Rational Farmers and Myopic Policies.

The Case of Crop Diversity Loss.

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Abstract

Crop genetic diversity plays an important role in supporting productivity and stability of agroecosystems. Recent studies based on LDC found that risk hedging, market integration, transaction costs, are key variables in determining the level of biodiversity. This paper focus on the impact of Agricultural Polices on diversity. And it provides a theoretical and empirical explanation to understand how stabilizing income packages in the EU may have leaded to a diversity loss pattern in a Vavilov megadiversity area.

1 Introduction

After the seminal contributions of Brush et al. 1992, Smale et al. 1997 and Heisey et al. 1998, a number of studies focusing on the importance of crop genetic diversity have been published in the agricultural and resource economics literature. A first strand of literature analyzed the contribution of diversity to the mean and the variance of agricultural yields (Smale et al., 1997,Widawsky et al. 1998, Di Falco, 2003) and to the mean and variance of farm income (Di Falco and Perrings, 2003). The second strand provided both theoretical and empirical investigation of the determinants of diversity. Market integration, agroecological conditions, the adoption of new high yielding varieties, and farmers risk aversion have been found key explanatory variables for diversity conservation (table 1 summarizes these findings).

Study,crop and location	Approach	Key variables
Brush (1992) *Potatoes, Peru*	Empirical	Introduction of HYV
Bellon et al. (1996) *Corn, Mexico*	Empirical	Agroecological and cultural factors
Barkley and Porter (1996) *Wheat, U S A*	Expected profits model and empirical	Production characteristics
Evenson and Gollin (1997) *Rice, LDC*	Empirical	International Progammes
Heisey et al. (1997) *Wheat, Pakistan*	Impure public good model and empirical	HYV Land availability
Perales et al. (1998) *Corn, Mexico*	Empirical	Risk, market imperfections
Bellon et al. (1998) *Rice, Philippines*	Empirical	intensification
Meng et al. (1998) *Wheat, Turkey*	Adoption model, Empirical	Risk and Market
Gomez et al. *Corn, Mexico*	Empirical	Agroecological and infrastructure
Bellon et al *Rice, Philippines*	Empirical	Intesification
Van Dusen (2001) *Milpa, Mexico*	Adoption model, Empirical	market integration
Smale et al. (1997) *Punjab*, Pakistan	Empirical	Rain fed
Birol et al. (2003) *Hungary*	Empirical	market integration

Table 1: Background literature on crop diversity

Surprisingly, the impact of agricultural policies on agrobiodiversity has been neglected. Policies that affect farming practices not only have an impact on resources use or environmental quality through, for instance, agricultural intensification and extensification (Just and Antle, 1991, Just and Bockstael, 1991, Abler and Shortle, 1992, Lewandrowsky et al., 1997). But also, on farmers' choices towards diversity. Furthermore, Leathers and Quiggin, (2001) using a method proposed by Meyer (1998) showed the important of farmers attitude toward risk in the interaction between agricultural and resource policy. Using a Just and Pope production function they showed that if farmers are risk averse they will use more of the risk reducing input with respect to a risk neutral farmer. Therefore, farmers' risk aversion might play a pivotal role in determining the level of agrobiodiversity. If crop diversification (either interspecies and intraspecies crop diversity) is a risk reducing strategy the aggregate level of diversity observed in the agroecosystem will be higher when farmers are risk averse (Di Falco and Perrings, 2003). However, policies aiming to support or stabilize farmers income, such as price support, grants, financial compensation, might become an alternative mean to hedging against risks. Hence, one by product of financial assistance to farmers may be in "de - linking" risk aversion from the diversity of the agro - ecosystem. Uncertainty is hedged through planting those species that have more support. This paper proceeds as follows. The next section will present a simple dynamic model where farmer determines the level of diversity of the agroecosystem by choosing the varietal land allocation strategy allowing for stochasticity. For this purpose we adopt the approach taken by Just and Pope (the mean-variance model). Successively, the study case site and the methodology implemented are presented. In section three, an empirical application in provided using data from the South of Italy (a Vavilov megadiversity spot for cereals) and the elasticity of substitution between two alternative strategies is estimated. The final section offer some conclusions.

2 The Model

Farmers' risk aversion seems to play an important role in explaining conservation choices. In this section a model in which farmers' diversity choices interplay with the CAP in an uncertain environment is presented. Quintessential features of agricultural production are the uncertainty to which farmers are exposed and the existence (e.g. in Europe and US) of a large body of instruments and regulations, set down by policy maker to guarantee farm incomes. This section attempts to fill this gap by providing a simple dynamic model where the farmer determines the level of diversity of agroecosystem by choosing the varietal land allocation, and where varietal diversification is a risk hedging strategy. It is found that policies that provide an alternative way of risk hedging reduce the level of diversity. An empirical application is provided using data from South of Italy (a Vavilov megadiversity spot for cereals). Once again we adopt the approach taken by Just and Pope (the mean-variance model). The model shows that optimal crop genetic diversity will vary with farmers' attitudes to risk, the impact of crop genetic diversity on the variance of both output and income and the availability of alternative means of stabilizing farm incomes.

The model illustrate the relations between farming activities (or strategies) and risk behavior in order to derive some qualitative insights into optimal choices of crop diversity in an uncertain environment. Farmers face risks that affect either the output of agricultural activities (the risk affects the quantity or quality of crops produced) or agricultural markets (the risk affects the prices of agricultural inputs or outputs). Farmers are assumed to hedge their risk exposure through varietal diversification. Different varieties respond in different ways to environmental or market risks. However, policy interventions can also reduce farmer exposure to risk. Price supports, price limits, tariff barriers all reduce market associated uncertainty. In addition, grants may well reduce the production uncertainty.

Let us assume that the farmer return, Ω, depends on the farming strategies. In an uncertain environment farmer may opt for a strategy that implies varietal diversity in land allocation l, and another strategy that implies more reliance on the external support from the policy maker, B [1]. This, for instance, would imply that farmer would prefer to allocate their land to those species that receive more protection, or they just take grants and do not diversify. The connection between the strategies and the diversity of the

[1] The two farming activities for land allocation are assumed to be $n < l < m$ and $b < l < d$ $\forall n, m, b, d \in \mathsf{R}^+$

agroecoecosystem D, is captured by the following equation:

$$\dot{D} = D_t - \eta(l_t, B_t)$$

(Di Falco and Perrings, 2003). Where the intercept represents the cumulative past behavior of D.An interesting feature of this formulation is that farmers affect the level of biodiversity in the agroecosystem by allocation of land among crops (interspecies diversity) and farming decisions have implications for the stock of diversity available in the future. Therefore, the farmer considers 1) the effect of crop diversity on revenues and 2) the effect of the loss of species and cultivars on future options. The formulation allows us to test two specific hypotheses:

· Are the strategies both risk reducing ?

· Are they substitutes?

It is assumed that the land allocation decision is captured by a index of spatial diversity (Smale et. al., 1997, Meng et al 1998). The benefit variable embeds all the mechanisms of financial support that the policy maker implements in order to support farm incomes such as price support, grants, and so on. Therefore, the framework includes the impact of the two strategies on the mean revenue:

$$\Omega(D_t, g_t, B_t) = f(D_t, l_t, B_t) + g(D_t, l_t, B_t)\theta \tag{1}$$

As before the revenue function depends on two component: a deterministic component and a stochastic component that depends on the same argument plus a stochastic disturbance that enters multiplicatively. This formulation does not distinguish which source of risk is at play (i.e. weather or price). This is somewhat limiting , but the reason is in the empirical section. Following the results presented in earlier chaprts we expect that:

$$\Omega_D > 0, \Omega_{DD} < 0$$

$$\Omega_l > 0, \Omega_{ll} < 0$$

$$\Omega_B > 0, \Omega_{BB} < 0$$

where the subscripts denote partial derivatives. The diversity of the agroecosystem positively affects farm revenue. Diversity improves production in the short and in the long rung as well as maintaining the stability of production. Land allocation to different varieties has the same impact on the revenue function. B is adopted following the policy maker target of sustaining the farm incomes. In order to include the interaction between the diversity of the agroecosystem and the other two arguments of the revenue function,crop diversity is assumed to evolve according to the following expression:

$$\dot{D} = D_t - \eta(l_t, B_t) \tag{2}$$

The diversity of the agroecosystem depends upon l and B. The function $\eta(l_t, B_t)$[2] links the two strategies to the level of diversity in the agroecosys-

[2] This function could be considered a diversity losss function (Cfr. Di Falco and Perrings, 2003)

tems[3]. By definition of the diversity index $\eta_l < 0$. We expect that $\eta_B > 0$. Since, supporting one variety with grants or prices creates an incentive to farmers to reduce their diversity in land allocation. This is, however, an empirical matter. It is important to stress that this formulation allows not to specify in which way the policies impact the diversity loss. Furthermore, it is possible that there is no connection between land allocation and a specific financial programme (i.e. $\eta_B = 0$).The farmer is assumed to be risk averse displaying a Von Neumann Morgenstern utility function U, assumed to be twice differentiable, increasing and concave in revenue Ω. Therefore the farmer problem is to:

$$Max_{l,B} E \int_{t=0}^{\infty} \{U(f(D_t, l_t, B_t) + g(D_t, l_t, B_t)\theta)\} e^{-rt}$$

s.t. equation 2, $D(0) = D_0 > 0, l_t > 0$ and $B_t > 0$. Where E is the expectation operator with respect to θ and r is the discount factor. The stochastic disturbance is normally distributed.[4]. The current value Hamiltonian for this standard optimal control problem is

$$\tilde{H} = E\{U(f(D_t, l_t, B_t) + g(D_t, l_t, B_t)\theta)\} + \lambda[D_t - \eta(l_t, B_t)] \qquad (3)$$

where λ is the current value shadow price for the diversity state equation. The Hamiltonian is strictly concave in l and B. Assuming an interior solution the sufficient conditions for a an optimal solution[5] (Leonard and Van Long,

[3] This interaction could have been represented in a more complex way. However, we choose to keep the model as simple as possible and coherent with the empirical part.

[4] $\theta = dV_t$ where V_t is a Brownian motion

[5] Please refers to the mathematical appendices

1998) are:

$$\tilde{H}_l = E\{U_\Omega[\Omega][f_l(D_t, l_t, B_t) + g_l(D_t, l_t, B_t)\theta] - \lambda\eta_l(l_t, B_t)\} = 0 \quad (4)$$

$$\tilde{H}_B = E\{U_\Omega[\Omega][f_B(D_t, l_t, B_t) + g_B(D_t, l_t, B_t)\theta] - \lambda\eta_B(l_t, B_t)\} = 0 \quad (5)$$

$$\tilde{H}_D = E\{U_\Omega[\Omega][f_D(D_t, l_t, B_t) + g_D(D_t, l_t, B_t)\theta]\} = r\lambda - \dot{\lambda} \quad (6)$$

$$\dot{D} = D_t - \eta(l_t, B_t)$$

Along the optimal path the expected marginal increase in utility in associated with an increase in one of the farming activities must be equal to the marginal change in the diversity function evaluated at the shadow price λ. Following Grepperud[6] (2000), we provide the analysis of the long run reaction of risk averse farmer in an uncertain environment. Combining the above equations in the steady state equilibrium we have:

$$f_l(D^*, l^*, B^*) + [g_l(D^*, l^*, B^*) - \frac{1}{r}\eta_l(l^*, B^*)g_l(D^*, l^*, B^*)]\frac{Cov(U_\Omega(\Omega^*, \theta)}{E(U_\Omega(\Omega^*))}$$
$$= \frac{1}{r}\eta(D^*, l^*, B^*)f_D(D^*, l^*, B^*)$$

and

$$f_B(D^*, l^*, B^*) + [g_B(D^*, l^*, B^*) - \frac{1}{r}\eta(l^*, B^*)g_B(D^*, l^*, B^*)]\frac{Cov(U_\Omega(\Omega^*, \theta)}{E(U_\Omega(\Omega^*))}$$
$$= \frac{1}{r}\eta_B(D^*, l^*, B^*)f_D(D^*, l^*, B^*)$$

[6] See also Di Falco and Perrings 2003

and $D_t = \eta_l(l^*, B^*)$. This formulation has the advantage of isolating the risk structure in each of the optimality conditions. The term $\frac{Cov(U_\Omega(\Omega^*,\theta)}{E(U_\Omega(\Omega^*))}$ represents the security equivalent for the stochastic component θ. The terms $g_l(D^*, l^*, B^*) - \frac{1}{r}\eta_l(l^*, B^*)g_l(D^*, l^*, B^*)$ and $g_B(D^*, l^*, B^*) - \frac{1}{r}\eta(l^*, B^*)g_B(D^*, l^*, B^*)$ represent the overall risk effect and are called the risk factors for each strategy. They are determined by the risk properties of the agricultural activity, given by the partial derivatives of the stochastic component with respect to the control variables, and the impact of the stock variable on the same component. The interaction between these given by η_l and η_B respectively. In order to analyse in the reactions of risk averse farmers in an uncertain environment the total problem is split into two partial models. The first ignores f_B and η_B, the second ignores f_l and η_l. This reduces the complexity of the setting and provides a straightforward analysis of the forces at play. Since Ω is assumed normally distributed the expected utility function may be presented as a separable function of mean and variance so

$$E[U(\Omega)] = E(\Omega) - \delta var(\Omega) \tag{7}$$

where δ represents risk aversion. Replacing the original objective function with the 7 and setting $\mathrm{var}(\Omega) = g(x)$, where $x = l, B$ the restated problem leads to:

$$\frac{\partial D^*}{\partial \delta} = \frac{g_x - \frac{\eta_x}{r} g_D}{H_{xD} - \frac{\eta_x}{r} H_{DD}} = \frac{g_x - \frac{\eta_x}{r} g_D}{D} \tag{8}$$

This formulation allows to undertake a straightforward analysis. The impact of the risk factor along with the risk property of the stock variable will define the sign on the 8. If η_x<0 it follows that $D < 0$. If varietal diversity has a negative impact on the stochastic component, a risk averse farmer will bring the agroecosystem to a higher level of diversity. Therefore, farmers hedge risk by diversifying their portfolio of crops and, in so doing the diversity level will be higher. Let us turn now to the case of the policy oriented strategy B. The revenue stabilization strategy will dominate the diversification strategy if policy stabilizes revenues more effectively ($g_x > \frac{\eta_x}{r} g_D$). In this case the best farmer strategy will not be to rely on diversity of crops, but to focus on the crops that attract subsidies or grants. The results is in de - linking of risk aversion from the diversity of the agroecosystem. Uncertainty is hedged through external policy support, and higher level of risk aversion will strength this result.

3 Cap and diversity estimation

Unfortunately data on regional EU agricultural intervention are not available. To cope with this lack of information we use a proxy: the credit for agriculture recorded by the Bank of Italy. This series contains all the financial resources going to the agricultural sector from all institutions. Nevertheless, it should be emphasized that between 1970 and 1993 the largest source of this was the European Union. Assuming that both mean and variance functions are Cobb

Douglas we have that[7],

$$\Omega = e^{\beta_0}(\Pi_{i=1}^{2} X_i^{\beta_i})(\Pi_{h=1}^{8} e^{\delta L})(\Pi_{k=1}^{24} e^{\gamma Y}) + u \tag{9}$$

$$u^2 = [h(X_i, \phi, \theta]^2 = e^{\phi_0}(\Pi_{i=1}^{2} X_i^{\phi_{1i}})e^{v} \tag{10}$$

$i = l, B$.

Hence we have that the mean equation is set to the 9 and the variance function is set to the 10. The mean and the variance of the farmers revenue are regressed against our diversity and benefit measures and the set of locational and time dummies. The results are shown in the table 2.

The estimation of the Just and Pope production function indicates that diversification and policy have similar impacts on the mean and the variance of revenues. The estimated coefficients are statistically significant for both variables. Diversity, at least in the long run has a role in sustaining an stabilizing farm revenues. Whether this result arises from market or production risks is not possible to establish. The policy oriented strategy has successfully supported and stabilized farm revenues. The simple fact that the two strategies displays same sign on the estimated coefficients allows us to conclude that they are substitutes. They both support the mean income and more important they are both risk reducing strategies.They are both negatively related to the revenue variance.

[7] Just and Pope, 1979.

	Mean Function	Variance Function
Diversity strategy	0.31** (0.14)	−2.7* (0.85)
Benefits induced strategy	0.2 (0.15)	−2.3* (0.91)
Constant	0.019 (0.022)	
Sigma		0.26* (0.019)
Adj − R^2= 0.38; F Test = 20.57 (*); *Wald* Test = 405 (*); n = 192;		
Significance level* =1%** = 5%; *** = 10%		
Please note standard errors are in parentheses		

Table 2: Estimation results of stochastic revenue function.

3.1 Elasticity of substitution

In an uncertain environment, farmers may diversify to hedge against production and market risks. Farmers may also rely on transfers via the CAP. The two means of income stabilization are actually substitute. Measuring elasticities of substitution between the two is an appropriate way to measure tradeoffs. In addition, however, inserting in the estimating equation an interaction term (ϕ_{int})[8] between land management regimes can be also intepreted as a partial measure of the influence of policy induced strategy to the diversity induced strategy. Boisvert (1982), showed that scaling data by their geometric mean and inserting allows a straightforward estimation of the elasticity of substitution applying the following formula on the estimated coefficients, hence

$$e_{l,B} = \frac{-(\phi_l + \phi_B)}{-(\phi_l + \phi_B) - (2\phi_{int}\phi_B\phi_l)/\phi_B\phi_l}$$

From which we have that the elasticity of substitution of the two startegies with respect to the variance function is

$$e_{l,B} = -\ 0.31$$

Therefore there is a substantial potential for substituting diversification for policy induced, and diversity reducing, strategy. The following table reports another interesitng piece of information.

The estimated coefficient ϕ_{int} is significant in the variance function sug-

[8] The in teraction term is constructed multiplying the variable diversity by the policy induced and then running the regression with this extra variable

Interaction	0.36 (0.18)	2.1^{**} (1.13)

Table 3: Estimation results of the interaction term in the stochastic revenue function.

gesting that diversity dampens the revenue stabilizing effect of support scheme. The same conclusion is instead, weakened for the mean function because the estimated coefficient is statistically not significant.

4 Summary of findings

Risk aversion may be an important driving force for diversity conservation. Risk averse farmers may hedge the uncertainty they face by allocating their land to different species. However, policies that aim to support and stabilize farm income may also change the farmers decision making in a risky environment. The model shows that if varietal diversity has a negative impact on the variability of revenues, a risk averse farmer will bring the agroecosystem to a higher level of diversity. However, policies aiming to support or stabilize income may alter this link. The revenue stabilization strategy will dominate the diversification strategy if policy stabilize more effectively the revenues. In this case farmer strategy will not rely on diversity of crops but on the crops that attract subsidies or grants. The results is the de - linking of risk aversion from the diversity of the agroecosystem. Uncertainty is hedged through the external policy support, and higher levels of risk aversion will strength this result. An empirical application based on data on a Vavilov megadiversity pocket is provided. The results leads to the following conclusions:

- Policies that aim to support or stabilize farmers income might become an alternative mean to hedging against risks. Farmers strategy will not rely on diversity of crops but on the land allocation strategy that get more subsidies, or on the grants.
- De - linking risk aversion from the diversity of the agro -ecosystem. Uncertainty is hedged through the exogenous policy and higher level of risk aversion strengthens this result.
- Diversification and policy induced strategies have the same positive impact on the mean of revenue
- Diversification and policy induced strategies are substitutes.

5 References

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