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Crop biodiversity repercussions of subsidized organic farming

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A B S T R A C T

This paper analyses the impact that the CAP financial support on selected organic crops has on agrobiodiversity under production uncertainty. A stochastic production function is employed and estimated to assess whether risk-averse farmers hedge risk by diversifying their portfolio of crops. The model is applied to farm-level data of organic crop farms in Greece. Organic farming financial support, in the form of agricultural subsidies for the cultivation of organic crops, poses a double-edged sword: on one side, organic farming is considered an agrobiodiversity enhancing cultivation method; on the other side, financial support may reduce agrobiodiversity if farmers decide it is optimal to cultivate only the few, supported crops. The study shows that risk aversion leads to agrobiodiversity conservation. However, the existence of CAP financial support on selected crops decreases the relationship between revenue risk management and agrobiodiversity, indirectly leading to agrobiodiversity loss.

Introduction

Agricultural biodiversity, or agrobiodiversity, is a sub-set of biodiversity that includes all forms of life directly relevant to agriculture, and can exist both within a farm and across farms. Ecologists have argued that at farm level, an increase in on-farm species richness and a diversity of overlapping groups of species enhances the level of agricultural biodiversity. This, in turn, increases ecological stability and crop resilience (Tilman et al., 1996). Crop biodiversity, the cultivation of a multitude of crops at the farm level, is an element of agricultural biodiversity, and creates differentiations in soil fauna, weeds, pests, and predators at the farm level. More importantly, crop biodiversity has been reported to increase agricultural productivity through the replenishment of agricultural soils and control of pest infestations, leading to greater farm income security and stability (Asrat et al., 2010; Di Falco et al., 2010; Di Falco and Perrings, 2005).

Decisions regarding the degree of farm level agrobiodiversity, usually depend on conditions in the relevant food, fuel and fiber markets (Smale et al., 2001). However, there are often market failures due to the existence of externalities and the public-good nature of biodiversity conservation. In addition to market signals, farmers' agrobiodiversity choices reflect a number of factors aside from market prices, including the social, political, and cultural conditions in which they operate. They are generally exogenous to the farmers' own decisions (Lambin et al., 2001), but are strongly influenced by policy at the national and international level. More specifically, institutional failures can cause changes in farm level agrobiodiversity.

One clear example of institutional failure lies in the perverse agricultural production subsidies, tax breaks and price controls that not only make a biodiversity-based agriculture uncompetitive, but that have systematically distorted farm-level decisions in both developed and developing countries for decades (Tilman et al., 2002). To illustrate the point, at the beginning of the century subsidies paid to the agricultural sectors of OECD countries averaged about one third the global value of agricultural products (over US$ 324 billion annually) (Pearce, 1999), creating significant distortions to market signals.

The European Union (EU) has designed and implemented through the years a number of agri-environmental policies aimed at protecting, among other things, agricultural biodiversity (Hodge, 2000). One such implemented policy was the promotion of organic agriculture. Organic agriculture, based on living ecological systems and cycles, works with them, emulates them and helps sustain them (Birol et al., 2006; Jackson et al., 2007). Organic farming practices are proven to increase biodiversity by an average of thirty percent (Bengtsson et al., 2005). Modern organic farm practices such as the removal of pesticides and the inclusion of animal manure, crop rotation, and multi-cultural crops provides the chance for biodiversity to thrive. Thus, organic agriculture also causes increased crop biodiversity (Smukler et al., 2008). However, when organic agriculture is subsidized, it can potentially become a double-edged sword in terms of crop biodiversity: on one side, it can be agrobiodiversity enhancing, while on the other it can reduce agrobiodiversity, if farmers choose to cultivate the few crops that

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are subsidized. Which of the two effects prevail are an empirical question and the aim of the present study. It should be noted that biodiversity in general might increase in both cases, even if crop biodiversity is reduced, due to organic cultivation. However, this question cannot be addressed with the existing dataset and, to the best of our knowledge, has not been addressed in the literature. The EU's Common Agricultural Policy (CAP) has provided financial support for the adoption of organic farming, which has provided a clear incentive for the increase of land cultivated organically with the most supported crops, potentially leading to a reduction in crop biodiversity. Farmers, may decide in order to manage risk that it is preferable to cultivate the most supported crop instead of maintaining crop biodiversity, therefore delinking crop biodiversity from risk management (Di Falco and Perrings, 2005). Furthermore, on-farm agrobiodiversity can be viewed as sustainable only if it enables farmers to stabilize and enhance agricultural income (Conway, 1993), posing potential conflicts between CAP financial support on organic crops and sustainable agricultural development.

By eliminating options toward productive diversification, a reduction in agrobiodiversity may also lock farmers into obsolete agricultural technologies (Perrings, 1998). In addition, loss of agricultural biodiversity has been linked to reduced long-term food security (Isakson, 2011). Therefore, maintaining a wider variety of technological and natural resource-based options in agricultural systems will likely maintain and enhance the capacity to respond to short-run shocks and stresses in constructive and creative ways.

A number of recent studies have analyzed the contribution of crop agrobiodiversity to the mean and variance of agricultural yields and farm income (Birol et al., 2006; Di Falco and Perrings, 2003, 2005; Schlapfer et al., 2002; Smale et al., 1998; Widawsky and Rozelle, 1998). These papers found that market integration, agroecological conditions, the adoption of high yielding varieties and farmers' risk aversion was significant determining factor of crop biodiversity conservation. Di Falco and Perrings (2005) were the first, and to the best of our knowledge, the only, to analyze the impact of agricultural policies on crop biodiversity. They found, using aggregate data, that financial support aimed at specific crops delinks crop biodiversity from the management of revenues risk. However, Richard Just has emphasized that aggregate sample yield variance underestimates farm-level yield variance, which may be from two to ten times greater than implied by aggregate data estimates (Just, 2003; Just and Weninger, 1999). In addition, the averaging over farms that takes place in aggregate data distorts the distributional character of farm-level risk suggesting that the effect of risk on variance can only be accurately measured using farm-level data.

Following Di Falco and Perrings (2005), this paper related the trade-off between financial farm support and crop selection in the management of production risk. If farmers are risk-averse, they will choose a higher number of crop species to hedge against yield uncertainty, which would result in a more diverse agroecosystem (Di Falco and Perrings, 2003). On the other hand, policies aimed at supporting farmers' revenues will provide an alternative means of hedging against risks, thus reducing agrobiodiversity (Di Falco and Perrings, 2005).

While there is considerable advantage in removing the perverse incentive effects of historic subsidies, few of the agricultural reforms are based on a serious valuation of the social opportunity cost of agrobiodiversity loss, and fewer still involve an appraisal of the allocative effects of the new payment schemes. This is especially true for organic farming, and raises serious doubts about the efficiency of such policies in terms of their impact on crop diversity in the farm level and in sustainable agricultural development at the macro level. In light of the ongoing discussions regarding the Common Agricultural Policy reform, this gives the issue policy relevance.

The objective of this study is to analyze farmers' choices regarding crop biodiversity under uncertainty, when agricultural support policies are present, using farm-level data and to determine whether CAP financial support on selected crop may be reducing crop biodiversity. The following section presents the empirical model specification. Data Description Section presents the data and Empirical Results Section presents the empirical results. The final section concludes.

Model specification

Two farming strategies are considered by the individual risk-averse farmer in decision-making, aimed at maximizing expected revenue (Di Falco and Perrings, 2005). The first strategy, the "biodiversity" strategy (B), is assumed to increase revenue levels and reduce revenue variation by enhancing crop biodiversity. The second strategy, the "financial support" strategy (F), is assumed to increase revenue levels and reduce revenue variation by providing higher dependence on subsidies, and thus, indirectly, reducing crop biodiversity.

Using a Just and Pope (1978, 1979) stochastic specification the role of the two farming strategies on revenues is estimated. The Just and Pope framework has been widely used in previous crop biodiversity studies (Di Falco and Perrings, 2005; Kato et al., 2009; Smale et al., 1998; Widawsky and Rozelle, 1998). The Just and Pope parametric approach allows yield-enhancing inputs to have either a positive or a negative effect on the variance of yield, by relating the variance of yield to explanatory variables in a multiplicative heteroskedastic regression model. Let $y = g(x, \nu)$ represent the stochastic production function, with y representing total farm revenues, x is a vector of the two strategies used, the biodiversity strategy B, and the financial support strategy, F, $x = (B, F)$, and ν the weather conditions and other factors unknown at planting time. Just and Pope (1978) proposed the following specification:

$$g(x, \nu) = f(x) + [h(x)]^{1/2} e(\nu) \tag{1}$$

where $h(x) > 0$ and $e(\nu)$ is a random variable with zero mean and variance $h(x)$. This implies that $f(x)$ represents the mean production function and $h(x)$ is the variance of output, where $E(y) = f(x)$ and $Var(y) = Var(e)h(x) = h(x)$. Given that $\partial Var(g(x, \nu))/\partial x = \partial Var(h(x))/\partial x$, it follows that $\partial Var(h(x))/\partial x > 0$ identifies strategies that are risk increasing and $\partial Var(h(x))/\partial x < 0$ identifies strategies that are risk decreasing (Di Falco and Perrings, 2005).

Just and Pope proposed estimating the specified model either by using three-stage feasible generalized least squares (FGLS) or full information maximum likelihood (FIML), estimating equations $f(x)$ and $h(x)$ simultaneously. Furthermore, in cases of small samples, Saha et al. (1997) show that FIML is more efficient and unbiased than FGLS estimation. Therefore, we proceed by estimating our model using the FIML estimator.

We assume that the mean function is a transcendental logarithmic:

$$\ln f = \beta_0 + \sum_i \beta_i \ln X_i + \frac{1}{2} \sum_i \sum_J \beta_{ij} \ln X_i \ln X_j + u \tag{2}$$

$i, j = B, A, i \neq j$ and the variance function is exponential:

$$u^2 = [g(\alpha, P)]^2 = e^{\phi_0} \left(\prod_{i=1}^{2} X_i^{\phi_i} \right) e^{\nu} \tag{3}$$

The transcendental logarithmic specification was employed because of its flexible form and because we are interested in