Explaining the Process for Conversion to Organic Dairy Farming in Sweden: An Alternative Modelling Approach

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Abstract

To date, the process of conversion to organic farming has been analysed as a choice between only two alternatives, conventional versus organic farming. However, the conversion process in the EU is a two-tier decision, which brings the possibility of a nested structure between mixed and organic farming. In the context of Sweden, where the conversion investment is flexible, we attempted to identify economic determinants of the organic conversion process. For that purpose, we applied the nested Logit random utility maximisation (NLRUM) model to data from the Swedish farm accounting data network for 2002-2012. The analysis showed that milk prices, milk yield and environmental support payments play a significant role in the organic conversion process. As expected, a decrease in conventional milk prices would induce conventional farms to convert to organic production. The scale of conversion to organic farming was more pronounced among dairy farms located in regions with higher environmental support payments, and in regions endowed with more pasture land and leys.

Key Words

mixed farming; nested logit model; organic dairy; Sweden

1 Introduction

In the EU, around one-quarter of organic producers follow a *mixed strategy*[1], whereby organic and conventional practices coexist on the same farm (EUROPEAN UNION COMMITTEE OF THE REGIONS, 2014). In the literature, a *mixed strategy*, i.e. *partial conversion* (as defined in KHALEDI et al., 2010; LEE et al., 2016) to organic farming, where farmers decide to convert one part of their land, is described (e.g. by ACS et al., 2009) as an optimal strategy among risk-neutral farmers. On the other hand, for more risk-averse farmers policy incentives in terms of lower taxes on pesticides, subsidies on conversion or a stable market for the organic products are needed. According to AKER et al. (2005) and KHALEDI et al. (2010) conversion to organic is a process whereby potential adopters: 1) learn the organic technology, 2) seek information on details concerning the technology, networks and marketing; 3) compare the costs and benefits of technological options; 4) decide whether to enter the adoption process; and finally, 5) make decisions on the share of production to convert to organic farming. In-depth interviews with British dairy farmers have shown that for a majority of them, partial conversion of a small block of land is common practice before the final decision to convert the whole farm is made (PADEL, 2001). The reasoning behind this is primarily to accumulate experience and knowledge (KHALEDI et al., 2010; LOCKERETZ, 1989; PADEL, 2001) of the organic system on their own farm in order to gain the necessary confidence and spread the risk over several years before they make a final commitment (e.g. PADEL, 2001). Polish farmers also find the partial conversion option beneficial, as it provides an opportunity to raise additional funds by shifting some part of their agricultural area to organic, especially when soil quality does not guarantee good yields under the conventional system (NACHTMAN, 2015).

For policy makers, farmers applying the mixed strategy (hereafter called ‘mixed farms’) can be seen as potential converters to organic and, as described in the literature (e.g. DARNHOFER et al., 2005; KHALEDI et al., 2010; KOESLING et al., 2008; LEE et al., 2016), this might have implications for the choice of agricultural policies for promoting the expansion of organic production. This situation is worth considering particularly for dairy farms[2] in Sweden with organically converted land or land located in naturally protected areas, where only six months of organic-based feeding is

[1] The mixed strategy as defined here does not imply “parallel production” of agricultural commodities of the same type, for example conventional and organic milk, or the same crop variety produced on the same farm.

[2] For comparison, in Sweden the conversion process to organic meat production is much longer, and requires two years of organic-based feeding, where at least 50% of the feed is produced on the farm.

necessary to convert from conventional to organic milk production (JORDBRUKSVERKET, 2015; LRF, 2016).

Decisions at farm level on conversion from conventional to organic, and vice versa, and the factors that induce conversion are of great interest to researchers and policy makers, in order to model and explain this phenomenon and develop adequate policies. Existing studies on such conversion decisions mainly focus on the choice between conventional and organic farming, or specifically the choice to convert from conventional to organic (e.g. KUMBHAKAR et al., 2008; LÄPPLE and KELLEY, 2014; PIETOLA and LANSINK, 2001; SCHMIDTNER et al., 2011), and the reversion from organic to conventional farming, i.e. abandoning organic farming (LÄPPLE, 2010; RIGBY et al., 2001).

Although it is recognised that there may also be a choice between conventional and full conversion (e.g. ACS et al., 2009; KOESLING et al., 2008; PADEL, 2001), this conversion choice, allowing the existence of mixed farms in addition to conventional and organic farms, has been overlooked in research. To our knowledge only LEE et al. (2016) and KHALEDI et al. (2010) have previously studied the probability of partial and complete adoption of organic farming in South Korea and Canada, respectively. In both studies, probabilities were based on singe-round surveys, collecting data in one year. As stated by LEE et al. (2016), for the results to be generalised and more robust, more research including different areas, farms and years are needed. Another empirical study considering mixed farms is the work by NACHTMAN (2015) on Polish farms, where the focus is on the competitiveness (in economic terms) of mixed compared with organic farms, but not the conversion decision on the mixed strategy.

Therefore, the aim of the present study was to examine farmers' conversion decisions from conventional to organic farming, whereby mixed farming, i.e. partial conversion, is part of the sequential conversion process from conventional to organic farming. Farmers' choices to convert their production are explained with respect to selected explanatory economic variables. In this study, as part of the decision-making process the farmer was assumed to first decide whether to stay conventional or join the conversion process, and then to make another choice between mixed and organic production. In this framework, the alternatives of mixed and organic farming exhibit a higher degree of similarity in their characteristics than conventional production, because they undergo the same conversion process. In this context, the nested logit (NL) model (KOPPELMAN and BHAT, 2006; MCFADDEN, 1978) is well suited to characterise the nested structure of mixed and organic farming. The NL model has been widely used in analysis of residential location choice (e.g. MCFADDEN, 1978) and travel mode choice (FORINASH and KOPPELMAN, 1993; KOPPELMAN and BHAT, 2006). To our knowledge, the NL model framework has not previously been applied to model farmers' choices of production system in the agriculture sector.

The empirical application was to data from dairy farms in Sweden, using an unbalanced panel of data from the Swedish farm accounting data network (FADN) database for the period 2002-2012, enabling the characteristics of the conversion process and its time dimension to be captured. Sweden is one of the leading European Union (EU) countries in converting to organic farming, with 17% of the total agricultural area converted, after Austria with 20% (EUROSTAT, 2016). However, given the national target of 20% organic area and 25% organic food consumption in the public institution sector (EKOLOGISKT FORUM, 2007), the uptake rate of organic farming is low and a major challenge to increasing the domestic supply of organic food.

The rest of the paper is structured as follows. Section 2 provides details on the conversion process to organic farming. Section 3 introduces the modelling framework for the assumed two-level decision process. Empirical results are presented and discussed in Section 4, and the main findings are summarised in Section 5.

2 Characteristics of the Organic Conversion Process

The organic conversion process, in general, tends to be similar across EU member states, but the policy incentives in the national agriculture plan may differ (KOESLING et al., 2008). For example, in Germany, Finland and Ireland, the conversion process is irreversible in the sense that farms undergoing the process of conversion, named *in-conversion farms* by ACS et al. (2009), have to operate under the rules of organic farming for three consecutive years before being granted organic status in the fourth year. During this period, they cannot quit the conversion process without a penalty (LÄPPLE, 2010; PIETOLA and LANSINK, 2001; SCHMIDTNER et al., 2011).

In Sweden, the choice between conventional and organic is rather flexible; the mandatory conversion period, in compliance with the EU standard regulation, takes only two years and farms can quit the conversion process at any time without penalty (LRF, 2016). However, in Sweden, *in-conversion* livestock farms may tend to prolong the conversion period for two purposes. First, they may follow a gradual process of first converting their arable and pasture land and then their livestock, in order to spread the conversion risk over several years (PADEL, 2001). Second, they may decide to convert partly, for example only convert their arable and/or pasture land, but not their livestock (JORDBRUKSVERKET, 2015; LRF, 2016), in order to claim subsidies for organically converted land (LOHR and SALOMONSSON, 2000). It is important to emphasise that, following Commission Regulation 2092/91, conventional and organic farming must be visibly distinguishable and organised only in separate operational units (EC, 1991). Moreover, the mixed strategy, i.e. partial conversion, does not mean 'parallel production' of agricultural commodities of the same type, for example conventional and organic milk, or the same crop variety produced on the same farm. According to EU regulations, such undistinguishable organic and conventional varieties/commodities have to be grown on separate holdings. In Sweden and Norway, 'parallel production' of conventional and organic products of the same commodity/variety is generally not allowed, except for education and research purposes (since 2016), where clear separation of the production units (such as land, buildings, livestock) used for the conventional and organic production system must exist (DEBIO, 2016; JORDBRUKSVERKET, 2015; LRF, 2016).

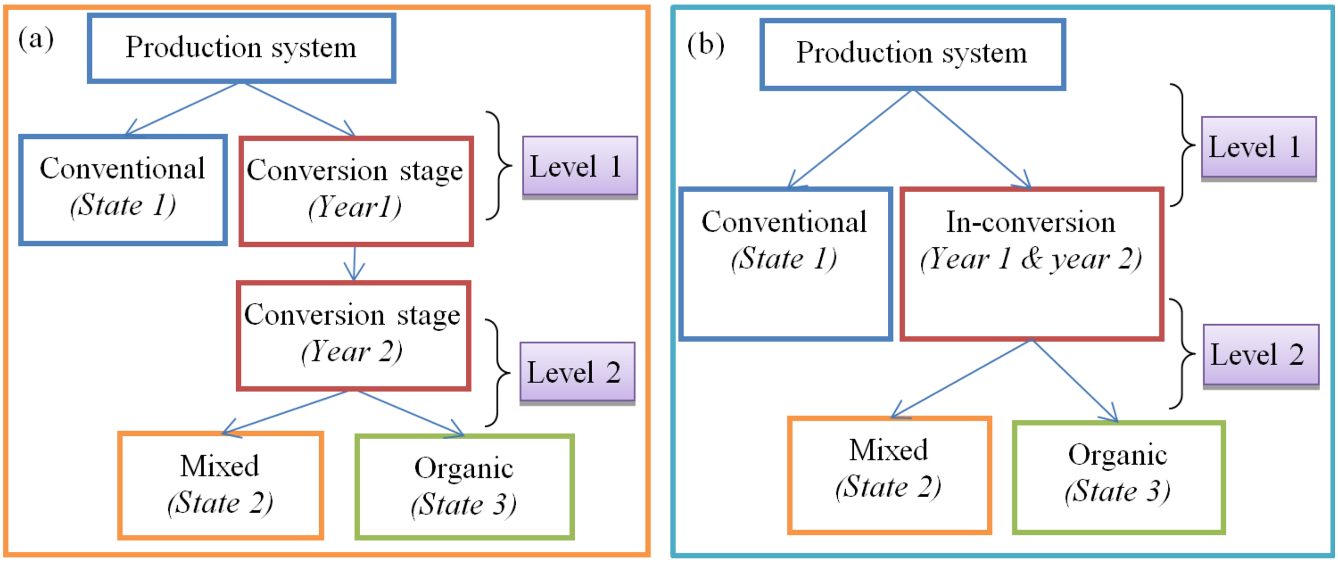
3 Model Framework

3.1 Modelling the Decision Process: the Two-level Framework

An unbalanced panel of data from the Swedish FADN database for the period 2002-2012 was used. In the Swedish FADN, data on organic farming are reported from 2002 onwards, which restricted the panel to starting in that year. Furthermore, given the mandatory minimal two-year conversion period (LRF, 2016), a threshold of three years of appearance of each farm in the dataset was set to observe the farm movements from conventional to organic production. In total, 3940 observations, with 619 dairy farms, satisfied this condition.

In the FADN dataset, based on Council Regulation (EEC) No. 2237/77 of 23 September 1977 on organic production, a farm is coded as: (code 1) a conventional farm if it has no organic production; (code 2) an organic farm if it has only organic production; and (code 3) an in-conversion farm, meaning the farm is in the process of converting to organic production, or a mixed farm, with both conventional and organic production in separate production units. Of the total observations in the study sample, about 75% were reported as conventional, while the remaining 25% had gone through the conversion stages at decision level 1 (see panel (a) of Figure 1). In fact, 14%

Figure 1. The organic conversion process*



Note: *(a) represents the conversion process from conventional to organic farming, and (b) is the assumed two-level nested choice structure including conventional, mixed, organic and in-conversion production states.
Source: authors

converted to organic, 7% remained in the conversion stage for more than two years as mixed farms, and 4% were in conversion stages (year 1 and year 2). The latter farms were excluded from the empirical analysis, in order to avoid having to account for the obligatory movements of in-conversion farms. As a result, the dummy nest of conversion stages (year 1 and year 2) in panel (a) of Figure 1 was reduced to the nest of in-conversion displayed in panel (b).

As shown in panel (b) of Figure 1, conventional farms cannot move directly to the organic state because of the mandatory two-year conversion period. First, they move to the conversion phase and then switch to organic at decision level 2. Alternatively, they may remain in the conversion phase for more than two years, in which case they are regarded as mixed farms in the present analysis. This two-level decision process therefore provides a nest of mixed and organic production systems. Compared with conventional farming, mixed and organic farming are more similar in their characteristics, because both require two years to be spent in the conversion process under the rules of organic farming. As a result, the property of independence from irrelevant alternatives (IIA) between mixed and organic farms does not hold. In other words, the addition or removal of an alternative from a choice set of production systems may affect the choice decision between two alternatives in a pair. With the violation of the IIA assumption, the multinomial logit (MNL) model does not provide a better specification and does not capture the two-level decision process (FORINASH and KOPPELMAN, 1993; TRAIN, 1986). A binary discrete choice model can also be applied to each pair of alternatives (as: conventional vs mixed; conventional vs organic; and organic vs mixed), but each analysis can potentially utilise a different sample. The nested logit (NL) is the most commonly used model when some alternatives have a higher degree of similarity and competitiveness than the alternatives in a different nest (KOPPELMAN and BHAT, 2006; MCFADDEN, 1978). The NL model, while creating a group of similar alternatives, relaxes the assumption of IIA, but requires the data structure to be choice-specific.

In the FADN data, information is available only on the attributes of the j^{th} alternative practised by the i^{th} individual at time t. In other words, information on counterfactual alternatives (e.g. conventional and mixed farming) does not exist if a farmer chooses organic farming, because these three choice alternatives are mutually exclusive. However, in this study, we explicitly assumed that farmers, when deciding upon type of production, are aware of relevant information on all possible alternatives through common market and advisory services at the local county level, the lowest level of administrative unit in Sweden. To capture this phenomenon, missing values of alternative attributes (farm-gate milk price, milk yield and environmental support payment, presented in detail in Section 3.3.) on counterfactual alternatives were approximated by their corresponding mean at the local county level, following the NUTS-3 level geographical subdivisions (NUTS stands for Nomenclature of Territorial Units for Statistics, established by Eurostat) (EUROPEAN COMMISSION, 2011). Sweden has a total of 21 counties, which have the responsibility for implementing policy support activities in line with goals set in national politics. This type of data generation process is useful for estimating the nested choice model empirically. SCHMIDTNER et al. (2011) applied a similar strategy to impute missing values for the city counties in Germany.

3.2 Empirical Model

We analysed the two-level nested structure of production alternatives using a random utility maximisation (RUM) model. In the RUM framework, the choice probabilities can be computed as a function of relative utilities among alternatives, which is assumed to be a sum of a deterministic component, V_{ij}, and a random term, ϵ_{ij}: $U_{ij} = V_{ij} + \epsilon_{ij}$. We defined V_{ij} as a linear additive function with a constant marginal utility of attributes of alternatives (FORINASH and KOPPELMAN, 1993; KOPPELMAN and BHAT, 2006) as:

$$V_{ij} = \beta X_{ij} + \alpha_j' Z_i \tag{1}$$

where X_{ij} and Z_i represent the vector of alternative- and case-specific variables, respectively, and β is the marginal utility of a change in X_{ij} and is assumed to be identical for all alternatives. For Z_i, the response is allowed to vary across alternatives, hence the subscript j on the coefficient α. As mentioned by FORINASH and KOPPELMAN (1993), the assumption about the distribution of ϵ_{ij} leads to different models. Since mixed and organic farming options are nested in a group of 'in-conversion' (see panel (b) of Figure 1), the utility for each alternative can be decomposed as follows:

$$\left.\begin{aligned} U_C &= V_C + \epsilon_C \\ U_M &= V_M + V_{IC} + \epsilon_M + \epsilon_{IC} \\ U_O &= V_O + V_{IC} + \epsilon_O + \epsilon_{IC} \end{aligned}\right\} \tag{2}$$

where C, M, O and IC stand for conventional, mixed, organic and in-conversion, respectively.

The common error term, ϵ_{IC}, represents covariance between the pairs of nested alternatives – mixed and organic farming. When ϵ_{IC} is equal to zero, the organic conversion model in panel (b) of Figure 1 reduces to the MNL model with no covariance of nested alternatives. The NL model in this sense is a general form of production system choice model, which can be tested empirically by the data. Assuming the error terms of each alternative (ϵ_C, $\epsilon_M + \epsilon_{IC}$ and $\epsilon_O + \epsilon_{IC}$) are distributed Gumbel (0,1) and the error terms of nested alternatives (ϵ_M and ϵ_O) are distributed independent Gumbel $(0, \theta)$, we can obtain the NL model (FORINASH and KOPPELMAN, 1993). The inclusive value $\Gamma_{IC} = \log(\sum_{i,k\epsilon IC} \exp(\beta' X_{ik})$ measures the expected maximum utility of the alternatives k in the nest IC. The term θ_{IC} is the scale parameter of the Gumbel distribution and validates the presence of a nested structure. A likelihood ratio (LR) test is applied for testing acceptance or rejection of the null hypothesis: $H_0: \theta_{IC} = 1$, where the dissimilarity parameter θ_{IC} is calculated as $\theta_{IC} = \sqrt{1 - \rho_{IC}}$ and ρ_{IC} is a correlation between alternatives within the nest IC. The probability of choosing any lower-nest alternative j by an individual i is then derived in the following manner:

$$P_{ij} = P_{i,k\epsilon IC} \times P_{ij|k\epsilon IC} = \frac{\exp\left(\frac{\beta' X_{ij}}{\theta_{IC}}\right)}{\exp(\Gamma_j)} \times \frac{\exp\left(\alpha'_j Z_i + \theta_{IC}\Gamma_{IC}\right)}{\sum_T \exp\left(\alpha'_{IC} Z_i + \theta_{IC}\Gamma_{IC}\right)} \qquad (3)$$

To estimate the model parameters, full information maximum likelihood (FIML) is the most efficient estimator and permits testing of whether the MNL model can be rejected by the data (FORINASH and KOPPELMAN, 1993; GREENE, 2003). Because the NL model is a non-linear function of the random data, GREENE (2003) and TRAIN (1986) suggest computing the probability elasticities at an individual sample point and evaluating the degree of sensitivity (direct and cross- elasticity) by averaging the individual sample values (see Table 1 for analytical expressions and their derivation in Appendix 1). These elasticities at individual sample points would also provide a meaningful interpretation for the dichotomous variables, as the values would either be 0 or converge towards model parameters, depending upon whether the dummy variable corresponds to 0 or 1. For the case-specific variables, the elasticities are simply the summation of one direct response and multiple cross-responses (KOPPELMAN and BHAT, 2006). In the NL model framework, the cross-elasticities are identical for the alternatives in a common nest. If θ_{IC} equals 1, the cross- (direct) elasticity collapses to the corresponding equation for the non-nested alternative. The same applies for the MNL model, where ϵ_{IC} is equal to zero. As θ_{IC} is between zero and one, the cross- (direct) elasticity for the nested alternative will be greater than that for the non-nested alternative.

Table 1. Analytical elasticities of selecting a production system in the adopted nested (NL) logit model

Probability Elasticity	**Changes in**		
	Conventional state	**Mixed state**	**Organic state**
A. Alternative-specific variables[1]			
Conventional state	$(1 - P_{iC})\beta X_{iC}$	$-P_{iM}\beta X_{iM}$	$-P_{iO}\beta X_{iO}$
Mixed state	$-P_{iC}\beta X_{iC}$	$\left[(1 - P_{iM}) + \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)(1 - P_{i,M\mid IC})\right] \times \beta X_{iM}$	$\left[P_{iO} + \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)P_{iO\mid IC}\right] \times \beta X_{iO}$
Organic state	$-P_{iC}\beta X_{iC}$	$\left[P_{iM} + \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)P_{iM\mid IC}\right] \times \beta X_{iM}$	$\left[(1 - P_{iO}) + \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)(1 - P_{i,O\mid IC})\right] \times \beta X_{iO}$
B. Case-specific variables[2]			
	$\left[\alpha_C - \sum_{k\epsilon IC} \alpha_k P_{ik}\right] \times Z_i$	$\left[\frac{1}{\theta_{IC}}\alpha_M - \sum_{k\epsilon IC} P_{ik}\alpha_k - \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)\sum_{k\epsilon IC} P_{i,k\mid IC}\alpha_k\right] \times Z_i$	$\left[\frac{1}{\theta_{IC}}\alpha_O - \sum_{k\epsilon IC} P_{ik}\alpha_k - \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)\sum_{k\epsilon IC} P_{i,k\mid IC}\alpha_k\right] \times Z_i$

Notes: [1] Modified from KOPPELMAN and BHAT (2006) and FORINASH and KOPPELMAN (1993); [2]own calculation (for derivation, see Appendix 1). The subscripts *C, M, O* and *IC* refer to conventional, mixed, organic and in-conversion production states corresponding to panel (b) of Figure 1.
Source: KOPPELMAN and BHAT (2006), FORINASH and KOPPELMAN (1993) and Appendix 1

3.3 Determinants and Hypotheses

In the literature, a wide range of economic and non-economic determinants for identifying the conversion process to organic farming are discussed (e.g., BRAGG and DALTON, 2004; KOESLING et al., 2008; LÄPPLE, 2010; PIETOLA and LANSINK, 2001; SAMSON et al., 2016; ZIMMERMANN and HECKELEI, 2012). Following the model framework and the data at hand, the conversion process in Sweden was examined here with a set of alternative- and case-specific variables. In this process, a set of hypotheses was formulated, based on existing knowledge. Their expected *a priori* outcomes and a description of the associated explanatory variables are presented in Table 2 and described at length in the rest of this Section. It is also important to stress at this point that the expected hypothesis outcomes are directly related to the expected signs of the coefficients β and α in the adopted nested logit model, which in turn will determine the sign of the elasticities for selected explanatory variables.

Alternative-specific variables allow for heterogeneity between the individual farms across production alternatives (conventional, mixed and organic dairy farms) over time. In the present study, farm-gate milk price, milk yield and environmental support payments received by each individual farm were considered.

Farm-gate milk price. High and stable milk prices slow down structural change in agriculture because of increased profitability (ZIMMERMANN and HECKELEI, 2012). In other words, an expected decline in milk prices will lead to low on-farm income and influence the decision to expand production (SAMSON et al., 2016) or exit dairy farming (BRAGG and DALTON, 2004). These types of effects from milk price cuts arising due to an increased supply of milk after abolition of the milk quota in April 2015, under the Common Agricultural Policy (CAP) reform, would be more visible in the regions with low quota rents (such as Sweden, the United Kingdom or the new EU member states) (SAMSON et al., 2016). In such a situation, organic farming could be an option to provide financial security through the organic subsidies and price premiums (PADEL, 2001). We, therefore, expect that low milk prices would raise interest among conventional dairy farmers in Sweden in adopting organic milk production (*Hypothesis H1*). LARSSON et al. (2013) and DARNHOFER et al. (2005) also state that the price premium for organic products (i.e. the price difference between organic and conventional milk) is an important determinant for conventional farmers to convert to organic farming, especially if the yields are lower (DARNHOFER et al., 2005). The farm-gate prices of conventional and organic milk per kg of milk production, expressed here in Swedish Krona (SEK), vary between farms and over years.

Milk yield. Milk production technologies undergo continuous development. For instance, the overall milk yield per cow in Sweden increased over the period 1998-2012 (HENRIKSSON, 2014). However, the yield on organic farms still remains below the level on conventional farms (see Table 3). Technological advances increase the probability of high-yielding conventional farms remaining in production (BRAGG and DALTON, 2004). PIETOLA and LANSINK (2001) concluded that low-yielding farms in Finland have a higher probability of switching to organic production. Milk yield as given here is an alternative-specific

Table 2. Explanatory variables and expected outcomes of hypotheses H1-H7

Variables	Units	Expected outcomes		Hypotheses
A. Alternative-specific variables				
Farm-gate milk price	Swedish Kronor (SEK) per kg	+		*H1*
Milk yield	100 kg per cow	+		*H2*
Environmental support	1000 SEK per cow	+		*H3*
B. Case-specific variables		**Production choice** (base category: conventional)		
		Mixed	**Organic**	
Farm size	European size unit (ESU) [1]	+	-	*H4*
Pasture land	Hectare	+	+	*H5*
National milk price index	Base 2005 = 100	-	-	*H6*
Regional distribution of farms [2]				
Region 1 (base)	Dummy = 1 if region 1, otherwise 0			
Region 2	Dummy = 1 if region 2, otherwise 0	+	-	*H7*
Region 3	Dummy = 1 if region 3, otherwise 0	+	+	

Notes: [1] ESU stands for European Size Unit. In the FADN methodology (EC, 1985), it is used to define the economic size of farm holdings in the EU. One ESU is equivalent to 1,200 Euros of the standard gross margin (or standard output after 2010) per hectare of crop and per head of livestock of each holding. [2] For a definition of regions, see Appendix 2.
Source: FADN database and authors

variable, estimated at farm level, where the yield for conventional/mixed/organic farms represents the actual milk yield in 100 kg per cow on farms included in the analysis and registered in FADN as conventional/organic or 'in transition' for more than two years for the mixed farms. Since farm size was already controlled for in the analysis through case-specific variables (see Table 4), we considered milk yield as a proxy to capture the differential growth in technological development across production types. The hypothesis tested was that farms with low milk yield are more likely to convert to organic milk production (*Hypothesis H2*).

Environmental support payments. Since organic farming has positive effects on the environment, the amount of agri-environmental subsidies received by farmers can be a proxy for their level of environmental performance. In the FADN data, subsidies for organic farming are not listed as a separate category, but are part of the total environmental subsidies included in rural development programs. Environmental subsidies are available to both conventional and organic farms for implementing environmental measures, which include organic farming. PIETOLA and LANSINK (2001) argue that this type of policy provides an incentive for conventional farms to switch to organic farming and, according to FAIRWEATHER (1999), it contributes to boosting structural change in the industry. According to KUMBHAKAR et al. (2008), such payments are important for promoting organic farming even if the organic production technology is inferior and the yield difference is not compensated for by the higher price of organic milk. Since having pasture land is already controlled for through case-specific variables (see below), we assumed that the environmental support payment (measured in thousand SEK per cow) would offset the higher average fixed cost of keeping cows under the rules of organic farming. Therefore, our hypothesis was that there is a positive impact of environmental support payments on the conversion process to organic farming (*Hypothesis H3*).

The case-specific variables describe the characteristics of the decision makers, i.e. milk producers, which may influence the relative attractiveness of alternatives. Prominent candidates are farm size, regional characteristics, availability of pasture land and national milk price index, along with year dummies to control for time-related omitted variables.

Farm size. Farm size is probably the most widely discussed determinant of structural change. Many studies (e.g., GARDEBROEK, 2006; KOESLING et al., 2008; PIETOLA and LANSINK, 2001) show that large-sized farms can enjoy economies of scale and gradually convert to organic. KHALEDI et al. (2010) showed that larger farms have a lower probability of fully adopting organic farming, because of the implied managerial problems resulting from a higher labour requirement and the gradual approach for converting to organic. Some studies (e.g., LÄPPLE, 2010; PADEL, 2001; SAMSON et al., 2016) argue that small farms can easily reduce average costs by increasing production, or have lower entry costs for organic farming. Furthermore, the policy support and higher price ratio of organic milk compared with conventional would encourage small farms to convert to organic farming.

Table 3. Descriptive statistics: means and standard deviations for conventional, mixed and organic farm data, 2002-2012

Variables	All farms (3,940 obs.)		Conventional (2,955 obs.)		Mixed (432 obs.)		Organic (553 obs.)	
A. Alternative-specific variables								
Farm-gate milk price	3.177	(0.456)	3.162	(0.446)	3.124	(0.400)	3.302	(0.524)
Milk yield	74.709	(14.518)	75.192	(14.692)	73.985	(14.438)	72.691	(13.418)
Environmental support	15.738	(19.505)	15.465	(18.862)	16.325	(19.957)	16.735	(22.296)
B. Case-specific variables								
Farm size	7.947	(0.830)	7.923	(0.823)	8.146	(0.814)	7.919	(0.861)
Pasture land	16.294	(33.724)	14.568	(25.766)	28.217	(70.471)	16.198	(23.497)
National milk price index	106.742	(7.167)	106.817	(7.114)	106.343	(7.420)	106.650	(7.239)
Regional distribution of farms								
Region 1 (obs.)	1848	[46.904]	1,479	[80.032]	150	[8.117]	219	[11.851]
Region 2 (obs.)	1175	[29.822]	924	[78.638]	137	[11.660]	114	[9.702]
Region 3 (obs.)	917	[23.274]	552	[60.196]	145	[15.813]	220	[23.991]

Notes: 1) Obs. stands for number of observations, which is equal to $N \times T$, where N is the number of farms and T is the time period in the study sample. 2) Figures in brackets are standard deviation. 3) Figures in square brackets are the percentage of farms in a given region.
Source: FADN database and author calculation

Large farms can be considered more likely to have production at physically separate locations, which following the Swedish regulation (JORDBRUKSVERKET, 2015; LRF, 2016) is a requirement for mixed or 'parallel production' to be adopted. Our hypothesis was therefore that smaller farms are more likely to convert to organic milk production and less likely to choose a strategy of mixed production (*Hypothesis H4*). Farm size is measured based on the European size unit (ESU) criterion defined by Commission Decision 85/377/EEC of 7 June 1985, where one ESU is equivalent to 1200 Euro of total standard gross margin[3] per hectare of crop and per head of livestock of each farm holding.

Regional dummy. Poor soil quality and a high share of nature protected areas or other areas eligible for environmental support favour organic conversion (NACHTMAN, 2015; PIETOLA and LANSINK, 2001; SCHMIDTNER et al., 2011). The transaction costs of conversion can be affected spatially because of heterogeneous policies or distribution of organic farms (LÄPPLE and KELLEY, 2014). Moreover, differences in public procurement of organic food across municipalities (LEHNER, 2010) suggest regional differences in demand for organic produce in Sweden. As a result, organic conversion is spatially concentrated. In the study sample, 46.90% of all observations were from the southern and central plains areas (region 1, map of the regions provided in Appendix 2), but only 8.12 and 11.85% of the observations represented mixed and organic production, respectively. In contrast, region 3, located in northern Sweden, contributed only 23.27% of all observations but had larger shares of mixed and organic farming (15.81 and 23.99%, respectively). According to KÄLLANDER (2000), region 3 is characterised by lower agricultural potential, a large share of grassland and ley, and more nature protected areas, which favours the expansion of mixed and organic farming. Our hypothesis was thus that farms situated in less productive areas with high environmental support are more likely to convert to organic farming (*Hypothesis H5*). We constructed regional dummy variables to capture the differences in agricultural and policy-related conditions.

Pasture land. According to the Swedish regulations for organic farming, at least 50% of the feed provided for the animals must be produced on the farm, and cattle older than six months have to be on pasture for at least six hours per day during the grazing season (AHLMAN, 2010; LRF, 2016). PIETOLA and LANSINK (2001) also reported that the availability of pasture land is an important factor that probably increases the probability of switching to organic farming. Therefore, we tested the hypothesis that availability of pasture land has a positive effect on conversion to organic dairy farming (*Hypothesis H6*).

Milk price index. In Sweden, a gradual decrease in real milk prices can be expected in the aftermath of the EU milk quota reform, because of excess supply of milk from the quota-binding EU member countries (MATTHEWS, 2015). As a result, the expected decrease in real milk prices may suggest that organic dairy farming can be seen as a viable option, supported by growing market demand and a strong preference for organic food in Sweden (KRAV, 2016), and a broad set of measures developed to support organic farming. In this study, the milk price index was considered an overall indicator that captures the dynamics of the dairy market at national level. In such a context, our hypothesis was that lower real milk price increases the probability of transition to organic dairy in Sweden, as a result of lower real milk price (*Hypothesis H7*).

Year dummies. During the period 2002-2012, the Swedish government made policy changes in relation to organic farming, such as abolition of a subsidy premium for organic feed and pasture land in the Rural Development Programme (RDP) (*Landbygdsprogrammet* in Swedish) (JORDBRUKSVERKET, 2010) and introduced the public procurement policy for organic food (EKOLOGISKT FORUM, 2007). Similarly, the in-conversion farms encountered difficulty registering as organic producers, particularly in regions 1 and 2, during the period 2010-2011 (RYEGÅRD, 2011). To capture the effects of all these types of policy-related omitted variables, year dummies were included in the empirical analysis. Since the technological factor is already controlled for in the analysis using milk yield, year dummies can proxy the influences of year-specific omitted variables such as institutional arrangement, policy support and market development. The year dummies are intended to control the time effect in the panel data and, furthermore, the expected outcome is not specified *a priori*.

4 Results and Discussion

Table 4 shows the results of the nested logit (NL) model estimations for the choice of production system alternatives for Swedish dairy farmers. In this estima-

3 From 2010 the standard output (SO) is used to measure economic size.

tion, conventional farming was set as a base category. The LR test for IIA in the NL model statistically rejected the MNL specification, indicating that the dissimilar parameter, θ_{IC}, is significantly different from 1. This implies that mixed and organic farming in the conversion process are more similar than mixed and conventional (or organic and conventional) farms. This finding provides an important and useful insight into the likely behavioural response of dairy farmers to changes in the attributes of alternatives. The addition of a third category – mixed farming – would actually affect the relative probability of choosing conventional and organic farming, as shown in previous studies utilising the MNL model.

Table 4. Estimation results of the nested logit model

Variables	Estimated coefficient	Standard error	p-value
A. Alternative-specific variables			
Farm-gate milk price	0.429	0.085	0.000
Milk yield	0.324	0.196	0.098
Environmental support	0.002	0.001	0.099
B. Case-specific variables			
Conventional (base category)	0 (base)	-	-
Mixed farming			
Farm size	0.269	0.064	0.000
Region 2	0.312	0.118	0.008
Region 3	1.300	0.109	0.000
Pasture land	0.009	0.002	0.000
National milk price index	-0.037	0.005	0.000
Year dummies (base = 2002)			
2003	0.028	0.206	0.891
2004	-0.345	0.201	0.086
2005	-0.382	0.203	0.060
2006	-0.432	0.206	0.036
2007	-0.269	0.201	0.179
2008	0.375	0.208	0.071
2009	-0.991	0.243	0.000
2010	-0.320	0.215	0.136
2011	-0.500	0.238	0.036
2012	-1.113	0.273	0.000
Organic farming			
Farm size	0.043	0.057	0.455
Region 2	-0.009	0.106	0.932
Region 3	1.241	0.103	0.000
Pasture land	0.008	0.002	0.000
National milk price index	-0.022	0.004	0.000
Year dummies (base = 2002)			
2003	0.147	0.211	0.486
2004	-0.109	0.202	0.591
2005	-0.006	0.200	0.978
2006	-0.099	0.200	0.619
2007	-0.016	0.202	0.936
2008	0.464	0.215	0.031
2009	-0.388	0.202	0.054
2010	0.051	0.205	0.805
2011	0.059	0.207	0.776
2012	-0.293	0.208	0.160
Dissimilarity parameter	0.476	0.108	0.000
LR test for IIA: Chi-Sq(2)	11.225	-	0.003
Model Wald Chi-Sq(33)	745.423	-	0.000
Number of cases ($N \times T$)	3940	-	-
Number of alternatives (Alt)	3	-	-
Total observations ($N \times T \times Alt$)	11820	-	-

Notes: N and T represent the number of dairy farms and the time period in the study sample, respectively.
Source: authors

Since the NL model is nonlinear, the parameter estimates are not equal to the marginal effects of the variables included. However, they can indicate the directional movement (increase or decrease) in the probability of choosing an alternative. To reveal the influences of each explanatory variable, we computed the probability elasticities with respect to a one percent change in those variables (Table 5). For instance, the sign of the estimated *own elasticities* for the alternative-specific variables indicates how the probability of remaining a conventional (mixed or organic) farm is affected by an increase in, for instance, the farm-gate price of milk from conventional (mixed or organic) farms. Similarly, the sign of the estimated *cross-elasticities* indicates how the probability of remaining a conventional farm is affected if, for instance, the farm-gate price of milk from mixed or organic farms increases (or how the probability of remaining a mixed farm is affected if the farm-gate price of milk from conventional or organic farms increases etc.).

Alternative-specific variables: there were statistically significant positive effects for the alternative-specific variables included in the model, namely farm-gate prices, milk yield and environmental support payments received by farmers.

Farm-gate milk price. The associated estimated parameter was positive and statistically significant at 1% level (see Table 4), thus confirming *Hypothesis H1*, that the farm-gate milk price is important for Swedish dairy farmers when choosing production system. As can be seen in Table 5, there were negative cross-elasticities from the scenario of a decrease in milk prices, indicating increased probability of switching to organic farming. The greater magnitudes of own and cross-elasticities for mixed and organic farming indicate higher sensitivity and exchangeability of nested alternatives. This outcome is typical in the nested structural model (FORINASH and KOPPELMAN, 1993). In regard to the present study, this finding makes sense, because mixed farms would find it easier to convert to organic production. As mentioned previously, in Sweden dairy farms with organically converted land require only six months of organic-based feeding to convert from conventional to organic milk production, and thereby reach the status of organic milk farm (JORDBRUKSVERKET, 2015; LRF, 2016). Moreover, because these production systems are nested in a common group, the farmers' responses would be very similar, with a higher degree of substitutability between organic and mixed production than between organic (or mixed) and conventional production.

Milk yield. Although the corresponding parameter estimate was positive and statistically significant at 10% level, it showed that milk yield has a weak influence on the choice of alternative production systems (see Table 4). As expected, the alternatives in a common nest (mixed and organic) showed the same degree of increased sensitivity (-0.19 in Table 5) in response to changes in the attributes of the alternative not in the nest (conventional). In general, however, the nested alternatives (mixed and organic farming) were more sensitive than conventional farming to milk yield, as shown by their larger elasticities. A positive value on own elasticity of organic farming (0.30 in Table 5) indicates an increased probability of continuing organic production with the development of organic methods and technologies. In the study sample, average yield was lower in organic than in conventional farming (see Table 3), but REGANOLD and WACHTER (2016) argue that organic farms have greater scope for improving farm yield in the long run, which could induce conventional farmers to transition to organic production. This hypothesis is supported by the negative sign of the cross-elasticities between conventional and organic farming. As a result, the low-yielding extensive conventional farms would be more likely to transform to organic dairy farming, confirming *Hypothesis H2*. PIETOLA and LANSINK (2001) and ACS et al. (2009) also report high movement of low-yielding farms to organic production. Because of higher yield in the conventional dairy sector, in-conversion farms would most likely convert their land only, and keep their milk production conventional (which, by definition, would classify them as mixed), as shown by a positive own elasticity for mixed in Table 5. However, the negative cross-elasticity between conventional and organic farming indicates that the improvements in yield on conventional farms do not provide incentives for the farmers to change the technology. KUMBHAKAR et al. (2008) concluded that technological improvement in organic production and provision of organic subsidies are essential in order to narrow the loss in farm profits due to yield differences between conventional and

Table 5. Estimated elasticities with respect to the selected explanatory variables

		Effects on the probability of choosing					
		Conventional		*Mixed*		*Organic*	
A one percent change in		Elast.	SD	Elast.	SD	Elast.	SD
A. Alternative-specific variables							
Farm-gate milk price	*Conventional*	0.329	0.147	-0.995	0.195	-0.995	0.195
	Mixed	-0.148	0.102	2.042	0.455	-1.125	0.509
	Organic	-0.206	0.135	-0.784	0.341	1.863	0.257
Milk yield	*Conventional*	0.062	0.026	-0.189	0.040	-0.189	0.040
	Mixed	-0.028	0.020	0.384	0.097	-0.171	0.066
	Organic	-0.031	0.017	-0.149	0.071	0.297	0.088
Environmental support	*Conventional*	0.004	0.008	-0.011	0.018	-0.011	0.018
	Mixed	-0.003	0.005	0.034	0.036	-0.036	0.038
	Organic	-0.007	0.009	-0.015	0.020	0.060	0.058
B. Case-specific variables							
Farm size		-1.854	0.306	3.017	0.576	-1.163	0.557
Region 2		-0.071	0.110	0.133	0.208	-0.062	0.101
Region 3		-0.356	0.065	0.276	0.156	0.080	0.128
Pasture land		-0.213	0.031	0.153	0.070	0.060	0.066
National milk price index		0.047	0.008	-0.012	0.016	-0.035	0.015

Notes: 1) "Elast." stand for "Elasticity". Elasticities for continuous variables and semi-elasticities for dummy variables (region 2 and region 3). 2) For the alternative-specific variables, the diagonal elements are own elasticities, while the off-diagonals are cross-elasticities. 3) SD refers to standard deviation.
Source: authors calculation

organic dairy farming. Otherwise, according to KOESLING et al. (2008), dairy farmers would be relatively less interested in full conversion to organic farming. In Sweden, the total costs of producing organic milk are significantly higher than for conventional milk, mainly due to higher feed and capital costs, whereby returns for both conventional and organic milk are below the production costs (ODEFEY et al., 2011), clearly indicating the necessity for support payments.

Environmental support. As conjectured in *Hypothesis H3*, the support payment to dairy farms for environmental protection had weak importance for the choice between conventional, mixed and organic farming (statistically significant coefficient at 10% level, see Table 4). The estimated elasticities associated with environmental support reported in Table 5 are relatively small (and not statistically significant) compared with the impacts of farm-gate price and milk yield. The weak effect is suspected to be due to the variable not allowing separation of the specific support to organic production. In the literature, support payment to organic production are regularly reported to be an incentive for organic producers as to some extent they offset the costs associated with the conversion process (FAIRWEATHER, 1999; KUMINOFF and WOSSINK, 2010; PIETOLA and LANSINK, 2001). ACS et al. (2009) also report that an increase in organic subsidies would make full conversion to organic farming more attractive for risk-averse farmers. Moreover, this support would raise the environmental awareness of the farmers. KÄLLANDER (2000); LOHR and SALOMONSSON (2000) also highlight the importance of this type of support for the promotion of organic farming.

Case-specific variables. Farm size, regional dummy and availability of pasture land were found to be positive triggers, but the national real price index for milk was a regressive factor for conversion to mixed and/or organic farming (see Table 4).

Farm size. In the present study, we found that the effect of farm size on conversion to organic was non-significant (see Table 4), indicating no clear evidence to accept or reject *Hypothesis H4*. In the literature, some studies (e.g., LÄPPLE, 2010; PADEL, 2001; SAMSON et al., 2016) are in favour of the null hypothesis, while a few (e.g. GARDEBROEK, 2006; KHALEDI et al., 2010; KOESLING et al., 2008; PIETOLA and LANSINK, 2001) accept the alternative hypothesis. Nevertheless, the negative sign of the probability elasticities for conventional and organic farming (see Table 5) indicates that smaller farms are more likely to choose conventional or organic production technologies. Similarly, LÄPPLE (2010), PADEL (2001) and SAMSON et al. (2016) argue that small and extensive farms would have lower entry costs for organic farming, while KHALEDI et al. (2010) conclude that small farms face less managerial difficulties in respect to labour. In the case of mixed farming, the effect of farm size was positive and statistically significant (Table 4). The estimated elasticities in Table 5 also show that the probabilities of staying in, or converting to, mixed farming would increase with farm size. This implies that large farms are more likely to follow the mixed strategy, keeping one part of the farms with stable, income-generating conventional production, while the riskier organic production may be compensated for by subsidies for organic production, as ACS et al. (2009) point out. Indeed, it may be conjectured that larger farms can more easily fulfil the requirement of the Swedish regulation on mixed farming (JORDBRUKSVERKET, 2015; LRF, 2016), where the production facilities (land, buildings, livestock) used for producing conventional and organic agricultural products must be physically separated. This finding complies with studies (KOESLING et al., 2008; PIETOLA and LANSINK, 2001) arguing that medium and large farms can enjoy economies of scale and gradually convert to mixed farming with organic production. KHALEDI et al. (2010) also showed that partly converted farms had a large area. The sample data in Table 3 also show larger herd size in mixed farms. Similarly, NACHTMAN (2015) found that more than one-quarter of the Polish mixed farms included in their analysis (FADN data were used) had over 50 ha of utilised agricultural area, while only one-tenth of the organic farms had that area. Moreover, even within the group with above 50 ha, mixed farms had on average 30% larger area and two-fold greater economic size than organic farms. Because of the greater magnitude of elasticity for mixed farming, the elasticity for conventional farming was found to be negative. This indicates that larger farms would be less likely switch back to conventional if the mixed farming strategy were implemented.

Regional dummies. The positive sign for the effect of region 3 in mixed and organic farming in Table 4 confirms *Hypothesis H5*, that dairy farms located in less productive areas with high environmental support payments (region 3) are more likely to convert to mixed and organic farming than farms in region 1 (base category). Given the elasticities presented in Table 5, *Hypothesis 5* is only supported for mixed farming, whereas the elasticities obtained for organic farming are statistically non-significant. In the study data sample, region 3 had the highest share of organic farms (23.99%) of all regions. KÄLLANDER (2000) also reports that organic dairy production is more common in northern Sweden (region 3) than in the south (region 1) because of large shares of grassland and ley. Our results also support previous findings reported by PIETOLA and LANSINK (2001); SCHMIDTNER et al. (2011). For region 2, the estimated coefficient for conversion to organic farming was not statistically significant (see Table 4). Nevertheless, the farms in this region are more likely to adopt the mixed farming strategy, as shown by positive and statistically significant coefficient in Table 4. The estimates on semi-elasticities for region 2 in Table 5 also confirm that farms in this region are more likely to follow a mixed farming strategy than farms in region 1. Moreover, we observed (Table 3) that in region 2, the share of mixed farms was relatively higher (11.64%) than the share of organic farms (9.70%).

Pasture land. The positive and statistically significant parameter estimates for pasture land in Table 4 indicate the importance of pasture land for the expansion of organic dairy farming in Sweden. They also confirm *Hypothesis H6,* that organic farming would expand if the availability of pasture land increased. Organic farming requires large areas of pasture for grazing livestock under Swedish regulations for organic farming, where more than 50% of the feed must be produced on the farm and animals must spend most of their time on pasture during the grazing season (AHLMAN, 2010; LRF, 2016). Based on the estimated elasticities in Table 5, we can infer that the probability of converting to mixed farming increases with the expansion of pasture land. These mixed farms could possibly have organic pasture land, but conventionally grown livestock, and lease out their grassland or sell the organically grown feed, as found to be the case by NACHTMAN (2015). In Table 5, the effect obtained for conversion to organic farming is not statistically significant.

National milk price index. In response to a decrease in national milk price index after the abolition of the milk quota in the EU, the probability of switching to mixed and organic farming increased. This is confirmed by the statistically significant negative parameter estimates of national milk price index for mixed and organic farming in Table 4, and the negative elasticities for organic farming (mixed statistically non-significant) in Table 5. This allowed us to accept *Hypothesis H7*, indicating higher attractiveness of organic milk production in the aftermath of the EU milk quota reform. Dairy farmers can choose organic milk production as an option to pursue extra benefit from the growing market demand and strong preference for organic food in Sweden (KRAV, 2016), where there are measures supporting organic farming. In other words, the decrease in profitability can be expected to accelerate the process of structural change in agricultural production, as argued by ZIMMERMANN and HECKELEI (2012).

Year dummies. The model estimation presented in Table 4 showed statistically significant parameter estimates for the year dummy of 2008 in the organic conversion option. This outcome could possibly be the effect of policy changes, for example introduction of the RDP in 2007 (JORDBRUKSVERKET, 2010) and the announcement of gradual abolition of the milk quota in 2008 as part of the Health Check of the CAP (JONGENEEL et al., 2011). These policy reforms could have yielded a positive and statistically significant (different from zero) estimate for the year dummy of 2008 in organic farming relative to conventional. SAMSON et al. (2016) also considered this year dummy of 2008, but did not find a statistically significant impact of the EU Health Check reform on the decision to expand farm size in terms of production in the Dutch dairy sector. In the case of mixed farming, the negative and statistically significant effects of the year dummies of 2004-2006 were probably due to the policy reforms (e.g. reduction in intervention prices, introduction of dairy premium, decoupling of direct payments) in the EU in 2003, as JONGENEEL et al. (2011) report. Similarly, for the year dummies of 2008 and 2009, the substantial price decrease in the economic crisis of 2008 (SAMSON et al., 2016) and the reduction of support payments in the RDP in 2009 could possibly be reasons for the statistically significant negative effects obtained for mixed farming relative to conventional. To sum up, the year dummy variable captured the effects of the policy reforms made at different times within the study period and the fall in milk prices owing to the economic crisis.

5 Conclusions

The choice of production system alternatives, i.e. conventional, mixed and organic farming, for Swedish dairy farmers was explained here using a model framework in a two-step procedure. First, an NLRUM decision model produced estimates indicating the directional movement (increase or decrease) in the probability of choosing an production alternative. Second, since the NL is non-linear and the parameter estimates are not equal to the marginal effects of the variables included, probability elasticities were calculated in a separate procedure.

Assuming a two-level sequential decision tree, the present study demonstrated the presence of a nested structure between mixed and organic farming in the organic conversion process observed for the Swedish dairy farms. The findings show that farmers' choice of production system – conventional, mixed or organic – is positively influenced by farm-gate milk prices. The impact of environmental support payments received by farmers and milk yield (i.e. the alternative-specific variables) was positive, but weak. Furthermore, organic farming is still a niche production alternative for low-yielding dairy farms, whereas large farms could opt for a combination of conventional and organic (mixed) production. Farms situated in environmentally sensitive regions are more likely to convert to organic production, either partly or fully, and thus become mixed or organic farms. Availability of pasture land is one of the preconditions for dairy organic farming.

From a policy point of view, this study indicates that smaller farms specialising in milk production and located in less productive, pasture-endowed regions could potentially benefit from policies promoting the adoption of organic farming. On the other hand, the partial adopters of organic farming should be targeted with policies acknowledging the special status of mixed production systems especially in the dairy sector.

The decision to convert to organic farming can also been explained by many other non-economic factors (i.e. social and behavioural) (e.g. DARNHOFER et al., 2005; HOWLEY, 2015), whereby farmers' decisions are a result of the interplay between both economic and the various non-economic incentives (DARNHOFER et al., 2005). Future research combining relevant farm accounting data and surveys on social and behavioural characteristics could be of great use for explaining the interplay between the different factors on different farms and in different regions. Moreover, as the conditions for organic production differ among production systems, the findings obtained in this study cannot be generalised to other farm types, thereby requiring for more research on specialist production systems.

The findings in this study are of both empirical and policy relevance. First, we considered a two-level sequential decision model, where in addition to conventional and organic, the presence of mixed-type farms in the dairy sector was identified. Second, the NL model framework, which has not previously been applied to model farmers' choices of production system was empirically tested and used to explain the existence of a nested choice structure with mixed and organic production systems. Moreover, farmers' choice to convert their production were explained by the estimated elasticities with respect to the selected explanatory economic variables. Last but not least, from a policy point of view the study provides valuable insights for decision makers regarding farmers' economic behaviour, the potential for conversion and the factors influencing the conversion process, from conventional to mixed and/or organic dairy farms, and vice versa.

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Appendix 1. Derivation of Analytical Elasticity to Changes in Farmers' Characteristics

For the sake of simplicity in deriving the probability elasticity, we re-write Equation (3) as:

$$P_{ij} = \Psi \times \frac{\exp(\alpha_j' Z_i)}{\sum_{k\epsilon IC} \exp(\alpha_k' Z_i)} \tag{A1}$$

where $\Psi = \frac{\exp\left(\frac{\beta' X_{ij}}{\theta_{IC}}\right)\exp(\alpha_j' Z_i)}{\exp(IV_j)\sum_{k\epsilon IC}\exp(\theta_k IV_k)}$ and j and k represent the non-nested and nested production alternatives, respectively, and IC stands for a "in-conversion" nest, comprised of mixed and organic farming.

a) Probability elasticity of a non-nested alternative "j"

Taking a derivative of Equation (A1) with respect to the farm characteristic variable, Z_i, we get:

$$\frac{\partial P_{ij}}{\partial Z_i} = \Psi \times \left[\frac{\exp(\alpha_j' Z_i)\,\alpha_j}{\sum_{k\epsilon IC}\exp(\alpha_k' Z_i)} - \frac{\exp(\alpha_j' Z_i)}{\sum_{k\epsilon IC}\exp(\alpha_k' Z_i)} \times \frac{\sum_{k\epsilon IC}(\alpha_k \times \exp(\alpha_k' Z_i))}{\sum_{k\epsilon IC}\exp(\alpha_k' Z_i)}\right]$$

$$\frac{\partial P_{ij}}{\partial Z_i} = \alpha_j P_{ij} - P_{ij}\left[\frac{\sum_{k\epsilon IC}(\alpha_k \times \exp(\alpha_k' Z_i))}{\sum_{k\epsilon IC}\exp(\alpha_k' Z_i)}\right]$$

$$\frac{\partial P_{ij}}{\partial Z_i} = P_{ij}\left[\alpha_j - \sum_{k\epsilon IC}\alpha_k P_{ik}\right]$$

Direct elasticity of non-nested alternative j in response to changes in Z_i can be written as follows:

$$\eta_Z^j = \frac{\partial P_{ij}}{\partial Z_i}\left(\frac{Z_i}{P_{ij}}\right) = \left[\alpha_j - \sum_{k\epsilon IC}\alpha_k P_{ik}\right] \times Z_i \tag{A2}$$

where η denotes the elasticity. In fact, the expression for η in Equation (A2) is a combination of one direct and multiple cross-responses (KOPPELMAN and BHAT, 2006), because Z_i is common to j and k for all i. Mathematically, the elasticity can be written as follows:

$$\eta^j = \eta_j^j + \sum_{k\epsilon IC}\eta_j^k \tag{A3}$$

For sake of simplicity, we drop the subscript Z in η. The first and second terms of the right-hand side of Equation (A3) are obtained from Table 1, but by replacing X_{ij} by Z_i and β by α_j. Now, Equation (A3) becomes:

$$\eta^C = (1 - P_{iC})\alpha_C Z_{iC} - (P_{iM}\alpha_M Z_{iM} + P_{iO}\alpha_O Z_{iO})$$

$$\eta^C = \left[\alpha_C - \sum_{k=C,k\epsilon IC} P_{ik}\alpha_k\right] \times Z_i \tag{A4}$$

where C, M and O stand for conventional, mixed and organic farming, respectively.
The base category receives the value of α which equals 0 (that is, $\alpha_C = 0$ in this paper), both Equations (A2) and (A4) converge to the same numerical value, $\eta_Z^C = -(\sum_{k\epsilon IC}\alpha_k P_{ik}) \times Z_i$.

b) Probability elasticity of nested-alternative "k"

Using the relationship in Equation (A3), the elasticity for mixed farming can be written as:

$$\eta^M = \left[-P_{iM}\alpha_C + \left((1 - P_{iM}) + \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)(1 - P_{i,M|IC})\right)\alpha_M - \left(P_{iO} + \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)P_{iO|IC}\right)\alpha_O\right] \times Z_i$$

$$\eta^M = \left[\frac{1}{\theta_{IC}}\alpha_M - \alpha_C P_{iM} - \alpha_M P_{iM} - \alpha_O P_{iO} - \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)(\alpha_M P_{i,M|IC} + \alpha_O P_{i,O|IC})\right] \times Z_i$$

Setting $\alpha_C = 0$ for the base category, we get:

$$\eta^M = \left[\frac{1}{\theta_{IC}}\alpha_M - \sum_{k\epsilon IC}\alpha_k P_{ik} - \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)\sum_{k\epsilon IC}\alpha_k P_{i,k|IC}\right] \times Z_i$$

Similarly, the elasticity η for the organic state can be written as:

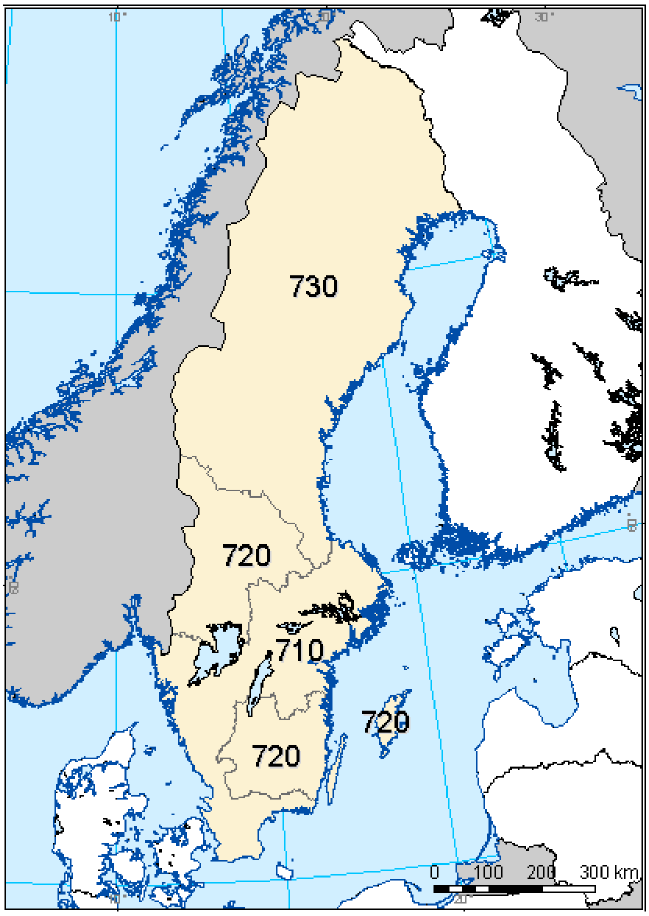
$$\eta^O = \left[\frac{1}{\theta_{IC}}\alpha_O - \sum_{k\epsilon IC}\alpha_k P_{ik} - \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)\sum_{k\epsilon IC}\alpha_k P_{i,k|IC}\right] \times Z_i$$

In general form, the elasticity η is given by the following expression:

$$\eta^k = \left[\frac{1}{\theta_{IC}}\alpha_k - \sum_{k\epsilon IC}\alpha_k P_{ik} - \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)\sum_{k\epsilon IC}\alpha_k P_{i,k|IC}\right] \times Z_i \quad \text{(A5)}$$

where $k\epsilon(M,O)$. If $\theta = 1$, the expression in Equation (A5) collapses to Equation (A2) and this is identical to the elasticity for the multinomial logit model.

Appendix 2. Regional Division of Sweden, following the Nomenclature of Territorial Units for Statistics - NUTS 1



710 plains areas (Region 1)
720 forest and valley areas (Region 2)
730 northern Sweden (Region 3)
Source: EUROPEAN COMMISSION, DG AGRI