876*	*-878*
Schwarz criterion		*-1322*	*-1317*	*-1404*	*-883*	*-842*	*-844*
Multicollinearity condition number		*21.3*	*22.29*	*22.10*	*12.25*	*13.44*	*14.04*
Spatial error Test [a]		*0.028*	*0.165*	*0.042*	*1.103*	*2.08*	*0.0152*
Spatial lag Test [b]		*0.0016*	*0.102*	*0.007*	*1.27*	*1.122*	*0.050*
Heteroskedastic Test [c]		*13.122*	*12.99*	*23.10**	*11.93*	*12.13*	*3.77*
Morans' I [d]		*0.312*	*0.056*	*0.257*	*-0.658*	*-1.074*	*0.554*

*, **, *** Statistical significance at levels 1, 5, and 10 % respectively

a) Lagrange multiplier tests (LM) for spatial error dependence tests the null hypothesis: the models residuals are not spatially autocorrelated.

b) Lagrange multiplier tests (LM) for spatial lag dependence tests the null hypothesis: the models dependent variables are not spatially autocorrelated.

c) Koenker-Bassett Test tests the null hypothesis: the models' errors are homoscedastic.

d) Morans' I tests the null hypothesis: the models' residuals are not spatially autocorrelated.

4. Conclusions

The small spatial scale of this study makes it possible to identify neighborhood influences in the immediate and distant neighborhood. As regards production changes, a positive neighborhood influence was confirmed only for the early time periods after the political change and for regions where the production technologies were not well-established and consequently represent a technological innovation. The results provide some evidence that neighborhood influence plays a specific role in the expansion of production changes from a sociological point of view in regions where the technology is not well-established. For production changes in regions where the technology is already well-established, no neighborhood influence in the early phase could be confirmed. For all regions and cantons, a persistent neighborhood influence prior to the later adoption periods could not be verified, which indicates that economic advantages based on the agglomeration of infrastructure and services were not developing. This indicates that simple models based on geographical spread are not suitable for acquiring an understanding of the spatial patterns of innovation distribution. A crucial factor would appear to be whether information flows rather than production choices have the opportunity to spread from one farmer to his neighbor. As soon as the necessary information is available, the neighborhood effect fades markedly because farmers (and probably other entrepreneurs too) rely on their social environment for options, not choices. However, the results show for all regions that the type of farming and organic production is highly important for the decision to convert to suckler cows.

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