THE CONVERSION PROCESS TO ORGANIC FARMING

Explaining the process for conversion to organic farming: An application to Swedish dairy farms

Shyam Kumar Basnet[*], Gordana Manevska-Tasevska[†], Yves Surry[*1], [*]Kostas Karantininis[*]

[*]Department of Economics, Swedish University of Agricultural Sciences,
PO Box 7013, SE-750 07 Uppsala, Sweden

[†]Agrifood Economic Center, Department of Economics, Swedish University of Agricultural Sciences, , PO Box 7013, SE-750 07 Uppsala, Sweden

[1]Corresponding author: Yves Surry; telephone: 018-671795; fax: 018-67 35 02; e-mail: Yves.Surry@slu.se

ABSTRACT

The process for conversion to organic farming has so far been analyzed 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 nested structure between mixed and organic farming. In the context of Sweden, where the conversion investment is flexible, we attempted to identify the economic and policy-related determinants of the organic conversion process. For that purpose, we applied the nested logit (NL) model to the Swedish Farm Accounting Data Network (FADN) data for 2002-2012. The findings show that milk prices, farm productivity, and environmental support payments play a significant role in the organic conversion process. As expected, a decrease in 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: organic dairy, mixed farming, Sweden, nested logit model.

JEL Codes. C25, C51, D22, Q12

INTRODUCTION

The organic conversion process, in general, tends to be similar across European Union (EU) member states, but the policy incentives in the national agriculture plan may differ. 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 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-conversion dairy farms* may 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 partially, for example only convert their land, but not their herd (Jordbruksverket, 2015; LRF, 2016), in order to claim subsidies for organically converted land (Lohr and Salomonsson, 2000).

In recent years, partial conversion to organic farming, where farmers decide to convert one part of their land, is becoming an optimal strategy among risk-neutral farmers (Acs et al., 2009). Polish farmers find the partial conversion option beneficial, especially when soil quality does not guarantee good yields under the conventional system. This provides an opportunity to raise additional funds by shifting some part of utilized agricultural area to organic (Nachtman, 2015). In fact, in the whole EU, around one quarter of organic producers follow this type of mixed strategy (EU The Committee of the Regions (CoR) 2014). However, following Commission Regulation 2092/91, conventional and organic farming must be visibly distinguishable and organized only on separate operational units (EC, 1991). Moreover, it needs to be emphasized that partial conversion or a mixed strategy as defined above 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. According to the EU regulation, 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 same commodity/variety is generally not allowed, except for educational 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).

Most previous studies have focused on the choice of whether or not to convert to organic production (e.g. Breustedt et al., 2011; Kumbhakar et al., 2008; Läpple and Kelley, 2014; Pietola and Lansink, 2001; Schmidtner et al., 2011). A few studies (e.g. Acs et al., 2009; Koesling et al., 2008; Padel, 2001) have recognized that there may also be a choice between partial and full conversion. However, they have not analyzed the factors that may induce prolongation of the conversion period, perhaps due to the fact that these farms (partial and full conversion) are not uniquely registered as such in the European Farm Accountancy Surveys (FAS), and the Farm Accounting Data Network (FADN). There is clearly a lack of research explaining the conversion dynamics with the existence of dairy farms that are in transition, partial, or full conversion[1]. In Sweden in particular, the choice between conventional and organic is relevant because the

[1] To our knowledge the only empirical study considering mixed farming is the work conducted by Nachtman (2015) on Polish farms, who considered that mixed farm denote coexistence between organic and conventional farming/practices on the same farm.

conversion process is rather flexible compared with that in some other countries, since in-conversion farms may choose to leave the process without paying a penalty.

In the present study, we defined farms that have been in the process of converting for more than the mandatory two years as "mixed category". More specifically, this group of farms includes: 1) the *partial adopters* of conventional and organic farming in separate operational units and 2) farms that have been in conversion for more than the mandatory two-year period. Both groups (1 and 2) may contain farms with different characteristics. For instance, in the case of dairy farms, *partial adoption* might mean that: i) the farm has organically converted land (the total farm area is not necessarily converted) and conventionally grown dairy livestock; or ii) the farm has some fields in naturally protected areas and the dairy livestock are conventional. *In-conversion farms,* i.e. farms where the process of conversion lasts more than two years, might mean: i) gradual conversion of land and livestock, ii) the prolongation being due to the requirements for organic farming not being fulfilled, or iii) not being accepted as organic milk producers due to market conditions (as was the case in some parts of Sweden in 2010-2011), etc. These "mixed category"[2] farms (partial adopters and in-conversion farms) can be seen as potential converters to organic and, as Koesling et al. (2008) mention, have implications for the choice of policies to promote expansion of organic production. This might apply especially for dairy farms with organically converted land, or land located in naturally protected areas, where only six months of organic-based feeding is necessary to convert from conventional to organic milk production. For comparison, in Sweden conversion to organic meat production requires two

[2] It is important to emphasize that the notion of mixed farming defined in this study differs from the mixed farming category as defined for the typology of agricultural holdings in the Farm Accounting Surveys, which refer to farms combining different types of production activities (for example, mixed crop and livestock farming) (EU Commission Regulation, 2008).

years of organic-based feeding, where 50% of the feed is produced on the farm (Jordbruksverket, 2015; LRF, 2016).

The aim of this study was therefore to develop and estimate a structural change decision model, whereby mixed farming is part of the sequential conversion process from conventional to organic farming, that considers the existence of a transition period during which the farmer can adopt organic farming partially/fully. In this conversion process, the farmer must first decide whether to stay conventional or join the conversion process, and then make another choice between mixed and organic production system. In this, 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 for two years. In this context, the nested logit (NL) model (Koppelman and Bhat, 2006; McFadden, 1978) is best suited to characterize the nested structure of mixed and organic farming.

The Swedish FADN data were used here to fit the NL model to the two-tier decision tree, to examine the nested structure of choice alternatives in the organic conversion process. In the EU, Sweden is one of the leaders in converting to organic farming, after Austria, with 17 percent of the total agricultural area converted (Statistics Sweden, 2014). Given the national target of 20 percent organic area and 25 percent organic food consumption in the public institution sector (Ekologiskt Forum, 2007), the low uptake rate of organic farming is surprising and a major challenge to increased supply of organic food crops. The current yearly increment rates of 1.4 and 1.7 percent for converted area and livestock (Statistics Sweden, 2014) are not enough to meet the targets by 2020 (Röös, 2014).

The contribution of our study is two-fold. First, we develop a conceptual farm structural change model, identifying the presence of mixed-type farms in the dairy sector, where the farmer does not intend, or has not succeeded, in full conversion to organic production. Second, we explain the existence of a nested choice structure with mixed and organic production systems, tested empirically with Swedish data. This study on the presence of nested structure in organic conversion in Sweden could also serve as the basis for a policy support strategy for other EU member states. 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.

MATERIAL AND METHODS

Data and conceptual 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, 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 the Council Regulation (EEC) No 2237/77 of 23 September 1977 on organic production, a farm is registered as: 1) conventional if it has no organic production; 2) organic if it has only organic production; and 3) in-conversion if it is in the process of converting to organic production, or mixed if it has both conventional and organic production on separate production units. Of the total observations in the study sample, about 75 percent were reported as conventional, while the remaining 25 percent had gone through the conversion stages at decision level 1 (see panel (a) of Figure 1). In fact, 14 percent converted to organic, 7 percent remained in the conversion stage for more than two years as mixed farms, and

4 percent were in the 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) of Figure

>>Figure 1<<

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 could remain in the conversion phase for more than two years, in which case they are regarded as mixed farms in this analysis. This two-level decision process therefore provides a nest of mixed and organic production systems. Mixed and organic farming are more similar in their characteristics than conventional and mixed (or conventional and organic) farming, because e.g., both mixed and organic farms have spent two years in the conversion process under the rules of organic farming. As a result, the property of Independence from Irrelevant Alternatives (IIA) does not hold. Put differently, 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 better explanatory power (Forinash and Koppelman, 1993; Train, 1986). A binary discrete choice model can also be applied to each pair of alternatives, but each analysis can potentially utilize a different sample. The nested logit (NL) is the most commonly used model when some alternatives have a higher degree of similarity and competiveness 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 practiced 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 extension 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 productivity, and environmental support payment) 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 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.

Empirical model and econometric method

We analyzed the two-level nested structure of production alternatives using a random utility maximization (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:

$$V_{ij} = \beta X_{ij} + \alpha_j' Z_i \quad (1)$$

where X_{ij} and Z_i represent the vectors 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:

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

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:

$$P_{ij} = P_{i,k\epsilon IC} \times P_{ij|k\epsilon IC} = \frac{\exp\left(\frac{\beta' x_{ij}}{\theta_{IC}}\right)}{\exp(\Gamma_j)} \times \frac{\exp\left(\alpha_j' Z_i + \theta_{IC}\Gamma_{IC}\right)}{\Sigma_T \exp(\alpha_{IC}' Z_i + \theta_{IC}\Gamma_{IC})} \tag{3}$$

To estimate the model parameters, full information maximum likelihood (FIML) is the most efficient estimator (Forinash and Koppelman, 1993; Greene, 2003) and permits testing of whether the MNL model can be rejected by the data (Forinash and Koppelman, 1993). 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 A1). These elasticities at individual sample points would also provide a meaningful interpretation for the dichotomous variables, as the values would be either 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 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. If θ 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<<

Determinants and hypotheses

In the literature, a wide range of economic and non-economic determinants for identifying the of farm structural change 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). In recent studies, economic factors have become more important, as market mechanisms are used through the existence of a special market for organic produce (Padel, 2001). In Sweden, the market share of organic produce is higher than in other EU member states (Larsson et al., 2013) and consumers are willing to pay a premium for locally produced organic food (KRAV, 2016). We therefore considered a set of alternative-specific and case-specific economic variables and examined their relevance in explaining dairy farm structural change in Sweden.

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 productivity, 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, the 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 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 this would raise the interest among conventional dairy farmers in Sweden in adopting organic milk production (*Hypothesis H1)*. Larsson et al. (2013) also state that the price premium for organic products is an important determinant for conventional farmers to convert to organic farming. The farm-gate prices of conventional and organic milk are measured per kg of milk production in Swedish Krona (SEK), which vary over farms and over years.

Milk productivity. Organic production technologies undergo continuous development. For instance, the overall milk yield per cow in Sweden increased over the period of 1998-2012 (Henriksson, 2014). However, productivity on organic farms still remains below the level on conventional farms (see Table 2). 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 have a higher probability of switching to organic production in Finland. Milk productivity as given here is an alternative-specific variable, estimated at farm level, where the productivity for conventional/mixed/organic farms represents the actual hundred kg milk yield 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 in the analysis through case-specific variables, we considered milk productivity as a proxy to capture the differential growth in technologicSal development across production types. We hypothesized that farms with low milk productivity 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 concern. 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 subsides 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 boost structural change in the industry. Kumbhakar et al. (2008) argue that such payments are important for promoting organic farming even if the organic production technology is inferior and the productivity differential 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. We therefore hypothesized that there is a positive impact of environmental support payments on the conversion process to organic farming (*Hypothesis H3*).

>>Table 2<<

The case-specific variables describe the characteristics of the decision makers (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. By contrast, 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 also encourage small farms to convert to organic farming. 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 farming to be adopted. We therefore hypothesized 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 (standard output after 2010) 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 favor 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 percent of all observations were from the southern and central plains area (region 1), but only 8.12 and 11.85 percent of the observations represented mixed and organic production. In contrast, region 3, located in northern Sweden, contributed only 23.27 percent of all observations but exhibited larger shares of mixed and organic farming (15.81 and 23.99 percent, respectively). According to Källander (2000), region 3 is characterized by lower agricultural potential, a large share of grassland and ley, and more nature protected areas, which favors the expansion of mixed and organic farming. We therefore hypothesized 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 percent 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 hypothesized that the 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, we hypothesized 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 program (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 productivity, year dummies can proxy the influences of year-specific omitted variables such as institutional arrangement, policy support, and market development.

RESULTS AND DISCUSSION

Table 3 shows the results of the nested logit (NL) model estimations for the choice of production system alternatives for Swedish dairy farmers. In this estimation, 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 behavioral 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 utilizing the MNL model.

Since the NL model is nonlinear, the parameter estimates are not equal to the marginal effects of the variables included. However, they can infer 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 alternative- and case-specific variables (Table 4). In the former case, the sign of the estimated *own elasticities* (non-shaded cells) 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* (shaded cells) 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.). Regarding case-specific variables, probability elasticities are also computed for farm size, pasture land and the national price index while semi-probability elasticities are derived for the two regional dummy variables.

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

Farm-gate milk price. The statistically significant parameter estimates (see Table 3) confirmed *Hypothesis H1,* that the farm-gate milk price is important for Swedish dairy farmers when choosing production system. As can be seen in Table 4, 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, 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 productivity. The positive and statistically significant parameter estimate in Table 3 clearly shows that milk productivity is one of the important factors influencing the choice of production system alternative. As expected, the alternatives in a common nest (mixed and organic) showed the same degree of increased sensitivity (-0.1887 in Table 4) 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 (0.2970 in Table 4) indicates an increased probability of continuing organic production with the development of organic methods and technologies. In the study sample, average productivity was lower in organic than in conventional farming (see Table 2), 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 agricultural farms to organic production. Because of higher productivity 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 4.). However, the negative cross-elasticity between conventional and organic farming indicates that the improvements in productivity 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 unavoidable in order to narrow the loss in farm profits due to productivity differentials in conventional and organic dairy farming. Otherwise, according to Koesling et al. (2008), dairy farmers would be relatively less interested in full conversion to organic farming.

Environmental support. As conjectured in *Hypothesis H3*, the support payment to dairy farms for environmental protection was important for the choice between conventional, mixed, and organic farming (statistically significant coefficient at 10% level, see Table 3). The estimated elasticities associated with environmental support reported in Table 4 are relatively small (and not statistically significant) compared with the impacts of farm-gate price and milk productivity. In the literature, this type of support payment is regularly reported to be an incentive for organic producers, as to some extent they offset the sunk cost associated with the conversion process (Fairweather, 1999; Kuminoff and Wossink, 2010; Manevska-Tasevska et al., 2013; 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.

>>Table 3<<

>>Table 4<<

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 technology (see Table 3).

Farm size. In the present study, we found that the effect of farm size on conversion to organic was non-significant (see Table 3), 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 favor of the null hypothesis, while a few (e.g., Gardebroek, 2006; 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 (shaded cells in Table 4) indicates that smaller farms are more likely to choose conventional or organic production technologies. Similarly, Läpple (2010); Padel (2001); Samson et al. (2016) argue that small and extensive farms would have lower entry costs for organic farming. In the case of mixed farming, the effect of farm size was positive and statistically significant (Table 3). The estimated elasticities in Table 4 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 fulfill 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 need to 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. The sample data in Table 2 also show larger herd size in mixed farms. Similarly, Nachtman (2015) found that more than a quarter of the Polish mixed farms included in their analysis (FADN data were used) had over 50 ha of utilized 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 percent 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 3 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 4, *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 percent) 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 3). 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 3. The estimates on semi-elasticities for region 2 in Table 4 also confirm that farms in this region are more likely to follow a mixed farming strategy than farms in region 1. We also observed (Table 2) that in region 2, the share of mixed farms was relatively higher (11.64 percent) than the share of organic farms (9.70 percent).

Pasture land. The positive and statistically significant parameter estimates for pasture land in Table 3 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. Indeed, organic farming requires large areas of pasture for grazing livestock under Swedish regulations for organic farming, where more than 50 percent 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 4, 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 4, 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 negative and statistically significant parameter estimates of national milk price index for mixed and organic farming in Table 3, and the negative elasticities for organic farming (shaded) in Table 4. 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 3 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 the reason for the negative and statistically significant effects obtained for mixed farming relative to conventional. To sum up, the present study 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.

CONCLUSIONS

Assuming a two-tier sequential decision tree, the present study demonstrated the presence of a nested structure between mixed and organic farming in the organic conversion process. The alternative-specific variables, such as farm-gate milk prices, environmental support payments received by the farmers, and farm productivity in terms of milk production, were shown to have positive influences on farmers' choice of production system – conventional, mixed, or organic farming. Given the scenario of an expected decrease in milk prices owing to the CAP reform on the EU milk quota, the organic price premium would be an incentive to compensate for the losses in farm profit.

Organic farming is still a niche production alternative for low-yielding dairy farms, but large farms could opt for the optimal mix of conventional and organic production system. Farms situated in environmentally sensitive regions are more likely to convert to organic production, either partially or fully. These partial adopters of organic farming are actually the potential converters to organic and have implications for the expansion of organic production, especially in the dairy sector where the farmers are less interested in full conversion to organic. Availability of pasture land is one of the preconditions for promotion of organic farming.

REFERENCES

Acs, S., P. Berentsen, R. Huirne, and M. Van Asseldonk. 2009. Effect of yield and price risk on conversion from conventional to organic farming. Aust. J. Agric. Resour. Econ. 53(3): 393– 411. doi: 10.1111/j.1467-8489.2009.00458.x.

Ahlman, T. 2010. Organic dairy production, Herd characteristics and genotype by environment interactions. PhD thesis. Swedish University of Agricultural Sciences, Uppsala, Sweden.

Bragg, L.-A., and T.-J. Dalton. 2004. Factors affecting the decision to exit dairy farming: a two-stage regression analysis. J. Dairy Sci. 87(9): 3092– 3098. doi: 10.3168/jds.S0022-0302(04)73444-X

Breustedt, G., U. Latacz-Lohmann, U., and T. Tiedemann. 2011. Organic or conventional? Optimal dairy farming technology under the EU milk quota system and organic subsidies. Food Policy. 36(2): 223-229.

Debio. 2016. DEBIO - Certification and inspection agency for organic farms and fish farms in Norway.

EC. (1985). 85/377/EEC: Commission Decision of 7 June 1985 establishing a Community typology for agricultural holdings *Official Journal of the European Communities, L 220*(17.08.85), 1-32. doi: http://data.europa.eu/eli/dec/1985/377/oj.

EC. (1991). Council Regulation (EEC) No 2092/91 of 24 June 1991 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs. *Official Journal of the European Communities, L 198*(22.7.91), 1-15. doi: http://data.europa.eu/eli/reg/1991/2092/oj.

Ekologiskt Forum. 2007. Aktionsplan 2010 för en ökad ekologisk konsumtion och produktion. Stockholm: Ekologisk Forum.

EU Commission Regulation. 2008. Establishing a community typology for agricultural holdings. Official Journal of the European Union.

EU The Committee of the Regions (CoR). 2014. Policy package on organic production" - Stakeholder consultation, COM(2014) 180.

European Commission. 2011. Regions in the European Union - Nomenclature of territorial units for statistics NUTS 2010/EU-27. In E. Commission (Ed.), *Eurostat Methodologies and Working papers*. Luxembourg: Publications Office of the European Union.

Fairweather, J. 1999. Understanding how farmers choose between organic and conventional production: Results from New Zealand and policy implications. Agric Human Values. 16(1): 51-63. doi: 10.1023/A:1007522819471.

Forinash, C. V., and F. S. Koppelman. 1993. Application and interpretation of nested logit models of intercity mode choice. Transp. Res. Rec.1413:98-106.

Gardebroek, C. 2006. Comparing risk attitudes of organic and non-organic farmers with a Bayesian random coefficient model. Eur. Rev. Agric. Econ. 33(4): 485-510. doi: 10.1093/erae/jbl029

Greene, W. H. 2003. Econometric analysis, 5th ed, Prentice Hall, Upper Saddle River, NJ.

Henriksson, M. 2014. Greenhouse gas emissions from Swedish milk production - Towards climate-smart milk production. PhD thesis. Swedish University of Agricultural Sciences, Alnarp, Sweden.

Jongeneel, R., A. Burrell, and A. Kavallari. 2011. Evaluation of CAP measures applied to the dairy sector. Brussels: European Commission Directorate-General for Agriculture and Rural Development.

Jordbruksverket. 2010. Hur styr miljöersättningen för ekologisk produktion? - effekter på marknad och miljö (Vol. Rapport 2010:1). Jönköping: Jordbruksverket.

Jordbruksverket. 2015. Parallellhproduktion inom djurhållning (In Swedish). Accessed 14 October 2015. http://www.jordbruksverket.se/amnesomraden/miljoklimat/ekologiskproduktion/reglerochcertifiering/ansokanomundantagochgodkannande/parallellproduktioninomdjurhallning.4.2c4057e915060022b2a80485.html.

Koesling, M., O. Flaten, and G. Lien. 2008. Factors influencing the conversion to organic farming in Norway. International Journal of.Agricultural.Resources, Governance and Ecology. 7(1): 78-95.

Koppelman, F., and C. Bhat. 2006. A Self-instructing course in mode choice modeling: Multinomial and Nested Logit models. Prepared Federal Transit Administration, U.S. Department of Transportation, Washington, DC.

KRAV. 2016. Allt fler svenskar är LOHAS (Lifestyle of Health And Sutainability) Marknadsrapport 2016. Uppsala: KRAV Ekonomisk förening.

Kumbhakar, S. C., E. G. Tsionas, and T. Sipiläinen. 2008. Joint estimation of technology choice and technical efficiency: an application to o://rganic and conventional dairy farming. J. Prod. Agric. 31(3): 151-161. doi: 10.1007/s11123-008-0081-y.

Kuminoff, N. V., and A. Wossink. 2010. Why Isn't more US farmland organic? J. Agr. Econ. 61(2): 240-258. doi: 10.1111/j.1477-9552.2009.00235.x.

Källander, I. 2000. Organic agriculture in Sweden. Organic Agriculture in Europe. htpp://www.organic.-europe.net,30.3.2000.

Larsson, M., L. Morin, T. Hahn and J. Sandahl, J. 2013. Institutional barriers to organic farming in Central and Eastern European countries of the Baltic Sea region. Agriculture and Food Economics. 1(5): 1-20. doi: 10.1186/2193-7532-1-5

Lehner, M. 2010. Policies to promote organic agriculture. Copenhagen: Copenhagen Resource Institute.

Lohr, L., and L. Salomonsson. 2000. Conversion subsidies for organic production: results from Sweden and lessons for the United States. Agric. Econ. 22(2): 133-146. doi.org/10.1016/S0169-5150(99)00045-6

LRF. (Lantbrukarnas Riksförbund - Federation of Swedish Farmers). 2016. Nationella riktlinjer för ekologisk produktion NR version 2, 2016-01-15.

Läpple, D. 2010. Adoption and abandonment of organic farming: An empirical investigation of the Irish drystock sector. J. Agric. Econ. 61(3): 697-714. doi: 10.1111/j.1477-9552.2010.00260.x

Läpple, D., and H. Kelley. 2014. Spatial dependence in the adoption of organic drystock farming in Ireland. Eur. Rev. Agric. Econ. 42(2):315-337. doi: 10.1093/erae/jbu024

Manevska-Tasevska, G., E. Rabinowicz, and Y. Surry. 2013. Policy impact on farm level efficiency in Sweden 1998-2008 *Working paper 2013:06* (pp. 35). Sweden: Agrifood Economics Centre.

Matthews, A. 2015. Is the removal of quotas responsible for the increase in EU milk production in 2015? Accessed March 31, 2016. http://capreform.eu/is-the-removal-of-quotas-responsible-for-the-increase-in-eu-milk-production-in-2015/

McFadden, D. 1978. Modelling the choice of residential location. Pages 75-96 in Spatial Interaction Theory and Planning Models. A. Karlqvist, L. Lundqvist, F. Snickars and J. Weibull. ed., North Holland, Amsterdam: The Netherlands.

Nachtman, G. 2015. Farms combining organic and conventional production methods at the background of organic farms. Problems of Agricultural Economics. 344(3): 128-146.

Padel, S. 2001. Conversion to organic farming: A typical example of the diffusion of an innovation? Sociol. Ruralis. 41(1): 40- 61. doi: 10.1111/1467-9523.00169

Pietola, K., and A. Lansink. 2001. Farmer response to policies promoting organic farming technologies in Finland. Eur. Rev. Agric. Econ. 28(1): 1-15. doi: 10.1093/erae/28.1.1

Reganold, J.-P., and J.-M.Wachter. 2016. Organic agriculture in the twenty-first century. Nat. Plants. 2:1-8. doi: 10.1038/nplants.2015.221

Ryegård, C. 2011. Läget på rekryteringsfronten (In English: The state on the recruitment front). *EkoWeb April 05.*

Röös, E. 2014. Dead heat on climate impact between organic and conventional milk production: what other benefits are there? Nordic Organic Research and Development (NORD), 1:4-8. Centre for Organic Food & Farming. Swedish UniversityofAgricultural Sciences, Uppsala, Sweden.

Samson, G.-S., Gardebroek C., and R.-A. Jongeneel. 2016. Explaining production expansion decisions of Dutch dairy farmers. NJAS - Wageningen Journal of Life Sciences. 76: 87-98. doi: http://dx.doi.org/10.1016/j.njas.2015.11.007

Schmidtner, E., C. Lipper, B. Engler, A.-M. Häring, J. Aurbacher, J., S. and S. Dabbert. 2011. Spatial distribution of organic farming in Germany: does neighbourhood matter? Eur. Rev. Agric. Econ. 39(4): 661-683. doi: 10.1093/erae/jbr047

Statistics Sweden. 2014. Yearbook of agriculture statistics 2014 (A. S. U. Statistics Sweden, Trans.) (Vol. 2014, pp. 199). Orebro: Agriculture Statistics Unit.

Train, K. 1986. Qualitative Choice Analysis: Theory, Econometrics, and an Application to Automobile Demand. The MIT press, Boston, MA.

Zimmermann, A., and T. Heckelei. 2012. Structural change of European dairy farms – a cross-regional analysis. J. Agric. Econ. 63(3), 576-603. doi: 10.1111/j.1477-9552.2012.00355.x.

APPENDIXES

APPENDIX A1: 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:

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

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

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:

$$\eta^C = (1 - P_{iC})\alpha_C Z_{iC} - (P_{iM}\alpha_M Z_{iM} + P_{io}\alpha_O Z_{iO}); \quad \eta^C = \left[\alpha_C - \textstyle\sum_{k=C,k\epsilon IC} P_{ik}\alpha_k\right] \times Z_i \quad \text{(A4)}$$

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:

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

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

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:

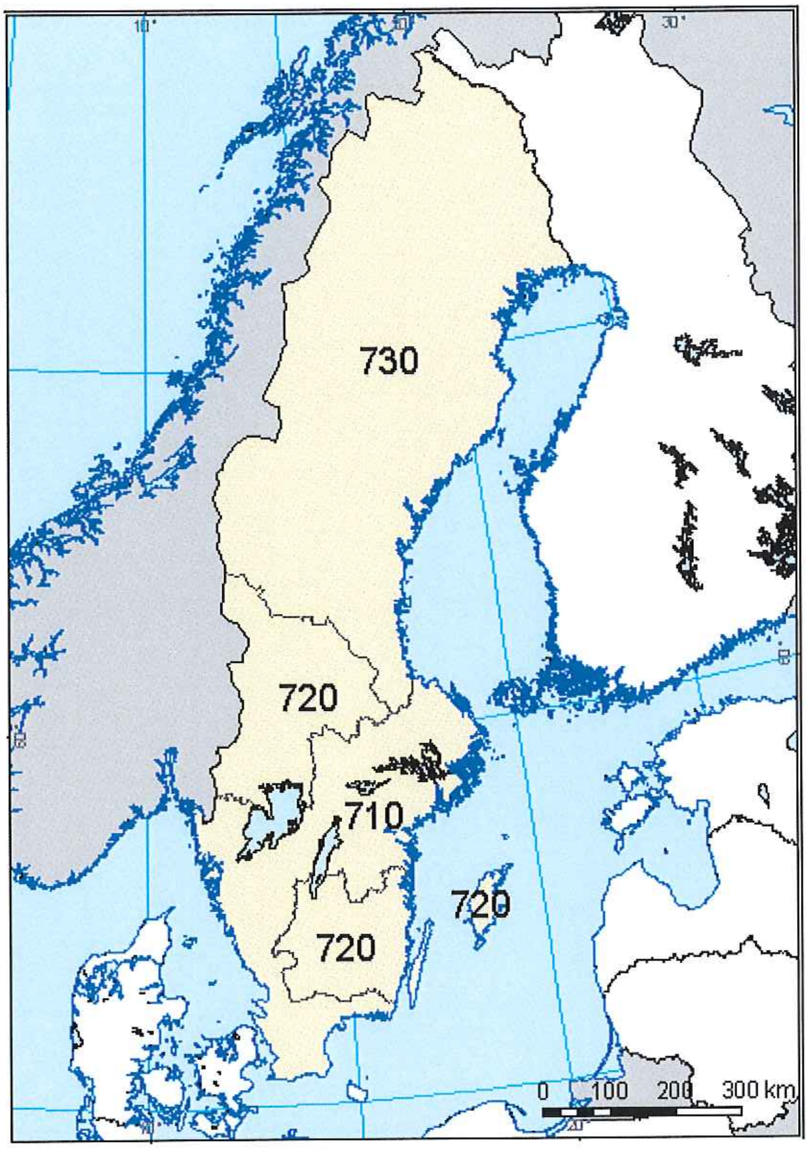
$$\eta^O = \left[\frac{1}{\theta_{IC}}\alpha_O - \sum_{k\epsilon IC} \alpha_k P_{ik} - \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)\sum_{k\epsilon IC} \alpha_k P_{i,k|IC}\right] \times Z_i$$

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

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

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 A2. FADN/RICA REGIONS OF SWEDEN.



710 Plains areas (Region 1)

720 Forest and valley areas (Region 2)

730 Northern Sweden (Region 3)

Source: European Commission, DG AGRI.

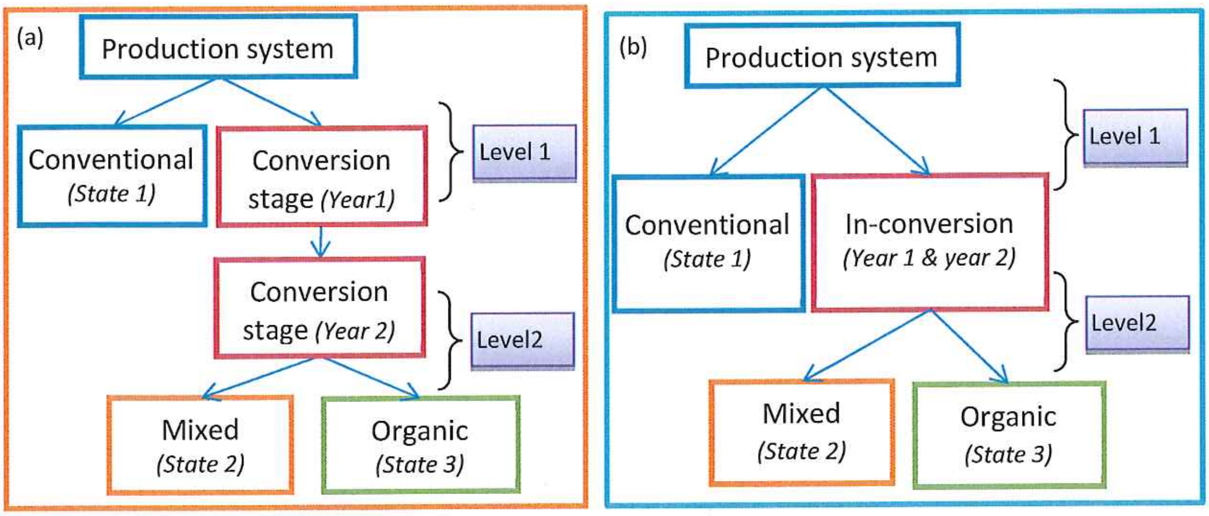


Figure 1. The organic conversion process, where (a) represents the conversion process from conventional to organic farming, and (b) is the two-level nested choice structure: production states conventional, mixed, and organic.

Table 1. Analytical elasticities of choosing a production system in the Nested Logit (NL) model

Probability Elasticity	Changes in		
	Conventional state	Mixed state	Organic state
A. Alternative-specific variable[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 variable[2]	$\left[\alpha_C-\sum_{k\in IC}\alpha_k P_{ik}\right] \times Z_i$	$\left[\frac{1}{\theta_{IC}}\alpha_M-\sum_{k\in IC}P_{ik}\alpha_k - \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)\sum_{k\in IC}P_{i,k\mid IC}\alpha_k\right]\times Z_i$	$\left[\frac{1}{\theta_{IC}}\alpha_O-\sum_{k\in IC}P_{ik}\alpha_k - \left(\frac{1-\theta_{IC}}{\theta_{IC}}\right)\sum_{k\in IC}P_{i,k\mid IC}\alpha_k\right]\times Z_i$

[1]Modified from Koppelman and Bhat (2006) and Forinash and Koppelman (1993).

[2]Own calculation (for derivation see appendix A1). The notation C, M, O, and IC indicates conventional, mixed, organic, and in-conversion state, corresponding to panel (b) of Figure 1.

Table 2. Descriptive statistics (means and standard deviation) – conventional, mixed, and organic farm data, 2002-2012

Variables	All farms (3,940 obs.[1])		Conventional (2,955 obs.)		Mixed (432 obs.)		Organic (553 obs.)	
A. Alternative-specific variables								
Farm-gate milk price (SEK/kg)	3.17	(0.46)[2]	3.16	(0.45)	3.12	(0.40)	3.30	(0.52)
Milk productivity ('00 kg/cow)	74.71	(14.53)	75.19	(14.69)	73.99	(14.46)	72.65	(13.43)
Environmental support ('000 SEK/cow)	15.74	(19.50)	15.46	(18.86)	16.32	(19.96)	27.58	(33.09)
B. Case-specific variables								
Farm size (ESU[3])	7.95	(0.83)	7.92	(0.82)	8.15	(0.82)	7.92	(0.86)
Pasture land (in hectare)	16.26	(33.71)	14.52	(25.67)	28.23	(70.75)	16.24	(23.54)
National milk price index (2005=100)	106.74	(7.16)	106.82	(7.11)	106.28	(7.41)	106.66	(7.24)
Regional distribution of farms (Dummy)								
Region 1[4]	1,848	[46.90][2]	1,479	[80.03]	150	[8.12)	219	[11.85]
Region 2	1,175	[29.82]	924	[78.64]	137	[11.64]	114	[9.70]
Region 3	917	[23.27]	552	[60.20]	145	[15.81]	220	[23.99]

[1] "obs." stands for the total number of observations, which is equal to $N \times T$, where N is the number of farms and T is the time period.

[2] Figures in parentheses are standard deviations, while those in square brackets are the percentages of farms in a given region.

[3] 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 1200 Euros of the standard gross margin (or standard output after 2010) per hectare of crop and per head of livestock of each holding.

[4] For a definition of regions, see Appendix 2.

Table 3. Estimation results of the Nested Logit model

Variables	Estimated coefficient	Standard Error
A. Alternative-specific variables		
Farm-gate milk price	0.4290***	0.0852
Milk productivity	0.3241*	0.1957
Environmental support	0.0019*	0.0010
B. Case-specific variables		
Conventional (base category)	0	-
Mixed farming		
Farm size	0.2692***	0.0637
Region 2	0.3123***	0.1179
Region 3	1.2997***	0.1086
Pasture land	0.0093***	0.0015
National milk price index	-0.0372***	0.0050
Year dummies (base = 2002)		
2003	0.0283	0.2055
2004	-0.3449*	0.2008
2005	-0.3823*	0.2031
2006	-0.4318**	0.2058
2007	-0.2694	0.2005
2008	0.3747*	0.2077
2009	-0.9909***	0.2429
2010	-0.3198	0.2145
2011	-0.5004**	0.2385
2012	-1.1130***	0.2729
Organic farming		
Farm size	0.0428	0.0571
Region 2	-0.0090	0.1056
Region 3	1.2409***	0.1027
Pasture land	0.0081***	0.0016
National milk price index	-0.0256***	0.0041
Year dummies (base = 2002)		
2003	0.1469	0.2106
2004	-0.1086	0.2023
2005	-0.0055	0.1997
2006	-0.0993	0.1995
2007	-0.0163	0.2015
2008	0.4638**	0.2152
2009	-0.3878	0.2015
2010	0.0505	0.2045
2011	0.0591	0.2071
2012	-0.2928	0.2081
Dissimilarity parameter	0.4756***	0.1086
Number of cases[1] ($N \times T$)	3940	-
Number of alternatives (Alt)	3	-
Total observations($N \times T \times Alt$)	11820	-
LR test for IIA: Chi-Sq(2)	11.2251***	-
Model Wald Chi-Sq(33)	745.4235***	-

Significance *** P<0.01. ** P <0.05. * Pp<0.1.

[1] N and T represent number of dairy farms and time period in the study sample, respectively.

Table 4. Estimated elasticities with respect to the selected explanatory variables

Variables		Effects on the probability of choosing					
		Conventional		Mixed		Organic	
		Elast.[1]	SD[2]	Elast.	SD	Elast.	SD
A. Alternative-specific variables[3]							
Farm-gate milk price	Conventional	0.3294	0.1478	-0.9949	0.1948	-0.9949	0.1948
	Mixed	-0.1480	0.1017	2.0660	0.4641	-1.1253	0.5091
	Organic	-0.2062	0.1345	-0.7843	0.3415	1.8632	0.2573
Milk productivity	Conventional	0.0618	0.0261	-0.1887	0.0398	-0.1887	0.0398
	Mixed	-0.0281	0.0197	0.3838	0.0967	-0.1712	0.0658
	Organic	-0.0310	0.0171	-0.1488	0.0709	0.2970	0.0875
Environmental support	Conventional	0.0041	0.0078	-0.0108	0.0181	-0.0108	0.0181
	Mixed	-0.0030	0.0050	0.0342	0.0363	-0.0362	0.0377
	Organic	-0.0067	0.0086	-0.0146	0.0199	0.0599	0.0578
B. Case-specific variables[4]							
Farm size		-1.8598	0.2721	3.0441	0.6104	-1.1843	0.6104
Region 2		-0.0678	0.0099	0.1427	0.0222	-0.0749	0.0211
Region 3		-0.4436	0.0649	0.2892	0.1456	0.1543	0.1382
Pasture land		-0.2132	0.0312	0.1529	0.0701	0.0604	0.0664
National milk price index		0.0470	0.0068	-0.0116	0.0154	-0.0354	0.0146

[1]"Elast." indicates elasticity for continuous variables or semi-elasticity for dummy variables (region 1 and region 2).

[2]"SD" refers to standard deviation.

[3]For the alternative-specific variables, the diagonal elements are own probability elasticities, while the off-diagonals (shaded) are cross probability elasticities.

[4] For the case-specific variables, shaded values correspond to negative (semi-) probability elasticity estimates.