Does Neighborhood Matter?
A Micro-level Spatial Analysis of the Entry and Exit of Organic Farming Program in Southern Sweden

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Abstract

We investigate farmers' decision to engage in organic production. Our objective is to identify the key factors that promote or hinder the update of organic farming. In particular, we focus on neighborhood factors and the spatial allocation of organic land parcels. A rich spatial panel data of all agricultural parcels is compiled and the information on land use, soil quality, biodiversity, local landscapes, and neighborhood characteristics are extracted using ArcGIS techniques.

We carry out both cross-sectional analyses and panel data models. In the cross –sectional analysis, we focus on the duration that a parcel stays in organic production: to temporarily enroll into organic farming program for subsidy or to convert to organic production permanently. In the panel data model, we analyze whether a parcel stays in organic production in a period by assuming there is or there is no temporary correlation.

We find that neighborhood characteristics do have significant effects on farmers' decision. Such effects manifest in the following four areas: 1) a farm with a higher share of organic land in its adjacent neighborhood is more likely to be organic temporarily or permanently; 2) a neighborhood with a higher share of ley and grass land, hence, a higher potential for biological control, can promote conversion to organic production; 3) a parcel with a larger shared border per unit area with other parcels are less likely to be engaged in organic production; and 4), a neighborhood with abundant floral species and more floral spices that are suitable to traditional agricultural production has more parcels being converted to organic production.

We also find that highly productive land is less likely to be enrolled into organic farming programs, which confirms the finding from literature that profits is an important factor that affects farmers' decision. Farmers tend to convert parcels that are far away from their houses to organic while keep the parcels close by in conventional production. Small farms and farms that are more diversified are more likely to be shifted to organic production. Our findings are hence in favor of the policy suggestions on agglomeration payments in biodiversity conservation.

Keyword: Organic farming, Neighborhood effect, Neighboring effect, Edge effect, Biodiversity

JEL codes: Q01, Q18, Q24, Q38, Q57, Q58

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Introduction

Organic farming is recognized as an approach that emphasizes the health of ecosystem, animal welfare, food quality and health, and the sustainable resource use. With the increasing awareness of biodiversity conservation, organic production draws significant policy attentions. The 2003 European Common Agricultural Policy (CAP) reform promotes organic production by separating direct payment from production and increasing the relative importance of environmental support.[1] Accordingly, the EU member states have been increasing their subsidies on organic production.

However, the economic incentive seems not working. The uptake of organic farming has being stagnating since the reform, and even worse, there appears to be a significant exit rate. The exit rate in 2007 is 7.3% at EU level according to Läpple (2010). Sauer and Park (2009) examine this phenomenon in Denmark, Madelrieux and Alavoine-Mornas (2012) in France, and Läpple (2010) in Ireland. Sweden is not an exception. The country increases the organic farming payment by 20% in 2005, the share of land dedicated to organic farming, however, drops from 16% in 2005 to 10.8% in 2007. The slow growth rate and high exit rate, combined with increasing environmental payments beg the following questions: Is subsidy the only factor that farmers will consider and what else affect farmers' decision?

The existing literatures on organic farming have covered several issues that affect the adoption of organic farming. Kuminoff and Wossink (2009) find that policy uncertainty increases option value of land, hence can delay the conversion to organic farming in the presence of a sunk cost. Sauer and Park (2009) discover a low growth rate of total factor productivity for Danish organic dairy farms. Their analysis indicates a positive association between subsidy and farm efficiency, which is in favor of the utilization of policy support to sustain a viable organic sector. Sauer and Park's (2009) findings are in line with these from

[1] The 2003 CAP reform can promote organic production from 3 areas. First, the decoupling of direct payment (subsidy) from agricultural production can help change the disadvantaged position of organic farming relative to conventional farming. Second, the cross-compliance rule, which requires that the recipients of direct payment comply with environmental regulations, might increase the cost of conventional farming compared to organic farming for receiving these direct payments. Third, the CAP reform agrees to reduce price support and increase the support for Rural Development Payment that umbrellas the organic farming payment.

Uematsu and Mishra (2012): the lack of stable income is the main factor preventing the adoption of organic farming.[2] Läpple (2010) estimates a duration model of the entry and exit of organic production in drystock sector in Ireland. She identifies income, farmers' environmental attitude/information, and time shock as the important factors influencing farmers' exit decision. She hence emphasizes the importance of stable and lucrative organic market and information provision from government agencies.

The above empirical analyses on the entry or exit of organic farming focus mainly on risk and economic factors. They leave out one important factor: neighborhood effect or spatial effect. Decisions on agricultural production and land use are processes in which spatial configuration and spatial network is highly relevant. One venue of the spatial effect is knowledge spillover. Farmers can observe what their neighbors do and learn from them. Neighboring farmers can also share information on market, new technologies, or beneficial farming practices. For example, an organic grower shares information with his neighboring farmers and encourage those who initially know very little about organic farming to adopt such technology. The second venue is spatial economy of scale on both production and marketing. On the production side, the economy of scale can manifest as an "edge effect externality" (Parker and Munroe 2007). For example, an organic grower in the presence of adjacent conventional farms may find that it is hard to maintain a population of beneficial insects. Such negative edge effect can increase the cost of pest control and/or reduce the pollination efficiency, resulting in yield loss. When neighboring farmers take joint action to adopt organic farming, the chance will be improved to maintain the population insect and improve the effectiveness of ecological process, which results in a positive spatial externality. On the market side, the agglomeration of organic producers will allow neighboring farmers to share facilities and earn a volume premium.

To the best of our knowledge, there are three published articles that examine spatial spillover effect using aggregated data or micro-level data. Using a county level data, Schmidtner et. al. (2012) conduct spatial lag models and spatial error models to examine the agglomeration of organic farming in West Germany. Parker and Munroe (2007) implement a spatial autoregressive model on a cross-sectional data of cropland in a county in California. They measure spillover effect (edge effect externalities) using parcel geometry (parcel size and

[2] Note that the two researches focus on slightly different economic factors. Uematsu and Mishra (2012) argue that organic farms in US have a very thin profit marginal due to high cost on labor and insurance and market charge.

shape) and adjacent land uses. While and Lewis, Barham, and Robinson (2011) carry out a panel data discrete choice analysis on dairy farms in six counties in Wisconsin. They approximate spatial effect using the number of organic dairy farms within a farm's 5-mile buffer and 5-10-mile buffer. All the three studies find a statistically significant correlation between spatial factors and the adoption of organic farming. They hence suggest that governments should intervene to promote efficient spatial allocation of organic production and to maintain the viability of organic sector.

While the above studies contribute to the organic farming literature, their neighborhood effect measures are rather coarse. Schmidtner et. al. (2012) is a county level analysis and hence is not able to address any within-county spatial allocation due to data limitation. Any spatial interaction along the county border rather than in the center can introduce bias in their estimation. They are also not able to address the entry and exit problem in Germany. Although Lewis, Barham, and Robinson (2011) use farm level data, their neighboring measures may not accurately approximate spatial influence. For example, buffer A has 100 farms and buffer B have 50 farms. When both buffers have five organic farms, the model will predict that they have the same spatial effect. However, the truth is that buffer B might have a stronger spatial effect than buffer A. While Parker and Munroe (2007) measure parcel geometry, spatial lag correlation, and nearby land use at micro-level, they are not able to control many other factors that influence the conversion of organic farming, eg, farm size, sunk cost.

In this study, we compile a unique spatial panel data with information on parcel geometry, farm scale, land use, soil quality, biodiversity measures, local landscapes, and neighborhood characteristics. This rich dataset, first, allows us to control key factors missing from the above three studies that could introduce bias. For example, we use the share of land area in organic farming in a parcel's neighborhood (50-meter, 100-meter, and 500-meter buffer) rather than the hectare as compared to Lewis, Barham, and Robinson (2011). Second, we analyze both the duration of organic farming in a cross-sectional model framework and the decision to stay organic in a panel data discrete choice model framework. We hence examine both the choice occasion and the viability of organic sector (both entry and exit).

Our study is at parcel level. To analyze the duration in which a parcel stays in organic production, we carry out a cross-sectional ordered Probit/Logit model of a categorical variable that measures the length or organic farming as well as a Pisson model on the number of year that a parcel is enrolled in organic farming. To model the decision of organic farming in reaction to time varying factors and potential unobserved individual effect, we implement both a panel data Probit/Logit models and panel data linear probability models. The two sets of model return quite similar results that support a strong neighborhood effect. Our results are consistent cross model specifications and subsamples. We find strong evidence that 1), the presence of neighboring organic farm increases the both the likelihood and the duration that a parcel is in organic production, 2) More diversified landscapes and better ecosystem quality promote the uptake of organic farming, 3) parcels sharing longer border with others are less likely to be organic due to risk expose and, 4) biodiversity can promote organic production.

Organic farming program in Sweden

The government support of organic production started from 1989 in Sweden. The main objective is to protect the farmland landscape and develop a sustainable food production, beneficial for biodiversity and environment. The budget has reached 20 million SEK (2,3 million EUR) annually and it accounts about a quarter of the budget for Rural Development (2.37 billion SEK). The organic sector since then has shown a stable and continuous growth path for almost two decades. In 2012, the total area in organic farming is 382,700 hectares, accounting for about 15% of the country's arable land (Statistics Sweden, 2012).

Sweden's national goal on organic farming has exclusive focus on the environmental services that organic agriculture provides. Both certified and non-certified organic production is eligible for subsidies. Farms with an organic certificate from KRAV, a private certification agency run by Swedish Organic Famers association, can market their products as organic and earn both an organic premium and the subsidy. The farms who choose not to acquire a KRAV certificate cannot market their products as organic but can still earn 50% of the organic subsidy as long as they fulfill other organic requirements.

There is a 5-year commitment for farms that are enrolled in organic farming programs. A farmer can renew his contract at the end of a contract term in order to continue on receiving organic payment. Quitting his contract early will require the pay back of the subsidies he received. The first two years is the transition period. During this period, farmers receive full payment (non-certified farmers receive 50% of full payment). The payment to organic production varies by crop, ranging from 41 EUR to 900 EUR per hectare of land.

Since late 1980s, the Swedish government has been ambitious in promoting organic agriculture. In 1994, the Swedish parliament sets a target that 10% of the agricultural land should be organic. This goal is achieved in 1999. In 2000, a new target of 20% was planned for the year of 2005. The target was not reached and is renewed to 2010, which fails again and is now renewed to 2013. The share of organic land has declined since 2005 (16%) while organic payments have been more than doubled (Statistics Sweden, 2012). In 2007, the organic payment increases about 20% and the organic payment level will be reviewed and adjusted every two years in the future.

Economic framework: farmers' decision on organic farming and neighborhood effect

A farmer's decision depends on the net benefits from organic production relative to that from conventional farming. He will participate into organic farming if the net benefits from doing so exceed a threshold level. We use a crop choice and production function model to illustrate the economic decision of farmers for one period and for multiple periods.

Decision for one year: a choice occasion

We assume perfectly competitive markets for agricultural goods, agricultural inputs and land. In addition, we assume that farmers produce crops on land parcels of size 1 and each farmer owns one unit of land. Production for output (crop) $i \in \{1,2,3,\dots,I\}$ is concave in inputs and outputs and hence is well-heaved production function:

$q_i = f_i(l, x, z)$.

l and x are labour input and chemical inputs (fertilizer or pesticide) respectively. The production function also depends on the availability of exogenously given inputs z, which is neighborhood effect (spillover effect, edge effect, spatial scale effect etc.). The input of l and x can vary with output on a given parcel of land, while z is out of the control of farmers as it is the outcome of neighboring farmers' joint action. [3]

For given output price, p_i, the farmer choose input expenditure for crop *i* in the most profitable manner. The profit function of the farmer is:

[3] Note that we ignore fixed costs such as capital input for now. In case of significant structural change, the fixed cost can change. For example, if a crop farm shift to dairy farm, the farmer will have to invest cow and corresponding equipment. Such assumption will not change the basic result of this model, though.

$$\Pi_i(p_i,\omega,c,z) = \max_{l_i,x_i}\{p_i f_i(l_i,x_i,z) - (\omega l_i + c x_i)\} = p_i q_i(p_i,\omega,c,z) - C_i(p_i,\omega,c,z)$$

Assume an interior solution to the maximization problem, the optimal amount of output for crop i is $q_i^*(p_i,\omega,c,z)$ while the profit-maximizing input expenditures is given by $l_i^*(p_i,\omega,c,z)$ and $x_i^*(p_i,\omega,c,z)$. The farmer will choose the crop that yields the highest profit for his parcel,

$$\Pi_{i^*}(p,\omega,c,z) = \max\{\Pi_1(p_1,C_1,z),\Pi_2(p_2,C_2,z),\dots,\Pi_I(p_I,C_I,z)\}$$

Where $p = (p_1,p_2,\dots,p_I)$, and the subscript i^* represents the optimal choice of crop and $i^* \in \{1,2,3,\dots,I\}$.[4] Note that it can happen that farmers choose a portfolio of crops that generate the same profits as a single crop.

Neighborhood characteristics (biodiversity or ecological quality etc.), measured by z, affect crop profits as conditions may become more favorable or less favorable for the current crop choice as z changes. A profit-maximizing farmer will shift to the most profitable input and crop combination. Hence, the z level surrounding a parcel affects the farmer's production expenditure, output level, and in the end the optimal crop choice. For example, the organic hectares in a farm's neighborhood might affect the cost of the farmer in pest control. If surrounding farms are all conventional farms, an organic grower might find it difficult to maintaining the population of beneficial insects on his land and to manage the migration of insects from neighboring areas (Hanson et.al 2004; Parker and Munroe 2007).

An organic farmer has to limit chemical applications below a required level of $\bar{x}_i$, which can lead to more labor input l_i. As a return to reducing chemical applications, he receives a payment for growing organic crop *i*. If the farmer decides to acquires an organic certificate (permanently shift to organic farming), he would also be able to earn a price premium for selling organic products. Denote the organic payment for crop *i* as a_i and price premium as b_i. The profits function for a farmer who participates into organic farming program is:

$$\Pi_i(p_i,\omega,c,z,\bar{x}_i,\mathrm{b}_i,a_i) = \max_{l_i}\{(p_i + \mathrm{b}_i) f_i(l_i,\bar{x}_i,z) - (\omega l_i + c\bar{x}_i) + a_i\}$$
$$= p_i q_i(p_i,\omega,c,z,\bar{x}_i,\mathrm{b}_i,a_i) - C_i(p_i,\omega,c,z,\bar{x}_i,\mathrm{b}_i,a_i)$$

[4] Please note that we focus on economic benefits the farmer can gain from the market. We hence temporally ignore the potential amenity value a farmer can enjoy from the biodiversity or ecosystem quality. This piece of benefits can appear as *E(z)* and the profit (benefit) function is: $\Pi_i(p_i,\omega,c,z) = \max_{l_i,x_i}\{p_i f_i(l_i,x_i,z) - (\omega l_i + c x_i) + E(z)\}$.

The optimal level of output for crop i is: $q_i^{**}(p_i, \omega, c, z, \bar{x}_i, \mathrm{b}_i, a_i)$ while the profit-maximizing input expenditures is given by $l_i^{**}(p_i, \omega, c, z, \bar{x}_i, \mathrm{b}_i, a_i)$. The same as conventional farming, the farmer chooses a crop or crop portfolio to maximize his profits,

$$\Pi_{i^{**}}(p, \omega, c, z, \bar{x}_i, \mathrm{b}_i, a_i) = \max\{\Pi_1(p_1, C_1, z, \bar{x}_i, \mathrm{b}_i, a_i), \Pi_2(p_2, C_2, z, \bar{x}_i, \mathrm{b}_i, a_i), \dots, \Pi_I(p_I, C_I, z, \bar{x}_i, \mathrm{b}_i, a_i)\}$$

Where $p = (p_1, p_2, \dots, p_I)$, and the subscript i^{**} represents the optimal choice of crop and $i^{**} \in \{1,2,3, \dots, I\}$.

The farmer decides whether to enroll his parcel based on the profit from the two scenarios. Denote the decision to enroll his land into organic farming as $\delta \in \{0,1\}$. The farmer's decision is:

$$\delta = \begin{cases} 1 & \text{if } \Pi_{i^{**}}(p, \omega, c, z, \bar{x}_i, \mathrm{b}_i, a_i) \geq \Pi_{i^*}(p, \omega, c, z) \\ 0 & \text{otherwise} \end{cases}$$

Adopt the concept of indirect utility and MacMadden's Random Utility model, the conditional indirect utility from the two options is:

$$U(\Pi_{i^{**}}(p, \omega, c, z, \bar{x}_i, \mathrm{b}_i, a_i), \Pi_{i^*}(p, \omega, c, z))$$

The probability that a farmer chooses $\delta = 1$ is:

$$\mathrm{P}(\delta = 1) = \mathrm{P}(\Pi_{i^{**}}(p, \omega, c, z, \bar{x}_i, \mathrm{b}_i, a_i) \geq \Pi_{i^*}(p, \omega, c, z))$$

The effect of z on the choice of δ depends on its marginal effect on yields, therefore profits. On conventional farms, the effect of environmental quality is subsided with the application of chemical fertilizer, pesticide and herbicide. In organic farms where the applications of chemicals are restricted, the effects of neighboring environment can be more pronounced. Hence, we expect that $\frac{\partial \Pi_{i^{**}}(p, \omega, c, z, \bar{x}_i, \mathrm{b}_i, a_i)}{\partial z} \geq \frac{\partial \Pi_{i^*}(p, \omega, c, z)}{\partial z}$. In addition, the neighborhood effect z can present increasing return to scale or increasing marginal benefits or threshold effect. A farm with more surrounding organic farms has a higher z level and hence can benefit more from the beneficial neighborhood effect, i.e., higher z level.

Note that the choice of crop i is now tied to the choice of δ. Since $\bar{x}_i$ is exogenously given, farmers decide to choose $\bar{x}_i$ or x_i. z is equivalent to some endowment that would affect farmers choice of the bundle $(\bar{x}_i, i^{**})$ and (x_i, i^*).

Decision for multiple years: how long to stay in organic farming?

In Sweden, farmers can choose to convert into organic production permanently (acquire organic certificates). They can also choose to stay in organic production temporarily (for one or several contract terms) for the organic subsidy and preserve the option to choose between the two for the future. Farmers usually sign a 5-year contract but they can withdraw before the contract terms ends conditional on returning organic subsidies that the farmers have received. Such phenomenon begs one question: what affect the duration that a farmer engages in organic production.

Let assume that a farmer stay in organic production for *t* periods in a row and *t* can be infinite or a finite number of years. The profit from organic production is hence $\sum_t \Pi_{i^{**}}(p, \omega, c, z, \bar{x}_i, \mathrm{b}_i, a_i)$. The profit from conventional farming is $\sum_t \Pi_{i^*}(p, \omega, c, z)$. The value of *t* depends on the benefit from the two options. Intuitively, when $\sum_t \Pi_{i^{**}}(p, \omega, c, z, \bar{x}_i, \mathrm{b}_i, a_i) >> \sum_t \Pi_{i^*}(p, \omega, c, z)$, a famer will be more likely to engage in organic farming for longer and possible permanently. When the profit marginal from organic farming as compare to conventional farming is small, a farmer is more likely to enrolment organic farming temporarily and keeps the option open for the future.

Similar to the choice occasion model, the effect of neighboring factor *z* is more pronounced when a farmer chooses organic production as compared to conventional production. Our assumption is hence a higher *z* can increase the duration of organic production.

Study area and Data

We focus on organic farming in Skåne, the leading agricultural area in Sweden. About half of the land in the county is arable and the agricultural land is the most fertile in the country. The yield per hectare of land is higher than in any other regions in Sweden. Skåne also concentrates around half of Sweden's food production and food processing industries. The county is among the most densely populated area and supports about 13% of the population in Sweden on its land that is 3% of the country's territory.

Skåne is doing well in most environmental indictors by Europeans Commission and is the home to several rare species. The county receives approximately 12% of the Swedish budget (SEK 36 billion) for the Rural Development Programs. Given the the combination of Skåne's agriculture and environment and the availability of biodiversity data, we choose this county as our study area.

We examine farmers' decision on enrolling their land into organic farming. The boundary datasets of organic parcels for each year during 2001-2011 are acquired from the Swedish Board of Agriculture (BOA). This data records area and crop that are enrolled in organic farming program. We also acquire from the Swedish BOA the boundary of all farmland and pasture land parcels and their crops information from 1999 to 2011.[5] The agricultural land boundary data are overlaid with the boundary data of organic parcel in order to calculate percent of land enrolled in organic farming program within 50-meter, 100-meter, and 500-meter buffer of a parcel. We also calculate two parcel geometry measures: parcel perimeter per unit of area that is not shared with any other parcels, and shared border per unit area with adjacent parcels.

Furthermore, the agricultural parcel boundary data is overlaid with other spatial data to extract for each parcel the information on local landscapes, biodiversity, and soil quality.

Corine, a land cover data, is downloaded from the European Environment Agency website. It is in raster format and records all land use types covering the entire Sweden for the year of 1990, 2000, and 2006. General land use types include categories such as urban land uses, forest, farm land, pasture, wetland, bare land, and water body. The Corine also contains sub-categories of the general land use types. We calculate for each agricultural land parcel every land use categories within its 50-meter, 100-meter, and 500-buffer. Distance measures of each parcel from its boundary to water, wetland, and urban boundary are also calculated.

Soil quality is approximate by the harvest regions and estimated yields of major crops for each region. A harvest region is delineated by the Swedish BOA at the finest scale such that the soil quality and hence the yields are homogeneous. A harvest region map is overlaid with our land parcel data to identify parcels' harvest region. The information on harvest region and yields are used to yield (opportunity cost) loss due to conversion to organic farming.[6]

[5] This dataset are compiled for the purpose of calculating subsidies to farmers and are updated annually.

[6] The higher the yield under conventional farming method, the higher the yield loss when a parcel is put in organic production. Take spring barley, the most commonly grown crop in Sweden as an example, the yield loss in 2012for the most productive land is 2950 kg/hectare (6410 kg/ha for conventional farm practice and 2460 for

Biodiversity information is extracted from three datasets. The first two are the counts of birds and floral population. These datasets are compiled for a sample of sites surveyed by the ecological research team at Lund University. The sites for bird population is 1km X 1km and for floral population is 2.5 km by 2.5km. The information is stored in digitized maps. Bird data was collected in 1995 and floral data was collected during 1999-2001.[7] The last source of biodiversity data is the Natura 2000, the EU-wide network of nature protection areas established under the 1992 Habitats Directive. The aim of the network is to assure the long-term survival of Europe's most valuable and threatened species and habitats. We use the number of floral species, the number of species that are suitable for traditional agricultural practices, and the percent of land in Natura 2000 to approximate the effect biodiversity.

We build a 10-year parcel level spatial panel data of farmland and pasture land. The parcels are defined by their natural boundary and administrative/ownership boundary. [8] Each parcel is managed by one operator. However, a parcel in early time periods might have multiple crops during a growing season. Change of ownership can happen for some parcels.

We control all factors that affect the net economic benefits from organic production, hence farmers' decision to shift to organic production temporarily or permanently. Table 1 presents the summary statistics of all variables for our cross-sectional sample, and Table 2 present the summary statistics for panel data samples. In our sample, about 12 percent of the land parcels are enrolled in organic farming program at least for one year. About 3 percent of the parcels stay in organic production for at least one contract terms and are still recorded as organic in the year of 2011, while the rest 9 percent have exited organic program at least once. The average duration of organic production is rather short, about 1.7 years. The percent of land in a parcel's 100-meter buffer that is managed by neighboring farmers and is enrolled into organic farming program is not very large either, about 1.3. This may be due to the fact that Scania is the most important agricultural area with most fertile land in the country.

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organic farming. The yield loss is 2330kg/ha and 1410 kg/ha is the even less productive region in Skäne (Statistics Sweden 2012).

[7] Note that the inventory of bird population is recoded for two 1X1 km^2 grids for each 10X10 km^2 of area of farmland.

[8] Since 1999, the Swedish BOA starts to add administrative/ownership boundary to the natural boundary such that each parcel is operated by only one farmer. This process is completed in 2008. So it can happen that one parcel before 2008 is managed by more than one operator. We use the natural boundary in this study and dropped the parcels with multiple operators, i.e., land parcels corresponding to multiple farm identities.

We calculate four sets of neighboring factors that might affect a farmer's decision. These factors are: parcel geometry, biodiversity, local land use, landscape structure or heterogeneity.

Parcel geometries include parcel size, border per unit of area, and border per unit that is and is not shared with any other land parcels. Shared border measures proxy potential disruption from neighboring land if they are in conventional farming. Border that are not shared with any parcels are natural boundaries and can provide a protection from nearby conventional farming or a passage of beneficial insect from nearby grassland or forest land.

We measure biodiversity using percentage of land in protected habitat area, total number of floral species, percentage of floral species that are suitable to tradition farming, and the length of outline or number of point objects, e.g., ponds and trees, receiving Agri-environment payment.

Our local land use measures include the proportion of land uses in several categories. They are: permanent agricultural crops, agricultural pasture land, mixed cultivation agricultural land, agricultural with vegetation, forest, shrub and grass, wetland, and water body.

The landscape structure or heterogeneity is approximated by the percent of lay and pasture land in a parcel's 50-meter, 100-meter, and 500-meter buffer before 2001. The higher the percent of ley and pasture, the higher the potential for biological control for pests and hence lower the cost of organic production.

Beside the above neighboring factors, we also include in our analysis the economic factors including potential yield loss from converting into organic farming and some farm characteristics. The potential yield loss is approximated by the estimated yield for each harvest region in which the soil quality is rather homogeneous. Farm level characteristics include farm scale, parcel size, fragmentation of land a farming enterprise management measured by the number of parcels that farm manages, distance to farm center, diversity of farming production (grain, pasture, tree crops).

Empirical Strategy

We model farmers' decision to adopt organic production in two different ways. First, we analyze the duration that land parcels stay in organic farming. We count for each land parcels the number of time periods it is in organic status as well as whether a parcel is taken out of organic production and enrolled again later. We thus divide our parcels into four groups according to the enrollment timing: never organic (category 0), flip-floppers (parcels being taken in and out of organic production more than once, category 1. It can be farmers' choice but can also due to the conflict between inspection agency, reason unknown), quitters (parcels enrolled into organic production for at least five year but leave organic production eventually, category 2), and always organic (parcels staying in organic since their enrollment, category 3). The intensity of a farmer's involvement into organic production is increasing with the category number: 0, 1, 2, 3.

Model the duration of organic farming

We run an ordered Probit/Logit model for the cross-sectional data (one parcels as one observation). A Poisson model on the maximum number of years a parcel enrolled in organic farming in a row is also implemented to check any possible mis-classification. Our independent variables in this model are time-invariant parcel attributes, farm characteristics, and local spatial characteristics.

Define an underlying latent variable, the net average benefits from organic farming on land parcel i, as Y_i^*, the net benefits is determined by a vector of time invariant variable X_i.

$$Y_i^* = X_i B + v_i$$

v_i is a random error term for individual i that follows a standard normal distribution. Let's assume $Y_i^* \sim N(X_i B, \sigma^2)$. We observe that a farmer chooses one of the four options for a parcel i:

$$\begin{aligned} Y_i &= 0 \text{ if } \quad Y_i^* < \alpha^1 \\ &= 1 \text{ if } \quad \alpha^1 \le Y_i^* < \alpha^2 \\ &= 2 \text{ if } \quad \alpha^2 \le Y_i^* < \alpha^3 \\ &= 3 \text{ if } \quad Y_i^* \ge \alpha^3 \end{aligned}$$

where $\alpha^3 > \alpha^2 > \alpha^1$. It follows, the probably that a parcel always stay in organic farming:

$$\Pr(Y_i = 3) = P\left(\frac{Y_i^* - X_i B}{\sigma} \ge \frac{\alpha^3 - X_i B}{\sigma}\right)$$

$$= F\left(\frac{\alpha^3}{\sigma} - \frac{X_i B}{\sigma}\right)$$

$$= F\left(X_i\frac{B}{\sigma} - \frac{\alpha^3}{\sigma}\right) = F(X_iB_*)$$

Where $B_* = \frac{B}{\sigma}$, $F(\cdot)$ is the density of v_i, and $\frac{\alpha^3}{\sigma}$ goes into constant.

The probability that a parcel fulfills one contract term and leaves organic farming is:

$$\Pr(Y_i = 2) = \Pr(Y_i^* \leq \alpha^3) - \Pr(Y_i^* \leq \alpha^2)$$

$$= 1 - F(X_iB_*) - \left[1 - P\left(\frac{Y_i^* - X_iB}{\sigma} \geq \frac{\alpha^2 - X_iB}{\sigma}\right)\right]$$

$$= 1 - F(X_iB_*) - \left[1 - F\left(X_i\frac{B}{\sigma} - \frac{\alpha^3}{\sigma} + \frac{\alpha^3 - \alpha^2}{\sigma}\right)\right]$$

$$= F\left(X_iB_* + \frac{\alpha^3 - \alpha^2}{\sigma}\right) - F(X_iB_*)$$

Using the similar rules, the probability that we observe a flip-flopper is:

$$\Pr(Y_i = 1) = \Pr(Y_i^* \leq \alpha^2) - \Pr(Y_i^* \leq \alpha^1)$$

$$= F\left(X_iB_* + \frac{\alpha^3 - \alpha^2}{\sigma} + \frac{\alpha^1}{\sigma}\right) - F\left(X_iB_* + \frac{\alpha^3 - \alpha^2}{\sigma}\right)$$

Lastly, the probability that we observe a never organic parcel is:

$$\Pr(Y_i = 0) = 1 - \Pr(Y_i = 1) - \Pr(Y_i = 2) - \Pr(Y_i = 3)$$

Our likelihood function is:

$$\mathrm{L} = \left(\prod_{i\in I_0}\Pr(Y_i = 0)\right)\left(\prod_{i\in I_1}\Pr(Y_i = 1)\right)\left(\prod_{i\in I_2}\Pr(Y_i = 2)\right)\left(\prod_{i\in I_3}\Pr(Y_i = 3)\right)$$

We hence estimate a Maximum likelihood L estimator of $\hat{B}_*$ and $\hat{\sigma}$. This procedure can be estimated using a standard package in Stata software.

Although weI assign the parcels into the four categories careful, there is chance of mis-classification. For example, we assign a parcel in group 3 (always organic) if a parcel was enrolled before 2005 and is still in organic production in 2011. It can happen that a farmer enters organic farming before 2005 and exit in 2013, which is observed in our data. We therefore run a Poisson regression of the number of consecutive years that a parcel stays in organic.

Model the choice occasion: organic farming or conventional farming

In the ordered probit/logit model, we implicitly assume that a farmer knows perfectly what is going to happen in the future. This assumption might not hold. Organic farming might a learning-by-doing process. New information or market shocks can be influential on farmers' decision to stay in organic or not.

The underlying latent variable is the net profit from parcel i in a time period t.

$$Y_{it}^* = X_{it}B + v_i + \epsilon_{it}$$

v_i is an unobserved individual characteristics, eg, farming skill, knowledge etc.. v_i is not or can be corrected with X_{it}. A farmer chooses to keep the land in organic production in period t if the net benefit from organic farming is positive

$$Y_{it} = 1 \text{ if } \quad Y_{it}^* \geq 0$$

and stay in conventional farming otherwise,

$$Y_{it} = 1 \text{ if } \quad Y_{it}^* < 0$$

A maximum likelihood estimator will be estimated using a Guass-hermite quadrature approximation. An integration point of 140 is used in this process. To check the robustness of the estimation, we can carry out a linear probability probit/logit model with a random effect.

Time effects are also included to control for economic and market shocks. In particular, during 2005-2007, the Swedish BOA increased the payments to organic farming, which might boost the uptake of organic during the period. The global food market crisis in 2007-2008 might induce lots of farmer to switch back to conventional forming for more profits. We control for these shocks by both using time dummies and conducting separate regressions for different time periods. To check the robustness of our model specification, we also run all our regressions on randomly selected subsamples.

Results

Table 3 presents the estimation results for our duration models. We estimate both Ordered Probit models and Ordered Logit models. Because the estimated coefficients are similar except the difference in scale, we present only the results from Order Logit model.

The Column (1) and (2) are Ordered Logit regressions for full sample and a balanced sample. Column (3) and Column (4) are the results from Poisson regression for full sample and the balanced sample, respectively. Our results indicate that farmers surrounded by larger share of organic parcels or organic farms are more likely to engage in organic farming and tends to stay longer. This result confirms the finding in Lewis, Barham, and Robinson (2012). Farmers indeed are aware of the spatial economy of scale and/or knowledge spillover.

The area with higher share of land growing pasture and ley, thus higher potential of biological control, can increase the probability that a farmer enroll his land into organic farming and stay longer in organic production. This is not a surprise, given that semi-natural grassland is considered to be a scare and ecologically important land use. Policy support for viable management of the grassland might spillover to organic farming.

The shared border per hectare discourages a parcel to be enrolled in organic farming. The length of a parcel's border that is not shared with any other parcel show a positive impact on adoption of organ farming. This finding is in line with that by Parker and Munroe (2007) that the shape of land parcels affects the organic production due to edge effect externality.

Biodiversity measures all have a positive sign and are statistically significant except the land share in protected habitat area. These results can have two meanings. First, the number of floral species and the share of floral species that are suitable conventional farming can be indications of ecosystem health. The more abundant the floral species, the healthier and more ecosystems services that the local ecosystem can provide. A health ecosystem can reduce the cost of organic farming and improve the agricultural productivity, eg, through pollination. Second, the abundance of floral species might be a result of farmers' effort in protecting the local environment in the past. These variables, therefore, is an indication of farmers' environmental attitude. Farmers, who are more eco-friendly, are more likely to engage their land in long-term organic production.

The local land use in pasture, mixed crop, and forest seems to be beneficial to organic farming, which is not a surprise for pasture land. Mixed crop might be an eco-friendly practice which increase agro-biodiversity and reduce pest population through rotation. The story might be quite different for forest land. The presence of higher share of forest land use can be an indication of lower soil quality and lower opportunity cost of converting land into organic.

Our parcel attribute such as area and estimated yield have a negative sign. The average yield is statistically significant at 10% level even after we control for harvest region fixed effects. This confirms the findings from Uematsu and Mishra (2012) that income incentive is an important factor that will affect the uptake of organic farming. Our regression results show weak evidences that farmers will convert the small parcels and leave large parcels to conventional farming. We also find that large farm tend not to engage in organic production, while farms with fragmented land parcels and that are more diversified are more likely to adopt organic production. Famers tend to enroll the parcels that are further away from his house into organic farming program but leave the one close by to his house for conventional farming, which in somehow in line with the estimated coefficient for yields.

Our regression results for sub-sample of our data return very similar results as that for our full sample. Table 4 presents our panel data models for linear probability model and Table 5 for panel data random effect Logit models. The column (1)-(4) are for full sample with regression (4) controls for policy shock during 2005-2007 and global food market shock during 2007-2008.

After controlling for unobserved individual parcel effect, the results are no very different from our results in cross-sectional analysis. A parcel with larger share of organic land in its immediate neighborhood has a higher probability to be enrolled into organic farming program by its operator. The share of neighboring land in 100-meter buffer as ley and pasture is also positively corrected to the propensity that a parcel is engaged into organic production in a year. The biodiversity measures remain positive and significant. The same applied to the border measures and local land use characteristics.

Conclusion and discussions

We investigate farmers' decision to engage in organic production. Our objective is to identify the key factors that promote or hinder the update of organic farming. In particular, we focus on neighborhood factors and hence the spatial allocation of organic land parcels. A rich spatial panel data of all agricultural parcels is compiled and the information on land use, soil quality, biodiversity, local landscapes, and neighborhood characteristics are calculated using ArcGIS techniques.

We carry out both cross-sectional analyses and panel data models in this study. In the cross – sectional analysis, we focus on the duration that a parcel stays in organic production: to temporarily enroll into organic farming program for subsidy or to convert to organic production permanently. In the panel data model, we analyze whether a parcel stays in organic production in a period by assuming there is or there is no temporary correlation.

We find that neighborhood characteristics have significant effects on farmers' decision. The effects manifest in the following four areas: 1) a farm with a higher share of organic land in its adjacent neighborhood is more likely to be organic temporarily or permanently; 2) a neighborhood with a higher share of ley and grass land, hence, a higher potential for biological control, can promote conversion to organic production; 3) a parcel with a larger shared border per unit area with other parcels are less likely to be engaged in organic production; and 4), a neighborhood with abundant floral species and more floral spices that are suitable to traditional agricultural production has more parcels being converted to organic production.[9]

Our findings are hence in favor of the policy suggestions on agglomeration payments in biodiversity conservation. The idea is to pay an extra fee or reduce the administrative costs to encourage farmers whose neighbors are organic to convert to organic production. Such policy can increase the contiguity of organic land (agglomeration), especially in the area where majority of parcels share borders. Indeed, contiguity has been highly valued in habitat conservation. Theoretical evidence shows that when preserving wildlife habitat, corner solutions, preserving all or none of the land as forest habitat, can lead to substantial welfare gain over spatially uniform incentive (Lewis, Plantinga, and Wu 2009). Habitat fragmentation is considered to be the key pressure on biodiversity loss and climate change (Opdam and Wascher 2003). To achieve contiguity of conserved land, government or land conservation agency can offer agglomeration bonus to motivate neighboring landowners taking joint action (Parkhurst and Shogren 2007; Parkhurst et. al. 2002, Fooks, et al 2013).

Our results also suggest that policies that target area with more desirable land uses or encourage such land uses can potentially reduce negative neighborhood effects and promote organic production. For example, the chance that a parcel is in organic production increases with proportion of pasture land and crop diversity in the parcel's neighborhood. This is an indication that the current policies that conserve the semi-natural pasture land can benefit organic farming program, which is a positive spillover effect cross different conservation programs. The Agri-environment schemes that encourage crop diversity seems to show the similar positive spillover effect.

[9] This might be an indication that farmers in the neighborhoods with richer floral species have the intention to protect environment. Hence these measures are actually indications of farmers' attitude towards environment.

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Table 1: Summary statistics for cross-sectional data Full sample (N=69,689)

Variable	Mean	Std.Dev.
Categorical duration variabler	0.27	0.77
never organic	0,88	
enter and exit organic farming program more than once	0.006	
stay organic for at least five years and leave	0,086	
stay organic for at least five years and is still organic in 2011	0,03	
Number of years that a parcel is enrolled in organic farming in a row	1.73	2.21
Parcel area (Ha)	4.54	8.00
Land area that an operator manages (1,000 Ha.)	0.148	0.234
Number of plots an enterprise manages	26.8	21.46
% 100-meter buffer enrolled in organic farming by other operators	0.013	0.055
Distance to farm center (km)	0,440	2
% land in 100-meter buffer ring as ley or pasture during 1999-2000	0.343	0.233
% land in protected habitat area	0.019	0.124
Total number floral species in a parcel's neighborhood	345	172
Percent of floral species suitable to traditional farming	0.466	0.214
The length of outlines receiving payment from Agricultural Environmental Schemes (AES), large number indicates high diversity	0.0069	0.008
Number of point objects receiving AES payments	11.82	27.41
Border per area that are not shared with neighboring plot	0.00032	0.00024
Shared border per ha	0.092	0.122
Distance to urban center (km)	2.27	1.61
% 100-meter buffer that are permanent agricultural crops	0.001	0.025
% 100-meter buffer that are agricultural pasture land	0.075	0.208
% 100-meter buffer that is mixed cultivation agricultural land	0.0063	0.06
% 100-meter buffer that agricultural but with significant areas of natural vegetation	0.046	0.169
% 100-meter buffer that are forests	0.252	0.365
% 100-meter buffer that are shrubs and grass	0.0092	0.071
% 100-meter buffer that are wetland	0.0017	0.029
% 100-meter buffer that is water	0.002	0.0341
Average yields of Spring Barley during 2001-2011 (Ton/Ha)	4.7	1.033
`=1 if a farm focus on grain production	0.776	0.417
`=1 if a farm focusing on pasture and animal husbandry	0.24	0.429
`=1 if a farmer defined as biodiversity important area	0.0007	0.026
`=1 if farm focus on tree crops and agricultural forest	0.0017	0.041
Number of activities that a farm engages during 2001-2011: grain production, pasture, tree crops, or biodiversity zone	1.097	0.300

Table 2: Summary statistics for panel data for panel data

	Pooled		Organic parcel		Conventional parcels	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
=1 organic, =0 otherwise	0.071	0.256				
Plot area (Ha)	4.603	8.167	3.27	5.77	4.70	8.314
Land area that an operator manages (1,000 Ha.)	0.156	0.241	0.148	0.2631	0.156	.2388
Number of plots an enterprise manages	28.98	25.25	36.66	29.81	28.4	24.77
% 100-meter buffer enrolled in organic farming by other operators	0.0163	0.063	0.035	0.094	0.015	0.0595
Distance to farm center (km)	0,41	1,56	0,497	1,704	0,4	1,541
% land in 100-meter buffer ring as ley or pasture during 1999-2000	0.35	0.231	0.405	0.222	0.34	0.231
% land in protected habitat area	0.019	0.12	0.015	0.112	0.019	0.12
Total number floral species in the neighborhood	345	171.8	347	171.4	345	172
Percent of floral species suitable to traditional farming	0.466	0.214	0.4750	0.206	0.465	0.215
The length of outlines receiving payment from Agricultural Environmental Schemes (AES), large number indicates high diversity	0.0069	0.008	0.007	0.008	0.007	0.008
Number of point objects receiving AES payments	11.8	27.4	16.58	35.8	11.48	26.65
Border per area that are not shared with neighboring plot	0.322	0.269	0.355	0.261	0.32	0.27
Shared border per ha	0.094	0.138	0.091	0.153	0.095	0.136
Distance to urban center (1,000 km)	2.26	1.604	2.486	1.622	2.24	1.601
% 100-meter buffer that are permanent agricultural crops	0.001	0.024	0.0012	0.028	0.001	0.024
% 100-meter buffer that are agricultural pasture land	0.076	0.209	0.086	0.225	.0754	0.208
% 100-meter buffer that is mixed cultivation agricultural land	0.0064	0.062	0.0064	0.061	0.0064	0.062
% 100-meter buffer that is agricultural but with significant areas of natural vegetation	0.0461	0.169	0.051	0.178	0.0456	0.164
% 100-meter buffer that are forests	0.251	0.36	0.3446	0.394	0.24	0.360
% 100-meter buffer that are shrubs and grass	0.0067	0.060	0.008	0.0676	0.0066	0.0596
% 100-meter buffer that is wetland	0.002	0.03	0.001	0.0232	0.002	0.030
% 100-meter buffer that is water	0.0025	0.034	0.0024	0.031	0.0025	0.034
Yield of barley (Ton/Ha)*	4.75	1.05	4.27	1.01	4.78	1.04
=1 if a farm focus on grain production	0.78	0.413	0.993	0.08	0.765	0.424
=1 if a farm focusing on pasture and animal husbandry	0.24	0.43	0.033	0.1792	0.253	0.435
=1 if a farmer defined as biodiversity important area	0.0007	0.026	0.001	0.033	0.0006	0.0253
=1 if farm focus on tree crops and agricultural forest	0.0016	0.040	0.001	0.031	0.002	0.041
Number of activities a farm take during 2001-2011:grain production, pasture, tree crops, or biodiversity zone	1.096	0.30	1.136	0.352	1.093	0.294

Table 3: Estimation results on the duration organic production (Dependent variable: =0 never organic, =1 enter and leave organic farming more than once ,=3 leave organic farming after 5 years, =3 stay in organic for at least 5 years and is still organic in 2011)

	Ordered Logit Model		Poisson model		Logit model	
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variablers	Full sample (N=69,689)	Balanced panel (N=59,045)	Full sample (N=69,689)	Balanced panel (N=59,045)	Subsample 1 (N=35,006)	subsample 1 (N=31,946)
Plot area (Ha)	-0.0068*	-0.0071	-0.0053***	-0.0064***	-0.0048	-0.0068
	(0,00408)	(0,00429)	(0,00157)	(0,00162)	(0,00558)	(0,00582)
Plot area squared	6.32e-05	6.86e-05	4.24e-05*	5.63e-05**	8.01e-05	9.33e-05
	(5.51e-05)	(5.69e-05)	(2.24e-05)	(2.26e-05)	(7.10e-05)	(7.43e-05)
Land area that an operator manages squared (1,000 Ha.)	-0.785***	-0.614***	-0.461***	-0.346***	-0.759***	-0.560**
	(0,147)	(0,159)	(0,0522)	(0,0564)	(0.210)	(0.220)
Land area that a operator manages squared	0.139**	0,0530	0.0681***	-0.00812	0,125	0.0239
	(0,0603)	(0,0729)	(0,0216)	(0.0268)	(0,0860)	(0.103)
Number of plots an enterprise manages	0.00800***	0.00774***	0.00789***	0.00774***	0.00731***	0.00711***
	(0.000734)	(0.000792)	(0.000250)	(0,000267)	(0.00104)	(0.00109)
% 100-meter buffer enrolled in organic farming by other operators	2.868***	2.669***	2.205***	2.100***	3.035***	2.993***
	(0.177)	(0.195)	(0.0564)	(0.0608)	(0.248)	(0.260)
Distance to farm center (km)	0,591***	0.00604***	0.00301***	0.00308***	0,774***	0,742***
	(0.00118)	(0.00136)	(0.000446)	(0.000504)	(0.00169)	(0.00179)
% land in 100-meter buffer as ley or pasture during 1999-2000	1.321***	1.448***	1.209***	1.264***	1.300***	1.376***
	(0.0647)	(0.0713)	(0.0233)	(0.0254)	(0.0914)	(0.0968)
Percent of land that is protected natural habitat area	0.0388	-0.0186	0.0305	-0.0111	0.0477	-0.0526
	(0.117)	(0.126)	(0.0418)	(0.0445)	(0.166)	(0.176)
Total number floral species in the neighborhood	0.000744***	0.000714***	0.000707***	0.000663***	0.000741***	0.000805***
	(0.000135)	(0.000147)	(5.01e-05)	(5.38e-05)	(0.000191)	(0.000200)
% floral species suitable to traditional farming	0.309***	0.279**	0.313***	0.269***	0.271*	0.361**
	(0.104)	(0.113)	(0.0388)	(0.0417)	(0.148)	(0.154)
Number of point objects receiving AES payments	0.00215***	0.00223***	0.00140***	0.00149***	0.00143**	0.00105*
	(0.000431)	(0.000470)	(0.000150)	(0.000162)	(0.000598)	(0.000631)
Border per area that are not shared with neighboring plot (meter/ha)	286.7***	0.347***	166.6***	0.214***	308.5***	339.2***
	(62.57)	(0.0725)	(23.35)	(0.0261)	(87.23)	(96.04)
Shared border per area (meter/ha)	-0.595***	-0.705***	-0.587***	-0.689***	-0.250	-0.309*
	(0.123)	(0.139)	(0.0456)	(0.0504)	(0.168)	(0.180)
% 100-meter buffer: permanent ag. crops	0.805	1.067*	1.023***	1.217***	0.114	0.0583

	(0.505)	(0.620)	(0.163)	(0.195)	(0.912)	(1.182)
% 100-meter buffer: ag. pasture	0.409***	0.439***	0.370***	0.390***	0.528***	0.513***
	(0.0618)	(0.0660)	(0.0214)	(0.0225)	(0.0864)	(0.0897)
% 100-meter buffer: mixed cultivation agricultural land	0.586***	0.735***	0.740***	0.841***	0.717**	0.812***
	(0.213)	(0.222)	(0.0699)	(0.0716)	(0.308)	(0.312)
% 100-meter buffer: agricultural but with significant areas of natural vegetation	0.339***	0.367***	0.257***	0.269***	0.482***	0.533***
	(0.0721)	(0.0769)	(0.0262)	(0.0275)	(0.102)	(0.105)
% 100-meter buffer: forests	0.582***	0.585***	0.482***	0.472***	0.672***	0.674***
	(0.0430)	(0.0468)	(0.0155)	(0.0166)	(0.0611)	(0.0638)
Average yields of Spring barley in 2001-2011 (Ton/Ha)	-1.006**	-2.260*	-1.782***	-1.162***	-1.031*	-2.852**
	(0.405)	(1.203)	(0.145)	(0.348)	(0.611)	(1.182)
`=1 if a farm focus on grain production	2.761***	2.992***	3.098***	3.411***	2.679***	2.796***
	(0.116)	(0.139)	(0.0585)	(0.0719)	(0.157)	(0.172)
`=1 if a farm focusing on pasture and animal husbandry	-0.758***	-0.663***	-0.786***	-0.699***	-0.775***	-0.737***
	(0.0746)	(0.0856)	(0.0295)	(0.0330)	(0.104)	(0.110)
Number of activities a farm engages in 2001-2011:grain production, pasture, tree crops, or biodiversity zone	0.567***	0.608***	0.436***	0.459***	0.624***	0.656***
	(0.0413)	(0.0449)	(0.0142)	(0.0152)	(0.0578)	(0.0601)

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Probit model return very similar results except a different magnitude.

A set of dummy variables indicating the 18 harvest region are not reported in this table.

Subsample 1: randomly selected half of the farms to check robustness of the regression results

Table 4: Estimation results from panel data linear probability model(Dependent variable: organic=1 if a parcel is enrolled in organic farming program, 0 otherwise

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variables	Full sample	Balanced panel	Balanced panel	Balanced panel	Sub-sample (2001-2004)	Sub-sample (2005-2007)	Sub-sample (2007-2008)	Sub-sample (2009-2011)
Dummy:=1 if in year 2005-2007				0.026***				
				(0.0005)				
Dummy:=1 if in year 2007-2008				-0.008***		-0.03***	0.13***	
				(0.0005)		(0.0006)	(0.013)	
Plot area (Ha)	-0.0009***	-0.00074***	-0.0008***	-0.0008***	-0.0004	-0.0007***	-0.0004**	-6.57e-05
	(0.0002)	(0.00018)	(0.00015)	(0.00015)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Plot area squared (Ha)	6.2e-06***	5.2e-06**	4.5e-06***	4.7e-06***	4.5e-06*	5.9e-06**	2.88e-06	9.61e-08
	(1.94e-06)	(2.07e-06)	(1.63e-06)	(1.63e-06)	(2.65e-06)	(2.57e-06)	(2.32e-06)	(1.91e-06)
Land area that an operator manages (1,000 Ha.)	-0.028***	-0.023***	-0.0051	-0.0097**	-0.076***	-0.096***	-0.09***	-0.057***
	(0.0049)	(0.0052)	(0.004)	(0.0044)	(0.0081)	(0.0082)	(0.008)	(0.0076)
Land area that an operator manages squared	0.006***	0.0053**	-0.0018	-6. 9e-05	0.028***	0.037***	0.037***	0.014***
	(0.002)	(0.0024)	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.0037)
Number of plots an enterprise manages	0.0006***	0.0006***	0.0005***	0.0006***	0.0006***	0.0009***	0.0008***	0.0007***
	(2.67e-05)	(2.86e-05)	(2.29e-05)	(2.29e-05)	(4.2e-05)	(4.45e-05)	(4.31e-05)	(3.50e-05)
% 100m buffer enrolled in organic farming program by other operators	0.129***	0.124***	0.136***	0.121***	0.100***	0.124***	0.0311***	0.0286***
	(0.00536)	(0.0058)	(0.0048)	(0.00478)	(0.00831)	(0.00854)	(0.00830)	(0.00728)
Distance to farm center (km)	0.00021**	0.00019*	0.00023***	0.00022***	0.0002**	0.0002*	0.0002*	0.0003***
	(8.50e-05)	(0.00010)	(7.97e-05)	(7.9e-05)	(0.0001)	(9.7e-05)	(8.8e-05)	(8.4e-05)
Distance to farm center squared (km)	-3.2e-08**	-3.00e-08*	-3.5e-08***	-3.4e-08***	-3.7e-08**	-2.9e-08*	-2.6e-08*	-4.3e-08***
	(1.33e-08)	(1.61e-08)	(1.25e-08)	(1.25e-08)	(1.64e-08)	(1.52e-08)	(1.38e-08)	(1.32e-08)
% 100-meter buffer ring as ley or pasture during 1999-2000	0.085***	0.101***	0.08***	0.081***	0.096***	0.092***	0.068***	0.060***
	(0.0039)	(0.0046)	(0.0037)	(0.0037)	(0.0049)	(0.0045)	(0.004)	(0.0039)
% land that is in protected habitat area	-0.0007	-0.0036	5.5e-05	3.6e-05	-0.0051	0.008	0.0031	0.0023
	(0.0068)	(0.0076)	(0.0064)	(0.0064)	(0.0083)	(0.0078)	(0.0071)	(0.0067)
Total number floral species in a parcel’s neighborhood	2.8e-05***	2.8e-05***	3.4e-05***	3.3e-05***	4.7e-05***	1.7e-05*	8.3e-06	4.0e-05***
	(8.30e-06)	(9.15e-06)	(7.73e-06)	(7.73e-06)	(1.00e-05)	(9.48e-06)	(8.58e-06)	(8.15e-06)

% floral species suitable to traditional farming	0.004	0.0035	0.009	0.0089	0.009	-0.0006	0.0019	0.025***
	(0.0067)	(0.007)	(0.0059)	(0.0059)	(0.0077)	(0.007)	(0.00676)	(0.0063)
The length of outlines receiving payment from Agricultural Environmental Schemes (AES), large number indicates high diversity	-0.353***	-0.343**	-0.246**	-0.242**	-0.447***	-0.485***	-0.141	0.0775
	(0.125)	(0.136)	(0.117)	(0.117)	(0.149)	(0.143)	(0.129)	(0.123)
Number of point objects receiving AES payments	0.00027***	0.00028***	0.00023***	0.00023***	0.00041***	0.0003***	6.9e-05**	-1.9e-05
	(3.38e-05)	(3.76e-05)	(3.16e-05)	(3.16e-05)	(4.05e-05)	(3.86e-05)	(3.49e-05)	(3.32e-05)
Border per area that are not shared with neighboring plot	-0.0010	-0.0017	-0.0060***	-0.0046**	0.027***	0.020***	0.0005	-0.00048
	(0.0024)	(0.0027)	(0.0018)	(0.0018)	(0.0045)	(0.004)	(0.0036)	(0.0023)
Shared border per hectare	-0.025***	-0.028***	-0.019***	-0.017***	-0.0098	-0.013*	-0.021***	-0.013***
	(0.0051)	(0.0056)	(0.0038)	(0.0037)	(0.0073)	(0.0076)	(0.0066)	(0.0042)
Distance to urban center (km)	-0.00242	-0.00392**	-0.00227	-0.00283*	0.00529**	-0.00144	-0.000958	0.00264
	(0.0018)	(0.0020)	(0.0017)	(0.0017)	(0.0024)	(0.002)	(0.0020)	(0.0019)
Distance to urban center squared (km)	0.0003	0.0006*	0.00034	0.00038	-0.0017***	-6.7e-05	5.4e-06	-0.0007**
	(0.00034)	(0.00037)	(0.00032)	(0.00032)	(0.00043)	(0.00039)	(0.0004)	(0.0004)
% 100-meter buffer: permanent agricultural crops	0.078**	0.097**	0.076**	0.076**	0.10**	0.082**	0.068**	0.06*
	(0.033)	(0.041)	(0.030)	(0.030)	(0.042)	(0.037)	(0.033)	(0.032)
% 100-meter buffer: agricultural pasture land	0.033***	0.035***	0.028***	0.028***	0.04***	0.041***	0.032***	0.020***
	(0.00391)	(0.00435)	(0.00366)	(0.00366)	(0.00501)	(0.00455)	(0.00424)	(0.00403)
% 100-meter buffer: mixed cultivation agricultural land	0.033***	0.041***	0.034***	0.035***	0.062***	0.038***	0.037***	0.040***
	(0.012)	(0.014)	(0.012)	(0.012)	(0.016)	(0.014)	(0.014)	(0.013)
% 100-meter buffer: agricultural with significant areas of natural vegetation	0.015***	0.017***	0.014***	0.014***	0.018***	0.024***	0.015***	0.012**
	(0.0049)	(0.0055)	(0.0046)	(0.0046)	(0.006)	(0.0057)	(0.005)	(0.0049)
% 100-meter buffer: forests	0.041***	0.045***	0.0377***	0.037***	0.053***	0.045***	0.023***	0.013***
	(0.00295)	(0.00331)	(0.00275)	(0.00275)	(0.00365)	(0.00340)	(0.00311)	(0.003)
% 100-meter buffer: shrubs and grass	0.0819***	0.0893***	0.0877***	0.0821***	0.0315**	0.0449***	0.00120	0.0312**
	(0.00701)	(0.00769)	(0.00672)	(0.00671)	(0.0137)	(0.00956)	(0.0158)	(0.0151)
% 100-meter buffer: wetland	0.0149	0.0150	0.00438	0.00666	0.0119	-0.000631	-0.00189	-0.00852
	(0.0233)	(0.0268)	(0.0218)	(0.0218)	(0.0340)	(0.0282)	(0.0276)	(0.0263)
% 100-meter buffer: water	0.0226	0.0116	0.0257	0.0261	-0.00658	0.0324	0.0428*	0.0424*
	(0.0228)	(0.0261)	(0.0213)	(0.0213)	(0.0291)	(0.0268)	(0.0246)	(0.0235)
yields of Spring barley (Ton/Ha)	-0.0158***	-0.0131***			0.0631***	0.0099	-0.044***	
	(0.0013)	(0.0013)			(0.0019)	(0.0062)	(0.0036)	
=1 if a farm focus on grain production	0.0572***	0.0682***	0.046***	0.046***	0.095***	0.068***	0.0058	-0.00028

	(0.0053)	(0.0066)	(0.005)	(0.005)	(0.0064)	(0.0061)	(0.0055)	(0.0052)
=1 if a farm focusing on pasture and animal husbandry	-0.061***	-0.056***	-0.065***	-0.0647***	-0.034***	-0.066***	-0.089***	-0.084***
	(0.0052)	(0.0064)	(0.0048)	(0.0048)	(0.0063)	(0.0059)	(0.0054)	(0.0051)
=1 if a farmer defined as biodiversity important area	0.0102	0.000110	0.009	0.0082	0.0107	0.0204	-0.015	-0.015
	(0.031)	(0.0362)	(0.0293)	(0.0293)	(0.0367)	(0.0355)	(0.0320)	(0.0306)
=1 if farm focus on tree crops and agricultural forest	-0.024	-0.0236	-0.034*	-0.0341*	0.011	-0.0139	-0.057***	-0.080***
	(0.02)	(0.025)	(0.019)	(0.019)	(0.024)	(0.023)	(0.021)	(0.020)
Number of activities a farm engage for 2001-2011:grain production, pasture, tree crops, or biodiversity zone	0.035***	0.040***	0.035***	0.035***	0.042***	0.035***	0.031***	0.031***
	(0.0030)	(0.0034)	(0.0028)	(0.0028)	(0.0036)	(0.0034)	(0.0031)	(0.003)
Constant	0.0456***	0.0102	0.00506	0.000428	-0.211***	-0.0169		-0.000234
	(0.00966)	(0.0111)	(0.00845)	(0.00845)	(0.0123)	(0.0189)		(0.00897)
Observations	542,536	472,100	675,380	675,380	196,088	207,793	138,514	202,207
R-squared								
Number of parcels	69,753	59,073	69,768	69,768	67,070	69,632	69,583	69,749

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5:Penal data Logit/Probit model (dependent variable:=1 if a parcel is enrolled in organic farming, =0 otherwise)

VARIABLES	(1) Random effect Logit	lnsig2u	(2) Random effect Logit	lnsig2u
Dummy:=1 if in year 2005-2007	1.083***		1.145***	
	(0.0270)		(0.0223)	
Dummy:=1 if in year 2007-2008	-0.690***		-0.384***	
	(0.0344)		(0.0278)	
Plot area (Ha)	-0.0644***		-0.0525***	
	(0.0131)		(0.00772)	
Plot area squared (Ha)	0.000428***		0.000351**	
	(0.000107)		(0.000153)	
Land area that an operator manages (1,000 Ha.)	-0.490		0.609*	
	(0.492)		(0.367)	
Land area that an operator manages squared	0.383*		-0.171	
	(0.221)		(0.178)	
Number of plots an enterprise manages	0.0190***		0.0136***	
	(0.00224)		(0.00153)	
% 100m buffer enrolled in organic farming program by other operators	2.220***		2.205***	
	(0.286)		(0.227)	
Distance to farm center (km)	0.0123***		0.0100***	
	(0.00436)		(0.00181)	
Distance to farm center squared (km)	-1.92e-06***		-1.56e-06***	
	(6.85e-07)		(2.84e-07)	
% 100-meter buffer ring as ley or pasture during 1999-2000	5.319***		3.651***	
	(0.259)		(0.173)	
% land that is in protected habitat area	-0.147		-0.104	
	(0.457)		(0.182)	
Total number floral species in a parcel’s neighborhood	0.00192***		0.00186***	
	(0.000508)		(0.000264)	
% floral species suitable to traditional farming	0.465		0.684***	
	(0.396)		(0.181)	
The length of outlines receiving payment from Agricultural Environmental	-11.91		-3.282	

Schemes (AES), large number indicates high diversity		
	(7.570)	(3.284)
Number of point objects receiving AES payments	0.00975***	0.00691***
	(0.00161)	(0.000859)
Border per area that are not shared with neighboring plot	-0.128	-0.551***
	(0.192)	(0.119)
Shared border per hectare	-2.616***	-2.192***
	(0.693)	(0.342)
Distance to urban center (km)	-0.203	-0.0784
	(0.127)	(0.0593)
Distance to urban center squared (km)	0.0273	0.00791
	(0.0233)	(0.0106)
% 100-meter buffer: permanent agricultural crops	5.127***	2.861***
	(1.968)	(0.738)
% 100-meter buffer: agricultural pasture land	1.350***	0.782***
	(0.244)	(0.103)
% 100-meter buffer: mixed cultivation agricultural land	1.134	1.048*
	(0.880)	(0.606)
% 100-meter buffer: agricultural with significant areas of natural vegetation	0.699**	0.504***
	(0.296)	(0.110)
% 100-meter buffer: forests	2.182***	1.243***
	(0.169)	(0.0852)
% 100-meter buffer: shrubs and grass	4.447***	2.949***
	(0.499)	(0.437)
% 100-meter buffer: wetland	0.779	3.722***
	(1.391)	(0.939)
% 100-meter buffer: water	0.700	0.907*
	(1.485)	(0.489)
yields of Spring barley (Ton/Ha)	-0.676***	
	(0.109)	
=1 if a farm focus on grain production	8.898***	7.687***
	(0.471)	(0.240)
=1 if a farm focusing on pasture and animal husbandry	-3.436***	-2.459***
	(0.332)	(0.143)
=1 if a farmer defined as biodiversity important area	1.779	1.237

	(1.879)		(1.101)	
=1 if farm focus on tree crops and agricultural forest	-0.450		-0.817	
	(1.491)		(0.611)	
Number of activities a farm engage for 2001-2011:grain production, pasture, tree crops, or biodiversity zone	2.324***		1.703***	
	(0.172)		(0.0843)	
Constant	-20.26***	3.911***	-18.54***	3.503***
	(0.677)	(0.0211)	(0.322)	(0.0340)
Observations	542,536	542,536	675,380	675,38
Number of parcels	69,753	69,753	69,768	69,768

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1