Reversion from Organic to Conventional Agriculture in Germany: An Event History Analysis

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Abstract

Organic farming has become increasingly important during recent decades, and the increasing number of organic farms shows a positive trend. Recent studies, however, find that there is a counterbalancing trend: farmers are leaving the organic sector and reverting to conventional methods. We contribute to this new branch of literature by performing event history analysis in order to examine reversion patterns in Germany for the first time. Moreover, we present new evidence for a comparable cohort of farms on which organic production was started in the same time period between 1999 and 2003. Our results show that 30% of these newly converted farms were reverted to conventional agriculture by 2010. Most of the reversions took place between 2003 to 2005. Thus, we can conclude that these farms were reverted within six years after they had become organic. Furthermore, we find that part-time farms and farms with fattened pigs or poultry face a higher probability of reverting, while farms with a higher income potential per labor unit, a higher degree of conversion, a higher share of vegetables, and a higher number of dairy or suckler cows are less likely to revert to conventional methods. Information on reversion behavior is needed when policy aims at reaching a higher share of organic area in a country. In order to prevent organic farmers from leaving the organic sector, we recommend offering an extended advisory service both before and during conversion as well as continuous support after conversion. Particular support for part-time farms or farms with pigs and poultry may contribute to the growth of the organic sector.

Key Words

event history analysis; organic agriculture; reversion

1 Introduction

Within the framework of the national sustainability strategy, the German Federal Government aims to reach a share of 20% organic area out of the total utilized agricultural area in the medium term, as organic farming practices are particularly characterized by the protection of animals, soil, and water as well as conservation of natural resources (DIE BUNDESREGIERUNG, 2002, 2012). When looking at the latest annual growth rates of the German organic area, which have continually decreased since 2010 (BMEL, 2015), the 20% target would be reached after more than 160 years. In order to achieve this aim sooner, it is not only important to entice conventional farmers to enter the organic sector, it is also crucial to prevent organic farmers from leaving the organic sector. Therefore, information on reversion behavior is needed.

Some studies concerning the abandonment of organic farming have already been performed. The literature review by SAHM et al. (2013) provides a comprehensive overview of reversion studies; e.g. RIGBY et al. (2001) for the UK, KALTOFT and RISGAARD (2006) for Denmark, and LÄPPLE (2010) for Ireland. SAHM et al. (2013) conclude that, for most farmers, the decision to revert is a result of different factors (e.g. economic motives, difficulties regarding certification, and control of or problems with organic production techniques). However, nearly all studies find that economic factors played a main role. In addition to the studies presented by SAHM et al. (2013), results are provided by MADELRIEUX and ALAVOINE-MORNAS (2013) for France, ALEXOPOULOS et al. (2010) for Western Greece, SAUER and PARK (2009) for Denmark, and ZANOLI et al. (2010) for farms in the Marches in Italy. Following SAHM et al.'s (2013) review, we present more details on these studies in Table 1.

Table 1. Studies on the abandonment of organic farming

Region	Year of survey	Data collection method	Analyzed sample	Analysis methods	Reasons for reversion
Marches (Italy) (ZANOLI et al., 2010)	1993 to 2006	Survey of 963 producers registered with a private Italian certification body (40% of the organic farms in the region)	963 organic farms	Descriptive analysis, event history analysis	– Probability of exiting increases with the age of the farmer. – Farms producing fruit and vegetables, wine, or olives are more likely to survive longer. – Reversion is more concentrated in grassland and cereal-growing areas. – Farmers converting after 2002 – under a new Rural Development funding Scheme – are also more likely to exit the sector.
Denmark (SAUER and PARK, 2009)	2002 to 2004	Panel of 56 organic milk farms, selected by stratified random sampling out of 480 organic milk farms	56 organic dairy farms	Bootstrapped bivariate probit model	– The longer the organic farm is operated by its current owner, the lower is the risk of exit. – A relatively high increase in total investment over the last years, an increase of the organic subsidies received and generating an increasing part of the total income by off farm activities are linked with a lower likelihood of market exit. – Higher investment in additional milk quota could increase exit probability.
Western Greece (ALEXOPOULOS et al., 2010)	2004	Survey addressing 187 organic farmes (10.2% of the organic farmers in the region)	187 organic farmers	Probit model	– Less innovative and pluriactive farmers, owning larger farms, experiencing low prices, and without supportive networks seem more likely to abandon organic farming.
France (MADELRIEUX and ALAVOINE-MORNAS, 2013)	2005 to 2010	a) Dataset provided by the Agence Bio (national level) b) Interviews with former organic farmers in the Rhône-Alpes region	a) Around 700 withdrawing organic farms per year b) 18 former organic farmers	a) Descriptive analysis b) Qualitative case study	– Trend towards earlier withdrawals – Two dimensions seemed to be discriminating regarding the process of withdrawal: the circumstances causing the farmers to leave organic farming and what farmers retained of their organic farming experience.
Germany I (KUHNERT et al., 2013)	a) 2003 to 2010 b) 2003 to 2009 c) 2010	a) German official agricultural statistics b) Written survey with all 4 616 farms that abandoned organic farming between 2003 and 2009 (1 271 responses) c) Qualitative expert interviews	a) Around 600 withdrawing organic farms per year b) 388 reverting farms, 338 abandonments c) 23 interviews	a), b) Descriptive analysis c) Qualitative case study	– Part-time farms, smaller farms, farms of older farmers, goat and sheep farms, and beef producers are more likely to revert. – Wineries, vegetable farms, and members of an organic farming association face rather low reversion rates. – Reversion probability declines with the duration of organic management. – Decision to revert is based on several personal, external, and farm-related reasons such as economic reasons and problems concerning organic standards and control.
Germany II (HEINZE and VOGEL, 2012)	2007/ 2010	German official agricultural statistics	13 013 organic farms, 1 258 reverting farms	Probit model	– Experience gathered in organic farming positively impacts the continuation of organic farming. – A larger share of fully converted land and the existence of organically reared livestock have a positive impact on the continuation of organic farming. – A higher proportion of permanent grassland shows a negative impact on the continuation of organic farming.

Note: presented are only studies that are not mentioned in SAHM et al.'s (2013) comprehensive literature review.
Source: own presentation

For Germany, there are basically two studies providing information on the dynamics of the national organic sector; HEINZE and VOGEL (2012) examined the reversion behavior of German organic farmers between 2007 and 2010, and the latest results can be found in KUHNERT et al. (2013), who amended analyses of the official statistics through personal interviews of experts and (former) organic farmers.

While HEINZE and VOGEL (2012) and KUHNERT et al. (2013) constructed their analyses as snapshots between two surveys in each case, the present study aims at analyzing the long-term development of a certain cohort of German organic farms. The considered cohort includes all farms that were managed conventionally in the year 1999 and that converted to organic farming by 2003. During this period the effects of the BSE crisis and the consequent policy change led to the initiation of a series of actions in order to improve the general conditions for the organic sector in Germany (e.g. introduction of an official organic seal, implementation of a German law on organic farming and start of a federal organic farming program (see e.g. NIEBERG et al., 2011, and KUHNERT et al., 2005). In fact, the highest growth rates regarding the number of organic farms as well as the organic area (an increase of 60%, respectively, see BMEL, 2015) could be observed between 1999 and 2003. Hence, our cohort belongs to the large group of farms that were converted during this period of newly improved conditions. Moreover, looking at a comparable cohort of farms on which organic production was started in the same time period leads to more robust results compared to studies based on farms which were converted at different times.

For our analysis, we track the farms of the considered cohort over a period of seven years until 2010 in order to answer the following questions:

1. How many farms reverted to conventional agriculture?
2. When did the reversion occur?
3. Which factors affect the likelihood of reversion?

As we include only newly converted farms in the analysis and, thus, the starting time period of organic management on the farm is known, we can also draw conclusions about the duration of the organic management on the reverted farms.

The analysis is carried out using discrete-time event history analysis, which is based on life tables and logit estimations. This method is particularly suitable for analyzing when a certain event occurs. However, to the best of our knowledge, there are only two studies which use event history analysis in order to examine reversion behavior of organic farmers: LÄPPLE (2010) examines the determinants that affect the abandonment of organic drystock farming in Ireland over time. Results reveal the highest dropout rates in years five and six of organic management. While the fact that the farm holder has an off-farm job seems to be positively related to the probability to exit organic farming, farms with a higher stocking density (measured in livestock units per ha) and farmers with a high environmental concern face a lower reversion probability. ZANOLI et al. (2010) apply event history analysis to organic farms in the Marches in Italy in order to detect the factors influencing the abandonment of organic farming (see Table 1 for more details).

We contribute to the literature by applying event history analysis in order to examine the reversion patterns in Germany for the first time. In contrast to the vast majority of studies on the abandonment of organic farming, which use sample survey data, our study is based on full census data and, thus, provides a complete overview on the reversion phenomenon in a unique way. Moreover, we present new evidence for a comparable cohort of farms on which organic production was started in the same time period.

The following sections of this paper provide an overview of the data source and data preparation. Subsequently, we explain the methodology and present the empirical results for the sample hazard and survivor function as well as the fitted discrete-time hazard model. The final section concludes.

2 Data

2.1 The Official Agricultural Statistics

The analysis is based on the micro data of the official statistics on German agriculture: farm structure surveys and agricultural censuses. More specifically, we use a panel dataset called AFiD-Panel Agriculture (AFiD stands for “Amtliche Firmendaten für Deutschland” (official firm data for Germany)). Within this data set, micro data of the farm structure surveys from 2003, 2005, and 2007 as well as the agricultural census 1999 were linked over the years through the farms’ IDs so that farms can be tracked over the entire period at an individual operational level (see HEINZE and VOGEL, 2010, for more information). Additionally, data of the agricultural census 2010 were included in the panel data set.

Our data set contains complete survey data on all German farms reaching specific minimum values. Thus, in a specific year, all farms above these thresholds of coverage were obliged to answer (at least parts of) the questionnaire. In 2010, farms with a minimum size of five hectares utilized agricultural area or those with a minimum extent of areas under specialized crops (e.g. 0.5 ha of vines) or animal production (e.g. 10 cattle) were questioned. From 1999 to 2007, lower thresholds of coverage were used. However, to get a consistent database, the data of the complete surveys between 1999 and 2007 were adapted retroactively to the higher thresholds of coverage of the agricultural census 2010. These thresholds of coverage must be considered, while interpreting the results (e.g. our results are not necessarily valid for small farms below the thresholds) and while checking the results against figures on organic farming that are based on other data sets (for example data of the Federal Ministry of Food and Agriculture).

2.2 Definition of Organic Farms

For all considered years (namely 1999, 2003, 2005, 2007 and 2010), information on whether a farm is managed organically or conventionally is consistently available in the data set. Farms are defined as organically managed if the agricultural holding produces crop and/or animal products according to the principles of Council Regulation (EC) No. 834/2007 or Council Regulation (EEC) No. 2092/91 on organic production and if the holding is subject to a compulsory control procedure performed by an approved control agency.

Council Regulation (EC) No. 834/2007 on organic farming permits partial conversions, but in Germany, farmers can receive organic support payments only if the whole farm is converted to organic management (NIEBERG et al., 2011). Therefore, in most cases, partial conversions do not represent an economically attractive option for organic farmers. However, official statistics aim at collecting information on whole operating units with a single management (see Regulation (EC) No. 1166/2008, Article 2). Thus, they try to account for one holding, even if it consists of several legally independent units but is under a single management. For this reason, the number of partially converted farms can be represented in official statistics as higher than expected. According to the data set, 1 516 farms (30%) of the considered cohort are only partially converted to organic farming. In the dataset, partially converted farms are coded as organic farms.

Moreover, farms under conversion are considered as organic. The conversion period lasts for two years in Germany. Within this period, farmers have to follow organic principles, but only can sell their produce as conversion or conventional goods (see Commission Regulation (EC) No. 889/2008 and BMEL, 2015).

2.3 Data Preparation

In the initial data set, we find 13 863 farms which were managed organically in 2003. After having applied the thresholds of coverage of the year 2010 to the data of the years from 1999 to 2007, the data set contains information on 13 169 organic farms in 2003. With a focus on the long-term development of a certain cohort of farms, this study solely takes farms into consideration, which have been managed conventionally in May 1999 (the survey month of the agricultural census 1999) and were managed organically in May 2003 (the survey month of the farm structure survey 2003). In doing so, we focus on farms on which organic production was started at some time during May 1999 and May 2003. This holds true for 5 586 farms.[1] As 604 of these farms show data gaps, they were excluded from the analysis. In these cases, comprehensive information is not available for all considered survey years. Thus, it is not possible to indicate clearly whether and when these farms were reverted to conventional farming. Data gaps can occur when a farm falls below the thresholds of coverage, gives up, merges with another farm, or moves to another federal state. Finally, a total of 4 982 organic farms in the year 2003 remain in the dataset and form the cohort, which is the basis for the following analysis. Descriptive statistics of the dataset can be found in Table A1 of the appendix.

While checking the data set, we identified 198 farms which were converted to organic farming immediately after reversion (participation pattern "organic / conventional / organic"). Of these 198 farms,

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1 For official agricultural statistics, farmers had to answer the question regarding whether they managed their farm conventionally or organically in 1999 for the first time. When data on a variable are collected for the first time, errors may occur, even if the utmost care was taken during data collection procedure. Thus, there may exist some farms that were conventionally managed in 1999, indicated erroneously as being managed organically in 1999 and actually were converted to organic management by 2003. Specific information on this phenomenon is missing, but if these farms really exist, it can be assumed that this only holds true for a very small number of farms.

112, which were marked to be managed organically in the years 2003, 2007 and 2010, could be identified in the data set as conventional farms in 2005, and 86 farms which were marked to be managed organically in the years 2003, 2005 and 2010 could be identified as conventional farms in 2007. As errors during data collection may have occurred, we recoded these ambiguous cases to organic farms for the following analysis.[2]

2.4 Definition of the Considered Periods

Since the exact date of reversion of the farms is unknown, but information whether a farm is managed organically or conventionally at the survey date can be extracted from the data set, we are only able to identify whether a farm was reverted to conventional methods at some time between two surveys. This has to be considered while interpreting the results.

Our observation period starts in May 2003, which is the survey month of the farm structure survey 2003. For the sample hazard and survivor functions, the first study period is defined by the survey month of the farm structure survey 2003 and the survey month of the following farm structure survey (May 2005) and thus covers a period of two years (as follows indicated as "[2003, 2005)"). Analogously, the next period is between May 2005 and May 2007, and the last period starts in May 2007 and ends in March 2010, which is the survey month of the agricultural census 2010. Due to the fact that in 2005 information of most of our exogenous variables is not available for all farms, the fitted discrete-time hazard model contains only two periods: [2003, 2007) and [2007, 2010).

3 Methodology

The analysis is based on discrete-time event history analysis, a statistical method which analyzes the duration until a certain event occurs. At the same time, the method provides information on the probability of the occurrence of that certain event. Thus, the method allows explaining the time span until a production technology is adopted or abandoned. Furthermore, methods of event history analysis are able to handle censored observations (see SINGER and WILLET, 2003). In our case, we face so-called "right-censoring", because for all farms that are still managed organically at the end of our observation period, we do not know whether or when they will be reverted to conventional farming. However, also for these farms information that reversion did not take place by the time of censoring in 2010 could be used by the methods of event history analysis.

In a first step, we use a life table (see SINGER and WILLET, 2003) to describe the reversion patterns of newly converted organic farms of the year 2003. This table forms the basis for computing the sample hazard function (share of reverted farms compared to all organic farms at the beginning of each period) and the sample survivor function (share of organic farms which were (still) not reverted at the end of a period compared to all organic farms at the beginning of the first period).

In a second step, we analyze which independent variables affect the likelihood of reversion. Following SINGER and WILLET (2003) and WILLET and SINGER (1993) we use a logistic regression to estimate a fitted discrete-time hazard model. Formally, our model can be expressed as

$$\text{logit } h(t_{ij}) = [\alpha_1 D_{1ij} + \alpha_2 D_{2ij}] + \beta_1 X_{ij} + \beta_2 Z_{ij} D_{1ij} + \beta_3 Z_{ij} D_{2ij} \quad (1)$$

with i representing the farm and j the time period index. *Logit* $h(t_{ij})$ is defined as the logit discrete-time hazard function for farm i in time period j. The dependent variable is an event indicator that records whether farm i reverted to conventional methods in period j or not (0 = no event, 1 = reversion).

The dummy variables D_1 and D_2 refer to the two time periods. In the first period (2003, 2007), D_1 equals 1 and D_2 is 0. In the second period (2007, 2010), D_2 equals 1 and D_1 is 0. The alpha parameters α_1 and α_2 act as multiple intercepts and represent the baseline hazard function. Vector X contains independent variables without interaction with time, while vector Z contains independent variables with interaction with time, and β_1, β_2 and β_3 indicate the **vectors** of parameter estimates.

Concerning the independent variables, the dataset provides information on

- whether or not the farm is a part-time farm (off farm income is higher than farm income),
- the income potential per labor unit, as a weak proxy to account for productivity of the farm,

[2] To check the robustness of our results, we estimated our model without these 198 ambiguous cases (farms that were converted to organic farming immediately after reversion). This estimation did not entail any changes in terms of signs and significance of the parameter estimates. The results of this robustness check are available from the authors on request.

Table 2. Definition of the explanatory variables and their expected impact

Variable	Definition (Dimension)	Expected impact on reversion*
Operational factors		
Part-time farm	Individual part-time farm = 1; individual full-time farm and legal persons under private or public law = 0 (dummy)	+
Income potential per labor unit	Standard gross margin per labor unit (Euro/LabU)	-
Degree of conversion	Share of organic area of total utilized agricultural area of the farm (%)	-
Conventional livestock	Existence of conventional livestock on the farm (dummy)	+
Utilized agricultural area	Utilized agricultural area (ha)	-
Share of vineyards	Share of vineyard area of total utilized agricultural area of the farm (%)	-
Share of vegetables	Share of vegetable area of total utilized agricultural area of the farm (%)	-
Share of fruits	Share of fruit area of total utilized agricultural area of the farm (%)	-
Dairy cows	Number of organic dairy cows in livestock units (LU)	+
Suckler cows	Number of organic suckler cows in livestock units (LU)	+
Sheep	Number of organic sheep in livestock units (LU)	+
Breeding sows	Number of organic breeding sows in livestock units (LU)	+
Fattening pigs	Number of organic fattening pigs in livestock units (LU)	+
Poultry	Number of organic poultry in livestock units (LU)	+
Regional factors		
Share of organic farms	Share of number of organic farms of all farms in the municipality (Gemeinde) (%)	-
Population density	Residents (31. December 2003 or 2007) per square kilometer (persons per km^2) in the municipality	+
Average household income	Average disposable income of private households in the county (Kreis) (Euro)	-
Federal state	Federal state (dummy)	
Time factors		
Period 1	May 2003 to May 2007 (dummy)	+
Period 2	May 2007 to March 2010 (dummy)	-

Note: * + = associated with a higher probability of reversion, - = associated with a lower probability of reversion.
Source: own presentation

- the degree of conversion (as the EU regulation on organic farming permits partial conversions; see data section for more details) and whether livestock is kept conventionally on the farm,
- the utilized agricultural area to account for farm size,
- special crops to control for the share of vineyard, vegetable, and fruit cultivation area on the farm and
- the organic livestock, namely on the number of dairy cows, suckler cows, sheep, breeding sows, fattening pigs, poultry.

Furthermore, three regional variables are included in the model to reflect the market environment:

- the share of organic farms in the municipality (local administrative unit) as a proxy for (informal) networks of organic producers,
- the population density in the municipality to control for scarcity of agricultural land and
- the average household income in the county as a proxy for sales opportunities.

In order to control for further regional factors, for example differences in premium amounts, a full set of time-interacted federal state dummies is included in the estimation.[3]

Detailed definitions of the variables and their expected impact on reversion are available in Table 2. In addition to the influencing factors provided by official agricultural statistics, various other variables may affect the reversion behavior of organic farmers. The literature shows that the farm manager's attitude (for example, concerning the environment or risk tolerance) as well as economic factors (for example, or-

[3] More specifically, we include dummies for Schleswig-Holstein and Hamburg, Lower Saxony and Bremen, Brandenburg and Berlin, Rhineland Palatinate and Saarland, Thuringia, Saxony, Saxony-Anhalt, Hesse, Mecklenburg Western Pomerania, North Rhine-Westphalia, Baden-Württemberg. Bavaria acts as a reference group.

ganic subsidies and producer prices) are particularly important in the decision to stay in or to leave the organic sector (see e.g. BURTON et al., 2003; LÄPPLE, 2014; SAHM et al., 2013). Due to the lack of some important variables, it should be noted that the estimated models only provide evidence on statistical correlations between explanatory variables and reversion decisions. Therefore, the results can be seen as first indications of how reverting farms differ from farms that stay organic, but this does not necessarily have to be a causal relationship.

Concerning the estimation procedure, we firstly estimate equation 1 by including interactions between all available independent variables and time in the model. Secondly, we use a correlation matrix to test for multicollinearity and exclude the time interaction of variables with high correlation. In a third step we examine for each variable the signs of the time interaction terms by time period. If the signs of the parameter estimates do not differ by time period (parameter estimates show the same sign in both periods), we exclude the time interaction terms of the respective variable, assuming that this variable has an identical effect in both time periods. Finally, vector *X* (independent variables without time interaction) contains the variables *part-time farm*, *income potential per labor unit*, *degree of conversion*, *conventional livestock*, *share of vineyards*, *share of vegetables*, *share of fruits*, *dairy cows*, *suckler cows*, *sheep*, *breeding sows*, *share of organic farms*, and *average household income*. Vector *Y* (independent variables with time interaction) contains the variables *utilized agricultural area*, *fattening pigs*, *poultry*, *population density*, and a full set of *federal state* (Bundesländer) *dummies*.

To test whether unobserved heterogeneity across farms due to time-invariant omitted variables is important or not, we additionally run a random effects model (see Equation 2).

$$\text{logit } h(t_{ij}) = [\alpha_1 D_{1ij} + \alpha_2 D_{2ij}] + \beta_1 X_{ij} + \beta_2 Z_{ij} D_{1ij} + \beta_3 Z_{ij} D_{2ij} + u_i \quad (2)$$

The random effect is represented by u_i that is assumed to be normally distributed with a mean of zero (~ N(0, σ^2_u)), while σ^2_u is the unobserved heterogeneity term. As a result, we find that unobserved heterogeneity seems to have no effect on the parameters of the model (the results of the random effects model are not reported here but are available upon request). First, the parameter estimates and odds ratios of the random effects model are equal to the pooled model without random effects. Furthermore, based on a likelihood ratio test (for normal standard errors) the hypothesis of ρ (which is the proportion of the total variance contributed by the panel-level variance component) being equal to zero could not be rejected. Thus, the panel-level variance-component (ln(σ^2_u)) seems to be not important, and therefore we use the model without random effects for our analysis.

4 Results

4.1 Life Table

The life table describing the reversion patterns of German organic farms which were converted between 1999 and 2003 shows that 70% were still managed organically in 2010, while almost every third of the considered farms was reverted to conventional methods within the following seven years (see Table 3). For an improved understanding of the importance of the reverted farms note that the cohort of all 4 982 newly converted farms cultivated 213 615 ha organic area in 2003. The 1 494 reverted farms managed 43 902 ha of organically cultivated land. This corresponds to a share of 21% of the total organic area of the considered farms in 2003.

Table 3. Life table describing the reversion patterns of organic farms that were converted between May 1999 and May 2003

Period	Number of organic farms		Sample hazard function	Sample survivor function
	at the beginning of the period	that were reverted during the period		
2003	4 982	–	–	100.0%
[2003, 2005)	4 982	809	16.2%	83.8%
[2005, 2007)	4 173	266	6.4%	78.4%
[2007, 2010)	3 907	419	10.7%	70.0%

Source: Research Data Centers of the Federal Statistical Office and the statistical offices of the federal states; AFiD-Panel Agriculture 1999, 2003, 2005, 2007; agricultural census 2010; authors' own calculations

The sample hazard function reveals that 809 reversions occurred between 2003 and 2005. While average annual reversion rates amount to 8% during this period, approximately 3% can be measured in the following periods. This is in line with the results of KUHNERT et al.'s (2013) survey, which show that reversion probability declines with the duration of organic management. According to our results, most of the reversions took place in the period 2003 to 2005. Thus, with regard to our specific cohort of farms (farms which converted between 1999 and 2003), we can conclude that these farms took this step between one and six years after they had become organic.

4.2 Fitted Discrete-time Hazard Model

Table 4 presents the fitted discrete-time hazard model (see Equation 1) that contains a number of independent variables to distinguish among farms.

A positive sign of the parameter estimate in Table 4 means that the associated independent variable has a positive effect on the hazard rate of reversion, leading to a higher probability of reverting to conventional agriculture. A negative sign of the parameter estimate indicates that the variable has a negative effect on the hazard rate. The value of each parameter estimate represents the size of the vertical differential in logit hazard corresponding to a one-unit difference

Table 4. Fitted discrete-time hazard model

	Parameter estimates	Odds ratio
Operational factors		
Part-time farm (dummy)	0.26*** (0.07)	1.29
Income potential per labor unit [x 10^4]	-0.05*** (0.01)	0.95
Degree of conversion [x 10^1]	-0.12*** (0.01)	0.89
Conventional livestock (dummy)	0.09 (0.09)	1.09
Utilized agricultural area period 1 [x 10^3]	0.23 (0.29)	1.26
Utilized agricultural area period 2 [x 10^3]	-0.05 (0.32)	0.95
Share of vineyards [x 10^1]	-0.03 (0.03)	0.97
Share of vegetables [x 10^1]	-0.26** (0.11)	0.77
Share of fruits [x 10^1]	-0.02 (0.03)	0.98
Dairy cows [x 10^1]	-0.07** (0.03)	0.93
Suckler cows [x 10^1]	-0.10*** (0.03)	0.91
Sheep [x 10^2]	-0.01 (0.25)	1.00
Breeding sows [x 10^1]	-0.23 (0.15)	0.80
Fattening pigs period 1 [x 10^1]	0.20*** (0.06)	1.23
Fattening pigs period 2 [x 10^1]	-0.18 (0.32)	0.83
Poultry period 1 [x 10^1]	0.30*** (0.07)	1.35
Poultry period 2 [x 10^1]	-4.48 (3.02)	0.01
Regional factors		
Share of organic farms [x 10^1]	-0.01 (0.03)	0.99
Population density period 1 [x 10^2]	0.02 (0.02)	1.02
Population density period 2 [x 10^2]	-0.03 (0.03)	0.97
Average household income [x 10^3]	-0.02 (0.02)	0.98
Federal state x time-interaction terms included	yes	
Time factors		
Period 1 (dummy)	0.26 (0.38)	1.29
Period 2 (dummy)	-0.45 (0.42)	0.64
Number of observations		
Number of observations		8 889
Number of farms		4 982

Note: presented are the parameter estimates, the estimated odds ratios and the cluster robust standard errors (in parentheses) from estimating Equation (1). *** and ** denote significance at the 1% and 5% level.

Source: Research Data Centers of the Federal Statistical Office and the statistical offices of the federal states; AFiD-Panel Agriculture 1999, 2003, 2005, 2007; agricultural census 2010; authors' own calculations

in its associated independent variable while statistically controlling for the other exogenous variables in the model. Note that we adjusted the units of the variables to facilitate their interpretation. For example, a one-unit difference in the case of the utilized agricultural area is defined as 1 000 ha (indicated by [x 10^3] in Table 4). In the case of dummy variables, the value of the parameter estimate indicates the vertical separation of the fitted logit hazard functions for the two groups. Antilogging the parameter estimates yields the odds-ratios, the ratio of the odds of event occurrence in two groups of farms (see SINGER and WILLET, 2003).

We find that part-time farms are more likely to revert to conventional farming than full-time farms. Looking at the odds ratios, we find that the estimated odds of reversion for part-time farms are 1.29 times the odds of reversion for full-time farms. This is in line with our expectations and in line with the results of LÄPPLE (2010) and KUHNERT et al. (2013), who conclude that part-time farmers or farmers with off-farm occupation are more likely to exit the organic sector, as compliance with comprehensive rules as well as a higher bureaucratic burden associated with organic farming could involve extensive effort for part-time farmers. Our findings contradict SAUER et al. (2007) and SAUER and PARK (2009), who show that the higher the off-farm income, the lower the probability to abandon organic farming. However, the farmer's underlying educational level might play an important role within this context.

As expected, a higher level of income potential per labor unit is associated with a statistically significant negative effect on the hazard rate of reversion. Concerning the interpretation of the odds ratios, consider two hypothetical farms with a 10 000 Euro difference in their standard gross margin per labor unit. The estimated odds of reversion of the farm with the higher income potential per labor unit are 5% lower than the odds of the farm with the lower income potential per labor unit. Due to the fact that the mean standard gross margin per labor unit is around 31 000 Euro, the reduction of the odds related with a higher potential income level of 10 000 Euro indicates that a higher income potential per labor unit is importantly linked to a lower reversion probability. The income potential might also act as a weak proxy to account for productivity of the farm. Farms that are more productive are mostly able to generate a sufficient income and, thus, these farms are less likely to be reverted to conventional methods. Moreover, managers of more productive organic farms probably have invested much time in gaining extensive knowledge of organic farming practices, which could prevent them from reverting to conventional methods.

Concerning the degree of conversion our expectations are confirmed by a significant negative parameter estimate. It might be reasonable to assume that a higher degree of conversion lowers the reversion probability, as those farmers can be members of organic farming associations, for example, and farmers had to invest more in becoming organic. The effect of the variable conventional livestock, however, is not statistically significant at any level. Furthermore, we find no statistically significant effect of the size of the utilized agricultural area on the hazard rate of reversion.

In line with the results of ZANOLI et al. (2010) and Kuhnert et al. (2013), the parameter estimate of the share of vegetables shows the expected negative statistically significant sign. Growing these special crops yields the potential to generate a particularly high added value per hectare. Moreover, vegetables are especially suitable for direct marketing, leaving a substantial margin for the farmer, as there are no traders involved in the supply chain. In addition, the cultivation of organic permanent crops bears high initial investment costs, which could be a factor leading the farmer to carefully consider conversion to organic farming. However, the parameter estimates of the share of vineyards and the share of fruits have no statistically significant effect on the hazard rate of reversion.

With regard to the livestock variables, we find the variables of dairy cows and suckler cows to be statistically significant. Both variables have negative parameter estimates, indicating a negative effect on the reversion probability. This is contrary to our expectations and contrary to the results of FERJANI et al. (2010) and KUHNERT et al. (2013), who show that dairy farmers and beef producers face an above-average probability of leaving the organic sector. They mention that problems associated with compliance with organic guidelines (e.g. obligatory 100% organic feeding for cattle, sheep, and goat farms since 2008) or economic reasons (e.g. unsatisfactory marketing opportunities) could be a possible explanation for the higher reversion rates. Our contradictory findings may be explained by the fact that extensive cattle farms are the most suited to be converted, as their management does not differ as substantially between conventional and organic farms compared to farms with pigs or poultry, for example, and thus face relatively low cost and burden for conversion (see BICHLER et al., 2005). In contrast to the number of cattle, the number of organic sheep shows no statistically significant effect in our model.

Moreover, we find that, in the first period (2003, 2007), a higher number of fattening pigs or poultry is associated with a higher probability of reversion. This is also in line with our expectations and in line with the results presented in BICHLER et al.'s (2005) literature review, who find that it is more difficult for pig and poultry farms to adapt their management to organic principles. Furthermore, these farms could face poorer income opportunities, high costs for bought-in forage, poor availability of certified organic inputs, or problems with the obligatory 100% organic feeding and animal health (see e.g. KUHNERT et al., 2013). In the second period (2007, 2010), however, fattening pigs and poultry show no statistically significant effect on the hazard rate of reversion. A possible explanation for this phenomenon could be that farmers, who managed to get through the first period, were those who successfully adapted to the particular challenges of organic fattening pig and poultry farming. Thus, our results could indicate that there is a steep initial learning curve concerning the management of organic fattening pig and poultry stocks, but once farmers are able to overcome this, they can be successful. Breeding sows, however, has no statistically significant effect on the hazard rate of reversion.

The regional factors, namely the share of organic farms, the population density, and the average household income, have no statistically significant effect, either. This holds also true for the time dummies. However, compared to period 1, we observe a lower coefficient in period 2, which indicates a falling baseline of hazard rate. This is in line with the findings based on the life table that reversion probability declines with the duration of organic management.

5 Conclusions

This paper contributes to the literature on the abandonment of organic farming by applying event history analysis in order to examine the reversion patterns of German organic farms for the first time and presents new evidence for a comparable cohort of farms. More specifically, we use full census data to analyze the long-term development of farms that were managed conventionally in the year 1999 and converted to organic farming by 2003 by tracking these farms over a period of seven years until 2010.

As a first step, we use a life table to describe the reversion patterns of the considered organic farms. In 2010, 70% of these farms were still managed organically, while almost every third of the farms reverted to conventional farming practices. While the average annual reversion rates amount to 8% in the period of 2003 to 2005, approximately 3% can be measured annually in the period of 2005 to 2010. According to our results, most of the reversions took place in the period 2003 to 2005. Thus, with regard to our specific cohort of farms (farms which were converted between 1999 and 2003), this means that these farms took this step between one and six years after they had become organic.

In a second step, we analyze the factors affecting the likelihood of reversion to conventional agriculture. For that purpose, we estimate a fitted discrete-time hazard model which contains several exogenous variables to distinguish among farms. A statistically significant higher probability of reversion is associated with part-time farms as well as with a higher number of fattening pigs and poultry on the farm (at least in the first period). A statistically significant negative effect on the reversion probability is associated with the farm's income potential per labor unit, the degree of conversion, the share of vegetables, and the number of dairy and suckler cows on the farm. However, it should be critically noted that our analysis could not consider some relevant variables, such as farmers' attitudes and economic factors, due to a lack of data (for these factors' relevance, see e.g. BURTON et al., 2003; LÄPPLE, 2014, and SAHM et al., 2013).

When policy aims at reaching a higher share of organic area in a country, it is not only important to entice conventional farmers into the organic sector, it is also crucial to prevent organic farmers from leaving the organic sector. Therefore, information on reversion behavior is needed. Our study reveals the highest reversion rates in the first period. As organic farming is a knowledge-intensive system (see e.g. SEPPÄNEN and FRANCIS, 2006) and it can be assumed that not all farmers who convert to organic farming have realistic expectations concerning the effort required and the income generated by organic management (see e.g. RIGBY et al., 2001), offering an extended advisory service both before and during conversion as well as continuous support after conversion (such as integration into existing market structures), in order to help farmers to cope better with the challenges of the new production method could be one means of mitigating the number of reversions (see also KUHNERT et al., 2013). Particular support for part-time farms that face above-average reversion rates may contribute to the growth of the organic sector. As it can be assumed that time is a main limited factor for part-time farmers, they would benefit notably from a reduction of the bureaucratic burden associated with organic farming. Moreover, our results have shown that a higher number of fattening pigs or poultry is associated with a higher probability of reversion in the first period, while there is no statistically significant effect on the hazard rate of reversion in the second period. Thus, our results could indicate that there is a steep initial learning curve concerning the management of organic fattening pig and poultry stocks. For these farmers, specialized advisory services in organic fattening pig and poultry management as well as possibilities to share professional experiences (e.g. in business networks) and to gain knowledge from farmers who already have undergone this critical period would be helpful in their first years of organic production. Furthermore, a lack of input (as described in the literature; see e.g. KUHNERT et al., 2013) could be one of the reasons for their management problems. Our results show that a higher number of organic fattening pigs is associated with a higher probability of reversion, while the number of breeding sows has no statistically significant effect on the hazard rate of reversion. Thus, the lack of certified organic piglets and problems to sell the fattened pigs could play a main role for the failure of organic pig-fattening farmers. This suggests that the improved availability of certified organic piglets as well as improved conditions for the marketing of organic fattened pigs could help to keep these farmers in the organic sector. These farmers should be integrated into existing organic market structures as soon as possible, ideally directly after conversion, and should seek to set up long-term supply relations with organic breeding sow farmers in order to satisfy their needs for organic piglets. However, in order to permit reliable statements to be made about the underlying causal relationships, further research is required.

One of our findings is that most of the reversions took place in our first considered period (2003 to 2005) and, thus, for these farms within six years after they had become organic. These farms were converted between 1999 and 2003 – a time when policy improved the framework conditions for the organic sector substantially (see e.g. NIEBERG et al., 2011 and KUHNERT et al., 2005) and sector growth reached an all-time high (see BMEL, 2015). This raises the question of whether farmers which were pushed by policy measures to convert to organic management are more likely to revert to conventional methods afterwards. A potential reason for this is that the high expectations raised by the policy environment might possibly not have been met, maybe due to the fact that organic supply chains have not grown as fast as the number of farms, and thus not all farmers were able to gain access to the market. We leave the analysis of this issue for future research.

References

ALEXOPOULOS, G., A. KOUTSOURIS and I. TZOURAMANI (2010): Should I stay or should I go? Factors affecting farmers' decision to convert to organic farming as well as to abandon it. Proceedings of the 9th European IFSA Symposium, Vienna.

BICHLER, B., C. LIPPERT, A.M. HÄRING and S. DABBERT (2005): Die Bestimmungsgründe der räumlichen Verteilung des ökologischen Landbaus in Deutschland. In: Berichte über Landwirtschaft 83 (1): 50-75.

BMEL (Bundesministerium für Ernährung und Landwirtschaft) (2015): Ökologischer Landbau in Deutschland. In: http://www.bmel.de/DE/Landwirtschaft/Nachhaltige-Landnutzung/Oekolandbau/_Texte/OekologischerLand bauDeutschland.html. Accessed: October 1, 2015, Berlin.

BURTON, M., D. RIGBY and T. YOUNG (2003): Modelling the adoption of organic horticultural technology in the UK using Duration Analysis. In: The Australian Journal of Agricultural and Resource Economics 47 (1): 29-54.

DIE BUNDESREGIERUNG (2002): Perspektiven für Deutschland – Unsere Strategie für eine nachhaltige Entwicklung. In: https://www.bundesregierung.de/Content/DE/_Anlagen/Nachhaltigkeit-wiederhergestellt/perspektiven-fuer-deutschland-langfassung.pdf?__blob=publication File&v=3. Accessed June 15, 2016, Berlin.

– (2012): Nationale Nachhaltigkeitsstrategie – Fortschrittsbericht 2012. In: https://www.bundesregierung.de/Content/DE/_Anlagen/Nachhaltigkeit-wiederhergestellt/2012-05-21-fortschrittsbericht-2012-barrierefrei.pdf?__blob=pub licationFile&v=1. Accessed June 15, 2016, Berlin.

FERJANI, A., L. REISSIG and S. MANN (2010): Biolandbau in der Schweiz – wer steigt aus, wer steigt ein? In: Agrarforschung Schweiz 1 (4): 142-147.

HEINZE, S. and A. VOGEL (2010): The AFiD-Panel Agriculture: New Potential for agricultural Research. In: Schmollers Jahrbuch 130: 623-633.

– (2012): Ökologischer Landbau in Deutschland – Zu den Bestimmungsgründen von Umstellung und Rückumstellung. In: Berichte über Landwirtschaft 90 (3): 467-489.

KALTOFT, P. and M.-L. RISGAARD (2006): Has organic farming modernized itself out of business? Reverting to conventional methods in Denmark. In: HOLT, G. and M. REED (eds.): Sociological Perspectives of Organic Agriculture: From Pioneer to Policy. CABI Publishing, Wallingford: 126-141.

KUHNERT, H., G. BEHRENS, U. HAMM, H. MÜLLER, H. NIEBERG, J. SANDERS and R. STROHM (2013): Ausstiege aus dem ökologischen Landbau: Umfang – Gründe – Handlungsoptionen. Johann Heinrich von Thünen-Institut, Braunschweig.

KUHNERT, H., R.H. FEINDT and V. BEUSMANN (2005): Ausweitung des ökologischen Landbaus in Deutschland – Voraussetzungen, Strategien, Implikationen, politische Optionen. Landwirtschaftsverlag, Münster-Hiltrup.

LÄPPLE, D. (2010): Adoption and Abandonment of Organic Farming: An Empirical Investigation of the Irish Drystock Sector. In: Journal of Agricultural Economics 61 (3): 697-714.

– (2014): Comparing attitudes and characteristics of organic, former organic and conventional farmers: Evidence from Ireland. In: Renewable Agriculture and Food Systems 28 (4): 329-337.

MADELRIEUX, S. and F. ALAVOINE-Mornas (2013): Withdrawal from organic farming in France. In: Agronomy for Sustainable Development 33 (3): 457-468.

NIEBERG, H., H. KUHNERT and J. SANDERS (2011): Förderung des ökologischen Landbaus in Deutschland – Stand, Entwicklung und internationale Perspektive. 2nd edition, Johann Heinrich von Thünen-Institut, Braunschweig.

RIGBY, D., T. YOUNG and M. BURTON (2001): The development of and prospects for organic farming in the UK. In: Food Policy 26 (6): 599-613.

SAHM, H., J. SANDERS, H. NIEBERG, G. BEHRENS, H. KUHNERT, R. STROHM and U. HAMM (2013): Reversion from organic to conventional agriculture: A review. In: Renewable Agriculture and Food Systems 28 (3): 263-275.

SAUER, J. and T. PARK (2009): Organic Farming in Scandinavia – Productivity and Market Exit. In: Ecological Economics 68 (8-9): 2243-2254.

SAUER, J., T. PARK and J. GRAVERSEN (2007): Organic Farming in Denmark – Productivity, technical change and market exit. Paper prepared for presentation at the 47th annual conference of the GEWISOLA and the 17th annual conference of the ÖGA. Changing Agricultural and Food Sector, September 26-28, 2007, Freising/ Weihenstephan.

SEPPÄNEN, L. and C. FRANCIS (2006): Design of farmer education and training in organic agriculture. In: Kristiansen, P., A. Taji and J. Reganold (eds.): Organic agriculture – A global perspective. CABI Publishing, Wallingford: 407-420.

SINGER, J.D. and J.B. WILLETT (2003): Applied Longitudinal Data Analysis – Modelling Change and Event Occurrence. Oxford University Press, Oxford.

WILLETT, J.B. and J.D. SINGER (1993): Investigating Onset, Cessation, Relapse, and Recovery: Why You Should, and How You Can, Use Discrete-Time Survival Analysis to Examine Event Occurrence. In: Journal of Consulting and Clinical Psychology 61 (6): 952-965.

ZANOLI, R., D. GAMBELLI and F. SOLFANELLI (2010): Come sopravvivere nel biologico: uno studio delle aziende agro-biologiche marchigiane mediante analisi di sopravvivenza. In: Rivista di Economia Agraria 65 (1): 63-82.

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Appendix

Table A1. Descriptive statistics of farms that were converted between May 1999 and May 2003

Variables	2003		2007	
	Mean	Standard Deviation	Mean	Standard Deviation
Operational factors				
Part-time farm (dummy)	0.54	0.50	0.51	0.50
Income potential (Euro/LabU)	31 705.88	45 001.02	30 633.58	52 868.10
Degree of conversion (%)	90.29	26.12	93.69	22.24
Conventional livestock (dummy)	0.15	0.36	0.09	0.29
Utilized agricultural area (ha)	51.93	144.21	58.98	147.47
Share of vineyards (%)	1.13	10.02	1.11	9.98
Share of vegetables (%)	0.87	6.93	1.14	8.15
Share of fruits (%)	1.60	11.13	1.68	11.59
Dairy cows (LU)	6.57	20.38	7.29	22.10
Suckler cows (LU)	8.39	26.20	9.71	27.62
Sheep (LU)	1.80	13.18	1.85	13.27
Breeding sows (LU)	0.26	3.43	0.29	3.51
Fattening pigs (LU)	0.52	6.53	0.54	4.95
Poultry (LU)	0.32	5.74	0.18	2.48
Regional factors				
Share of organic farms (%)	8.74	11.76	9.50	11.30
Population density (persons per km^2)	176.12	246.80	175.86	253.18
Average household income (Euro)	17 192.29	1 882.37	18 810.60	2 169.42
Number of observations				
		4 982		3 907

Source: Research Data Centers of the Federal Statistical Office and the statistical offices of the federal states; AFiD-Panel Agriculture 1999, 2003, 2005, 2007; agricultural census 2010; authors' own calculations