DETERMINING FACTORS OF STRUCTURAL CHANGE IN AGRICULTURE IN SWITZERLAND

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Abstract

This study used data from the Swiss Farm Structure Survey (FSS) and the non-randomly sampled Farm Accountancy Data Network (FADN) data to analyse the forces driving farm exits between 2001 and 2011. These data were used in binary logistic regression models to estimate exit probabilities, controlling for structural and economic factors.

Using both FSS and FADN data, the logit results show that the probability of farm exit is directly related to farm size, operator age, number of manpower units per hectare, and farming system. The probability of farm exit decreases for younger but increases for older operators. Organic farming, family size and farming full-time are also found to have a significant negative influence on exit. By contrast, work intensity and sex of the farm operator positively influence farm exits.

The logit model based on the FADN dataset revealed that economic variables are less useful than structural/social characteristics for explaining the variance of the exit probability. At first glance, this finding is surprising, since it reveals that the economic situation is not of primary importance in the decision to exit or remain in the sector.

Keywords: farm exit, structural change, logistic regression, FADN, farm survey

1. Introduction

Switzerland has seen significant structural change in the agricultural sector over the past few decades. In addition to influencing job opportunities in farming, agricultural structure has consequences for other areas such as the extent of agricultural-policy measures, the necessary number of training positions, spatial-planning measures, and the landscape in general. That is why it is of interest to identify the determining factors of structural change.

This paper focuses on the farms exiting from the agricultural sector and the factors influencing this exit. To allow for a more precise forecasting of structural change in agriculture, the present study draws on both the agricultural structure censuses and the accountancy test-farm network / Farm Accountancy Data Network over a period of around ten years.

The paper is organized as follows. Chapter 2 outlines the methods and the underlying data used. Chapter 3 contains the results and discussion, while Chapter 4 consists of the conclusions.

2. Method and data

2.1. Main data sources

In order to identify and better understand the factors influencing structural change, two data sources are used. The first, Swiss agricultural census data, also known as the Farm Structure Survey (FSS), includes all farms in Switzerland, and has enabled the assessment and monitoring of Swiss agriculture (BfS/ FSO, 2012). FSS provides detailed insight into the structural, technical and socio-demographic situation of almost all Swiss farms on an annual basis but contains no economic data. The current investigation is based on the FSS's from 2001 and 2011 covering a total population of 68,784 farms in the year 2001. In addition to the FSS data, frequent use is made of economic information from the non-randomly sampled FADN data. The FADN is administered by Agroscope Reckenholz-Tänikon Research Station ART. This comprehensive database includes detailed information on cost accounting from about 3,300 farms per year.

2.2. The Logit Model

In this article, a logistic regression model is used to estimate the probability of farm exit *(P)* during the period 2001-2011:

$$\log\left(\frac{P_j(\mathbf{Y}=\mathbf{1})}{\mathbf{1}-P_j(\mathbf{Y}=\mathbf{1})}\right)=\boldsymbol{\alpha}+\sum_{\mathbf{i}=\mathbf{1}}^{\mathbf{k}}\boldsymbol{\beta}_i\cdot\mathbf{x}_{\mathbf{ji}}+\boldsymbol{\varepsilon}_{\mathbf{j}}$$

where log is the natural logarithm, X_j is a vector of k exogenous variables (e.g. various farm and operator characteristics) for the j-th farm, β is a vector of k coefficients to be estimated, and ε_j is a stochastic error term.

2.3. Structural variables influencing farm exit

Decisive factors for structural change have already been the subject of numerous investigations (Baur, 1999; Hofer, 2002; Mann, 2003; Foltz, 2004; Snell, 2005; Hoppe and Korb, 2006; Juvancic, 2006; Key and Roberts, 2006; Weiss, 2006; Kirner and Gazzarin, 2007; Rossier, 2007; Meier et al., 2009; Pushkarskaya and Vedenov, 2009; Petrick and Zier, 2011). According to this literature, factors affecting structural change can be grouped under human capital, farm structure, structural environment and socio-economic categories.

We use the following set of structural variables in the logistic regression based on the FSS data (Table 1).

The dependent variable (FARMEXIT) represents whether a farm exits the agricultural sector during the period 2001 to 2011. The variable FARMEXIT is equal to 1 when a farm (i) leaves the sector between 2001 and 2011, or (ii) is merged with another farm, or (iii) is handed over to a new farm operator who is not a member of the family.

2.4. Economic variables influencing farm exit

Most analyses of the likelihood of exit of specific farm operators only take structural and social factors such as land size and education and age of the operator into account, while ignoring the economic perspective. Given that farm structure surveys do not provide economic data at individual-farm level, this is hardly surprising. By matching FADN farms with FSS farms[1], we can model the influence of key economic variables on exit probability. This section sets out the economic variables that may affect the decision to exit (cf. Table 2). The factors are grouped into different categories, and are based on a literature review (e.g. Goetz and Depertin, 2001; Foltz, 2004; Key and Roberts, 2006; Hoppe and Korb, 2006; Breustedt and Glauben, 2007; Petrick and Zier, 2011), as well as on available information.

[1] A sample of 2484 farms could be matched.

Table 1. Definition of variables used in the 'exit of/entry to agricultural sector' model

Variables	Description
Dependent variable	
FARMEXIT	1-The producer exits the agricultural sector (or his ID number changes); 0-The farm exists from the beginning to end of the time period
Explanatory variables	
AGE	Age of the producer (years; recorded in 2001)
AGE^2	Square of the age of the producer ($years^2$)
FEMALE	1-The producer is female; 0-Male
FAMILY	Number of workers belonging to the family (No.)
EMPLOYEES	Number of employees (No.; Part-time employees weighted according to hours worked)
LAND	Utilised agricultural area (ha)
$LAND^2$	Square of the utilised agricultural area (ha^2)
GROWTH	1-The average change in utilised agricultural area per year between 2001 and 2011 (or the last year the farm exists) is greater than 1 ha; 0-Otherwise
LULAND	Livestock units per area (LU/ha)
$LULAND^2$	Square of livestock units per area ($(LU/ha)^2$)
FULLTIME	1-Full-time farm; 0-Part-time
ORGANIC	1-Organic farm; 0-Non-organic
WORKLAND	Number of workers (family members and employees) per area (No./ha; Part-time workers weighted according to hours worked)
CALCWORK	Calculated working hours required for crops and livestock, per number of workers (hours/No.; Part-time workers weighted according to hours worked)
CALCBENEFIT	Standardised contribution margin per area (CHF 1000 /ha; standard values per crop and livestock unit)
TYPCROP	1-Crop farm (Open arable land accounts for over 70% of total area); 0-Otherwise
TYPSPECIAL	1-'Special crops' farm (Special crops account for over 10% of total area); 0-Otherwise
TYPMILK	1-Dairy farm (Cattle account for over 75% of livestock, of which at least 25% are dairy cows); 0-Otherwise
TYPSUCKLER	1-'Suckler cow' farm (Cattle account for over 75% of livestock, of which at least 25% are suckler cows); 0-Otherwise
TYPCATTLE	1-'Other cattle' farm (Cattle account for over 75% of livestock, of which fewer than 25% are cows); 0-Otherwise
TYPHORSE	1-Horse, sheep or goat farm (Horses, sheep and goats account for over 50% of livestock); 0-Otherwise
TYPPIGPOUL	1-Pig or poultry farm (Pigs and poultry account for over 50% of livestock); 0-Otherwise
TYPCOMBCROP	1-Combined farm with crops (Other farms, open arable land account for over 40% of total area); 0-Otherwise

Table 2. Economic variables influencing farm exit

Category	*Variable*[1]	
Income	Work income per family member	*WIFAM*
	Agricultural income per hectare	*AIHEC*
	Ratio of off-farm income to total income	*OFFARM*
Investment	Investment-to-assets ratio* * Buildings, machinery, installations, land (without livestock)	*INVASS*
Financial situation of farm	Degree of external financing = debt/equity ratio	*DER*
	Ratio of (fixed) assets* to labour * Buildings, machinery, installations, land (without livestock)	*ASSLU*
	Ratio of direct payments to total gross performance* * Total gross performance does not include subsidies	*SUBSGP*
	Direct payments per hectare	*SUBS*
Partial-productivity indicators	Labour productivity = $\frac{\text{gross performance}}{\text{annual labour unit}}$	*LAPR*
	Capital productivity = $\frac{\text{gross performance}}{\text{capital}}$	*CAPPR*
	Land productivity = $\frac{\text{gross performance}}{\text{UAA}}$	*LANDPR*

[1] The *italicised* abbreviations in CAPS are used throughout the text

3. Results and discussion

The first section of the results is based on the FSS data. Due to the high number of farms, the analysis can be performed separately for different farm types. The subsequent two sections focus on FADN farms.

3.1. FSS model

The results of the logit model based on the FSS database (hereinafter referred to as the FSS model) are listed in Table 3. It shows that the probability of farm exits is significantly influenced by characteristics such as farm size, previous farm growth, and farm type (as an index of on-farm diversification). Farm size and size squared are both highly significant. Coefficient signs of the two farm-size variables indicate a nonlinear relation between farm size and exit.

In addition to these farm characteristics, Table 3 suggests a number of personal characteristics of the farm owner which have a significant influence on farm succession and exit. In particular, a significant life-cycle pattern can be observed in the farmer's succession and exit behaviour. The effect of age (AGE) on the probability of farm exit is negative for young farmers, becoming positive when AGE exceeds 38 years. The size of the farming family (FAMILY) is another important factor for determining farm succession and exits. A highly significant and negative impact on farm succession and exits is reported in Table 3 for farms with larger families. These results are not surprising, since family members provide both an incentive and the necessary labour resources for continuing the family-farm business. All else being equal, farms operated by a woman (FEMALE = 1) are 1.22 times more likely to exit than farms operated by a man. The parameter estimate for FULLTIME is highly significant. If the farm manager spends over 1500 working hours on the farm (FULLTIME = 1), the probability of exit decreases by almost 50% relative to a part-time farm.

Table 3. Parameter estimates for the FSS model for the whole population and two selected farm types

	All farms			Crop farms			Dairy farms		
	coefficient		odds ratio	coefficient		odds ratio	coefficient		odds ratio
Constant	2.509	***		2.507	***		4.137	***	
FEMALE	0.198	***	1.220	0.126		1.134	0.271	*	1.311
EMPLOYEES	0.032	***	1.032	-0.195		0.823	0.081		1.085
FULLTIME	-0.611	***	0.543	-0.463	***	0.629	-0.511	***	0.600
ORGANIC	-0.357	***	0.700	0.179		1.196	-0.518	***	0.596
WORKLAND	0.261	***	1.299	1.884		6.578	1.107	**	3.026
CALCWORK	-0.112	***	0.894	-0.158	**	0.854	-0.042		0.959
CALCBENEFIT	-0.008	*	0.992	-0.069		0.934	-0.015		0.985
FAMILY	-0.364	***	0.695	-0.387	***	0.679	-0.474	***	0.623
AGE	-0.134	***	0.875	-0.130	***	0.878	-0.192	***	0.826
AGE^2	0.002	***	1.002	0.002	***	1.002	0.003	***	1.003
LAND	-0.037	***	0.963	-0.028	***	0.972	-0.048	***	0.953
$LAND^2$	0.020	***	1.021	0.014	*	1.014	0.037	***	1.038
LULAND	-0.277	***	0.758	-1.670	***	0.188	-0.707	***	0.493
$LULAND^2$	0.041	***	1.042	1.865	***	6.455	0.124	***	1.132
GROWTH	-0.553	***	0.575	-0.700	***	0.497	-0.644	***	0.525
TYPCROP	0.129	**	1.138						
TYPSPECIAL	0.084		1.087						
TYPMILK	0.156	***	1.168						
TYPSUCKLER	-0.160	**	0.852						
TYPCATTLE	0.183	***	1.200						
TYPHORSE	0.234	***	1.264						
TYPPIGPOUL	-0.060		0.941						
TYPCOMBCROP	-0.087		0.917						
R^2	0.296			0.342			0.235		

* indicates statistical significance at the 10%-level; ** indicates statistical significance at the 5%-level; *** indicates statistical significance at the 1%-level

Diversification of farm has been controlled for by using several farming-type dummy variables (TYPCROP, TYPMILK, etc.). Table 3 also reports a significant impact of on-farm specialisation on farm exits and succession (for the sake of brevity results for only two farm types are shown).

3.2. Logit regression of economic FADN data

Logistic regression analysis was used to investigate the effect of the economic variables on the probability of exiting the agricultural sector. The basic model was set up with the dependent variable FARMEXIT (1 = exit, 0 otherwise) and the 11 explanatory variables given in Table 2. The logarithm (base 10) was used for the three partial-productivity indicators (LAPR, CAPPR, LANDPR) and ASSLU. Because of negative values in WIFAM and AIHEC, these two variables may not be log-transformed.

The full model was simplified by the stepwise omission of non-significant variables (based on the Akaike Information Criterion (AIC) criterion) in order to obtain a meaningful and interpretable model (hereinafter referred to as the reduced model). Interactions of variables have not been taken into account. The results of the logit regression of the reduced model are summarised in Table 4. The Pseudo-R^2 is 0.083. The Pseudo-R^2 of the full model (with all 11 economic variables from Table 2) is only slightly higher (R^2 = 0.089). Thus, economic variables only explain approximately 9% of the total variance of the dependent variable FARMEXIT. Nevertheless, the model gives a valuable insight into factors which are significant triggers of exit probabilities.

Table 4. Results of logistic regression (explanatory variables restricted to economic factors)

Variable	***Coefficient***		***Standard error***	***Odds ratio***	***Marginal effect***[2]
Constant	16.5	***	3.20		
WIFAM[1]	$-5.0 \cdot 10^{-5}$	**	$2.93 \cdot 10^{-6}$	1.000	$-2.2 \cdot 10^{-7}$
log(SUBS)	-0.818	**	0.36	0.441	-0.037
log(ASSLU)	-2.673	***	0.47	0.069	-0.120
log(CAPPR	-1.672	***	0.65	0.188	-0.075

[1] Note that the variable WIFAM is not log-transformed;

[2] Marginal effects are evaluated at the median of the data

From Table 4 we conclude that an increase in agricultural income per family member leads to a lower probability of exit. Given that a (too-) low income from agricultural activity is likely to be a relevant factor in farm exit, this is to be expected. The model reveals that an increase in WIFAM by CHF 100,000 decreases the probability of exit by 0.022 (2.2%). The farm operator is obviously more motivated to stay in the sector when he or she receives higher subsidies per hectare (SUBS). Thus, the model suggests that subsidies negatively impact on farm exit: a tenfold increase in SUBS decreases the exit probability by 3.7% (0.037). The existing literature has failed to reach a consensus on the impact of subsidies on agricultural employment. In line with our findings, some authors report the expected, negative impact (e.g. Foltz, 2004; Key and Roberts, 2006), whilst others find the impact to be positive (Hoppe and Korb, 2006; Petrick and Zier, 2011). Berlinschi et al. (2011) argue that subsidies have a positive effect on the educational level of farmers' children, and thus on long-term labour supply. The factor ASSLU (assets per labour unit) also impacts negatively on exits from the agricultural sector. This result was predictable, since capital-intensive farms generally invest more in their machinery and buildings, thus indicating their commitment to continuing to farm. The marginal effect of -0.075 (Table 4) states that a tenfold increase in the capital productivity CAPPR decreases the exit probability by 0.075 (7.5%).

3.3. Logit regression of combined structural and economic data

In this section, we estimate the logistic regression using both structural/social and economic variables from the FADN database. The full model therefore includes the merged variable set from Tables 1 and 2 (ignoring the dummies for the farm types). Of particular interest here is whether economic or structural/social data explain more of the variance of the goal variable FARMEXIT.

Again, as in the previous section, the reduced model arising from the stepwise omission of non-significant variables (based on the AIC criterion) is presented, rather than the detailed results for the full model. The final model explains 25% of the total variance (i.e. Pseudo-R^2 = 0.25) of

Table 5. Results of logistic regression including both structural/social and economic variables

Variable	Coefficient		Standard Error	Odds Ratio	Marginal Effect
Constant	11.80	***	4.06		
AGE	-0.305	***	0.089	0.737	-0.0132
AGE^2	0.00371	***	0.00094	1.004	0.000161
LAND	-0.0633	***	0.017	0.939	-0.00274
WORKLAND	8.87	***	2.81	7095	0.385
log(LANDPR)	-3.32	***	0.89	0.036	-0.144
log(ASSLU)	-1.82	***	0.49	0.1625	-0.0788
AIHEC[1]	$-1.52 \cdot 10^{-4}$	***	$5.76 \cdot 10^{-5}$	0.998	$-6.59 \cdot 10^{-6}$

[1] Note that the variable AIHEC is not log-transformed

the dependent variable FARMEXIT. The full model is only marginally better, with a Pseudo-R^2 of 0.262. From this and from the results in Section 3.2, we learn that the structural/social vari-ables are significantly more important for modelling exit probability. Table 5 provides detailed information on the (logistic) output of the reduced model.

An analysis of the statistical model's output given in Table 5 reveals that the reduced model includes seven significant explanatory variables, three of which are economic parameters. A comparison of Tables 4 and 5 shows that the significant economic variables differ for the model including structural/economic variables and the model considering economic data only.

The effect of age on the exit probability FARMEXIT is displayed in Figure 1. The figure shows that exit probability decreases with operator age at a young age, but increases once a threshold age is reached. Farm exits due to financial stress are more likely among farmers in the early phase of their careers. Furthermore, it is probably easier for younger farmers to find a job outside the business (Breustedt and Glauben, 2007). The negative relationship reported for farm operators at younger ages may be explicable in terms of learning effects and the acquisition of experience (Jovanovic, 1982). Furthermore, switching from farming to a non-farm job becomes a less viable option as the individual ages, since specific human-capital investments are involved. The exit probability of older farmers strongly increases because of lower opportunity costs associated with off-farm work; operators thus end up staying in agriculture until natural retirement. This finding is in line with the bulk of the available literature (e.g. Gale, 2003; Weiss, 2006; Breustedt and Glauben, 2007). Note that age can be also seen as a proxy for various distinct effects such as management skills, life horizon, physical depreciation, and others.

Farm size (LAND) is highly significant in the model. The negative coefficient (see Table 5) indicates that as farm size increases, farms are less likely to exit. Hence, farm size contributes positively to farm survival, since larger farms are more likely to provide the farming family with a reasonable, sustainable income. This is borne out by many other studies (e.g. Baur; 1999; Hofer, 2002; Breustedt and Glauben, 2007). Farm size thus has a negative marginal effect (-0.00274) on FARMEXIT, the probability of which tends to decrease by approximately 0.03 when farm size increases by ten hectares.

The variable WORKLAND impacts positively on exit probability: Given farms of equal size, those with more employees tend to leave the sector more frequently. Labour efficiency and thus a streamlining of the business would therefore appear to be crucial for the survival of farms. The logit model gives us a 0.0385 increase in FARMEXIT for each 0.1 increase in the number of employees per hectare.

As expected, we find that increased land productivity (LANDPR) decreases the probability of exit from the farming sector. Increasing LANDPR by a factor of ten leads to a decrease of 0.144 in exit probability. The fixed-assets-to-labour ratio (ASSLU) impacts negatively on farm exit. Farms with capital-intensive machinery and well-equipped animal housing thus encourage farm operators to remain in the sector. The economic status of the farm is directly reflected in the agricultural income per hectare (AIHEC). Clearly, increasing AIHEC values reduce the desire of the farm manager to leave the sector.

It is of some interest that the two variables which include subsidy payments (SUBSGP, SUBS) do not enter the final model. This in line with Barkley (1990), who suggests that government payments do not necessarily influence changes in agricultural employment, and thus the number of farms, whilst e.g. Breustedt and Glauben (2007) find that higher subsidies lower the exit probability in European countries.

4. Summary and conclusions

This study used data from the Swiss Farm Structure Survey (FSS) and the non-randomly sampled FADN data to analyse the forces driving farm exits between 2001 and 2011. These data were used in binary logistic regression models to estimate exit probabilities, controlling for structural and economic factors.

Using both FSS and FADN data, the logit results show that the probability of farm exit is directly related to farm size, operator age, number of manpower units per hectare, and farming system. The probability of farm exit decreases for younger but increases for older operators. Organic farming, family size and farming full-time are also found to have a significant negative influence on exit. By contrast, work intensity and sex of the farm operator positively influence farm exits.

The results of the model with the full set of variables (i.e. including economic variables) show that farm exit (FARMEXIT) is significantly influenced by the three economic variables LANDPR, ASSLU, and AIHEC. Despite this, the two variables which include subsidy payments (SUBS, SUBSGP) and investments (INVASS), do not enter the reduced model after the omission of variables. These findings are in line with those of Barkley (1990), who discovered no relevant impact of government payments on agricultural employment, and those of Breustedt and Glauben (2007) who concluded that the subsidy variable is not significant in the regression. A possible reason for the non-significant investment variable INVASS may be the typical investment/divestment pattern according to the three stages of life-cycle models (Pushkarskaya and Vedenov, 2009) which are well represented by the (highly significant) variable AGE.

The logit model based on the FADN dataset revealed that economic variables are less useful than structural/social characteristics for explaining the variance of the exit probability FARMEXIT. At first glance, this finding is surprising, since it reveals that the economic situation is not of primary importance in the decision to exit or remain in the sector.

It is evident from the literature that numerous other factors such as good management practices, knowledge and early adoption of new technology, and love of farming impact on farm success (e.g. Hassan and Nhemachena, 2008). In addition, information on the farm manager's decision-making process and the organisation of the farm may affect farm profitability. As this information is not available in either the FSS or the FADN data, however, an additional survey would be required to allow a more-detailed analysis to be performed.

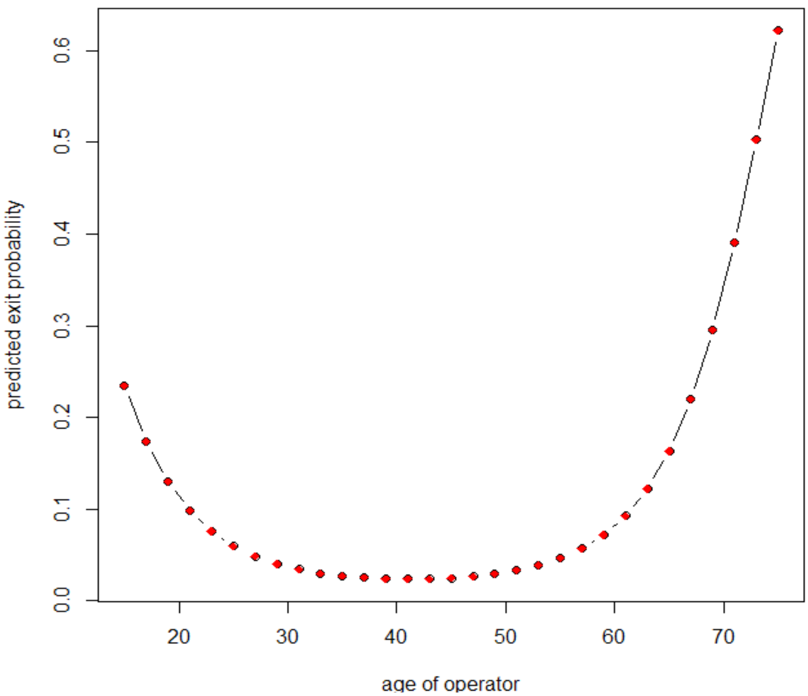

Figure 1. Effect plot for exit probability based on the reduced logit model as described in Section 3.3. Variables other than *age* and *age2* are kept constant to their median value

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