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The role of agricultural cooperatives in sustaining the wheat diversity and productivity: the case of southern Italy

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Abstract We hypothesize that institutions such as agricultural cooperatives influence regional levels of variety diversity through input supply, processing or marketing functions. This diversity can also affect yield, a partial measure of crop productivity. We test these hypotheses with data from southern Italy, a mega-diversity spot and centre of diversity for durum wheat. Cooperatives in the southern regions of Italy process farmers' harvests of durum wheat into bread, label it, and sell it locally. In this relatively marginalized region of the country, cooperatives enable farmers to capture more of the value of the final product and reduce marketing costs. To test the hypothesis, we apply a two-stage estimation approach with a Cobb-Douglas production function and panel data analysis. Findings suggest that the density of cooperatives in a region is associated with greater spatial diversity in wheat varieties grown, and that, over a 14-year period, this diversity positively affected crop yields.

Keywords Crop biodiversity · Wheat varieties · Productivity · Cooperatives

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1 Introduction

Society benefits from a "legacy" of crop genetic resources that have been selected, multiplied, traded and conserved over the generations by farmers and plant breeders (Brush 2000; Harlan 1992). This process has depended on a store of genetic diversity housed in crop plants. Crop genetic diversity comprises all the variation in the genes of individual plants within a cultivated plant species. Some have argued that genetic diversity is also the fundamental building block of ecological and organism diversity (Cox and Wood 1999).

People depend on crop genetic diversity directly and indirectly, as farmers and as consumers. In agricultural systems, farmers need genetic diversity in resistance and tolerance to combat pests, diseases, and climatic vicissitudes. The narrow genetic base of major crops can increase vulnerability to pests and pathogens, contributing to yield variability (National Research Council 1972). Pests have more ability to spread through crops with the same genetic base or genetic sources of resistance (Priestley and Bayles 1980; Sumner et al. 1981; Altieri and Lieberman 1986). The performance of different crop varieties depends on climatic and other environmental conditions. Having functionally similar plants that respond differently to weather randomness contributes to productivity by ensuring that whatever the environmental conditions, there will be plants that thrive (Heal 2000). Individual varieties respond differently to adverse biotic pressures and environmental conditions, which can contribute to stability over time (Tilman and Dowling 1994; Tilman et al. 1996).

Crop genetic diversity also underpins the breadth of dietary needs and services that consumers demand as societies become wealthier. As incomes rise, consumers are willing to pay for an increasingly differentiated array of goods and services. Much of this differentiation is related to quality-related attributes. In Europe, as is well known, restricted labelling systems have long been used to ensure consumer quality and authenticity. Recently, "buying local" has been advocated by some consumer groups in the U.S. and elsewhere as a means of renewing local economies, supporting local farmers, and improving nutrition. Under some conditions, a local consumer base could imply more local diversification of farm products, particularly if they are fresh or minimally processed.

While crop genetic diversity delivers goods and services that are excludable and rival, it embeds information, it is not readily visible to those who use it, and it is generally not traded in markets. Thus, crop genetic diversity has important public good properties that lead to its under-provision by farmers relative to the social optimum (Heisey et al. 1997; Heal et al. 2004). To assure that social optima are met, theory predicts the need for public interventions. Obvious examples of public interventions include gene banks, botanical gardens, plant breeding programs, and in situ conservation programs.

Using production and cost function frameworks, several recent studies have tested the hypothesis that crop genetic diversity enhances crop yields and reduces yield variability, generally based on regional or district-level data (Widawsky and Rozelle 1998; Smale et al. 1998). To explore the potential trade-offs between maintaining diversity and yields in farmers' fields, Heisey et al. (1997) used the theory of impure public goods to relate the variety choices of farmers, the rusts of wheat, and genetic diversity in the Punjab of Pakistan. They showed that in the aggregate, farmers often chose to grow varieties that were higher yielding, but not necessarily less susceptible to rust. In some years, both aggregate wheat yields and latent, genetic resistance to rust might have been increased by growing a different combination of varieties; in others, a more genetically diverse mix would have incurred private costs in terms of crop output foregone, with possible social consequences for Pakistan.

Heisey et al. (1997) assumed that each farmer acted without the knowledge of other farmers' actions or the interests of other farmers in mind. Here we pose two questions. First, do rural institutions affect the diversity of wheat varieties grown by farmers? Second, does the diversity of wheat varieties grown by farmers affect crop yields? We address the role of one type of rural institution—agricultural cooperatives. Thus, we consider genetic diversity as a club good (a type of impure public good), for which the level is determined by the actions of the members of an agricultural cooperative. We test the effect of agricultural cooperatives on levels of wheat diversity, and the effect of wheat diversity on wheat yields.

Hypotheses are tested using a two-stage estimation approach with a Cobb-Douglas production function and panel data analysis. The model is applied to secondary data from 8 regions in southern Italy. Southern Italy is a Vavilovian mega-diversity spot and a centre of diversity for durum wheat (Vavilov 1951; Harlan 1992). Agriculture in southern Italy is also characterized by a large number of cooperatives involved in producing, processing and marketing of crop products.

The next section presents the background to this study, reports findings from related studies and states our research interest in cooperative behaviour. This is followed by a characterization of the historical context of cooperatives and cereals production in southern Italy. The empirical approach used to investigate the relationship of cooperatives to wheat diversity, and the relationship of diversity to productivity, is summarized. Econometric results are then discussed, and conclusions are drawn in the final section.

2 Background

Several applied economics studies have tested the hypothesis that crop genetic diversity affects crop yields. Clearly, the mix and pattern of varieties grown across a crop-producing landscape determines crop yields through genetic interactions with environmental factors, including management and agroclimate. Still, whether higher levels of crop genetic diversity is associated with higher levels of productivity is a testable hypotheses.

In a study of the Punjab of Pakistan, Smale et al. (1998) related wheat yields to several diversity indicators using a Just and Pope (1978) stochastic production function. The authors found that the production environment determines the sign of the relationship between diversity and yields. For instance, among rain fed districts, genealogical distance and number of varieties grown were associated with higher mean yields and lower yields variability. In the irrigated areas, instead, a high concentration of wheat area among fewer varieties, or greater genetic uniformity, had an important, positive effect on expected yields.

A similar approach was employed by Widawsky and Rozelle (1998). These authors used a more generalized function form and an area-weighted, Solow–Polasky index to test the impact of rice variety diversity on the mean and the variance of yields using township data. Widawsky and Rozelle found that variety diversity reduced both the mean and the variance of yields, although the effect on variance was not statistically significant.

Meng et al. (2003) modelled the productivity–diversity relationship as endogenously determined for modern wheat varieties in China, using a cost share system. Although the econometric results indicated that evenness in morphological groups was a positive factor in per hectare costs of wheat produced, some of the input share equations implied potentially important cost savings for farmers. For example, diversity may have contributed to a more efficient use of pesticides, which otherwise would have been required to maintain a similar level of production stability.

Given the emphasis of these studies on formal econometric modelling of diversity-productivity relationships, and the preoccupation with defining appropriate diversity indices, the role of institutions was neglected—other than a brief mention of markets, plant breeding and extension programs. Nonetheless, institutions are clearly one of the driving forces of diversity loss or conservation.

Generally defined, institutions are humanly devised constraints that structure political, economic and social interactions (North 1991). They consist of formal constraints, such as laws and property rights, but also of informal constraints, such as more general customs or codes of conduct. In crop production systems, a range of formal and informal institutions affects the crop variety choices of individual farmers. More formal institutions include plant breeding programs, seed companies and markets. Examples of informal institutions are the social networks and village or town associations in which farmers often exchange seed or seed-related information. Many of these act indirectly on crop variety choices, since they exist for reasons other than the circulation of crop genetic material or products (Van Dusen et al. 2006; Bela et al. 2006).

A cooperative is an example of a formal institution. A cooperative is a voluntary group of individuals who derive mutual benefit from the coordination of production decisions, shared access to inputs, including seed, enhanced market power and more effective lobbying capacity. The cooperative can obtain information about seeds and crops, obtain the seed, process the crop or market the product in order to create added value and to distribute the revenues to members. From the cooperative perspective, having varieties with diverse traits serves the two purposes already mentioned: fitting the distinctive agronomic traits of varieties to their local environmental niches, and fitting various quality traits to consumer markets. Cooperatives provide members with an opportunity to acquire inputs, processing or market-related information more cheaply, to gain bargaining power in a particular market, or to locate an exploitable market niche.

We hypothesize that, in a fully commercialized agricultural economy, under certain conditions, consumer demand can drive farmer demand for a more diverse set of crop varieties. Agricultural cooperatives can enhance the articulation of this demand by reducing the costs of obtaining market information and improving bargaining power for particular markets. If, in turn, the diversity of crop varieties influences yields positively, marketing cooperatives could represent a way to internalize some of the economic and ecological benefits of genetic resources. The role of wheat cooperatives and wheat varieties in the study area is described next.

3 Wheat cooperatives in southern Italy

Economic, cultural and climatic characteristics make cereal production an important sector in southern Italy. During the time span considered here, 42% of agricultural land was allocated to cereals. The eight regions focus of this paper were all designated

Table 1 Durum wheat yields, three decades comparison, southern Italy

	1969–1971	1979–1981	1989–1991
Abruzzi	2.22	2.43	2.74
Molise	1.95	2.21	2.67
Campania	1.79	2.16	2.8
Puglia	2.20	2.30	2.3
Basilicata	1.71	1.84	1.78
Calabria	1.50	1.9	1.8
Sicilia	1.60	1.79	1.8
Sardegna	1.35	1.74	1.38

Source: Authors' calculation on ISTAT data. Yield in mt/ha, three-year averages

Table 2 Cereals share of agricultural land and durum wheat share of land in cereals, southern Italy 1970–1993

	% Cereals	% Durum Wheat
Abruzzi	37	24.4
Molise	44	38.8
Campania	36	28.2
Puglia	55	46.6
Basilicata	54	35.1
Calabria	38	20.2
Sicilia	45	38.3
Sardegna	28	23.7

Source: Authors' calculations using ISTAT data

"Objective 1" for development by the European Union, meaning that their economies are marginalized relative to those of other regions. The areas under "Objective 1" are given a high priority for development, supported by substantial levels of financial assistance and "ad hoc" policy interventions by decision-makers.

The production of cereals is particularly favoured by the dry, relatively warmer weather in southern regions of Italy. Yields are negatively affected, instead, by cold, frosty winters or sudden changes in temperature. These weather conditions also reduce the spread and proliferation of pests, which spread more when humidity is high. In some areas the soil is sandy, reducing the ability of plant roots to absorb fertilizers and hence, the benefit in using the nutrient. For this reason, application of pesticides and fertilizers appears to be relatively unimportant for the growth of cereals in southern Italy.

Southern Italy is roughly composed of eight regions. These regions differ somewhat in climate and topography, but the agricultural sectors, and particularly the cereals production sectors, are reasonably homogeneous. Table 1 compares average yield levels for the past three decades. Data represent three-year averages around 1970, 1980, and 1990. Productivity ranges from 1.3 up to 2.7 mt/ha. In the major regions for durum wheat production (Sicilia and Puglia), average yield levels appear not to have changed much over the three decades. In Abruzzi, Molise and Campania, average yield levels appear to have increased.

A large proportion of land in each of the eight regions is sown to cereals. Table 2 shows the average share of all agricultural land allocated to cereals, and the share of cereals area sown to durum wheat, from 1970 to 1990. Cereals occupied 28 to 55 percent of all agricultural land at the regional level during these decades. In Puglia and Basilicata, cereals account for over half of all agricultural land, and in Sicilia, they represented 45%. Among cereals, durum wheat is the most widely grown crop, with more than 38 % of the land share for all regions taken together. Aside from rice, which is grown in a humid environment, other cereals grown include bread wheat, barley, and maize.

Durum wheat is used to produce the Italy's staple food, pasta, and a range of other products. Data from the Italian statistical office (ISTAT) indicates that in the past twenty years, 68% of national durum wheat production came from the southern regions of the country (ISTAT). The regions of Sicilia and Puglia alone produced 40% of Italy's output of durum wheat.

In southern Italy, as compared to northern Italy, durum wheat is also used instead of bread wheat to make bread that is locally appreciated by consumers. Farmers often grow more than one durum wheat variety at a time, probably driven by a combination of farming conditions and end-use demand. The area is prone to drought and in some regions there is no irrigation. Some varieties provide higher protein content or preferred grain colour, characteristics that matter in processing.

Table 3 lists some of the varieties of durum wheat grow in the study regions from 1970 to 2000 by improvement status. Though the adoption of newer varieties (e.g. Ciccio, Gianni, Colosseo) is increasing rapidly, some farmers' varieties (e.g. Russello, Timilia) were still in use. Newer varieties are typically of shorter stature. Old improved varieties are still widely grown, including Adamello, Appulo, Capeiti, Simeto, Trinakria, and Valnova. Farmers have grown some of these taller varieties for decades and know their performance well. A number of the old improved varieties incorporate genetic material from farmers' varieties or improved varieties used in the 1920s (e.g. Cappelli). Indeed, recent molecular analysis has supported the hypothesis that genetic variability in Italian durum wheat has been constant throughout the breeding process during the last century (Martos et al. 2005).

In southern Italy, agricultural cooperatives play a crucial role in producing, processing and marketing durum wheat. After the 1950 agrarian reform, the agricultural sector in the South was partitioned into very small landholdings tenured by a multitude of different owners. Production cooperatives developed in order to overcome difficulties associated with this structural feature.

Table 4 shows the dramatic development and spread of agricultural cooperatives in southern Italy.[1] For instance, in Campania the number of agricultural cooperatives grew from only 34 in 1951 to 430 in twenty years. During the same time span in Sardegna the number of cooperatives passed from 86 to 686. In 1971, in Sicilia, there were 1161 registered cooperatives. This upward trend continued steadily throughout the 1980s and 1990s. Figure 1 depicts the change in the number of cooperatives over the time span considered in the empirical analysis.

Cooperative members retain private property rights on their land, but can share a common property regime for some fixed capital, such as threshing machines. Each cooperative markets the harvest as a monopsonist vis-à-vis its members. In the case of durum wheat, members gather their harvest at the end of the season and transfer the crop to the cooperative. Durum wheat constitutes the raw material for bakery products that local consumers prefer to products made from bread wheat. The cooperative processes the wheat and markets the bakery products, distributing revenues to members. Different wheat varieties also have different qualitative characteristics such as protein content, colour, and grain moisture or humidity. In the less economically

[1] The expansion of cooperatives was also promoted by favourable legislation that encouraged this form of association by providing a set of benefits through taxes.

Table 3 Some of the varieties grown in study regions from 1970 to 2000, southern Italy

Cultivars	Year of release	Improvement status
Adamello	1980	Old improved variety
Appulo	1970	Old improved variety
Arcangelo	1986	New variety
Balsamo	1993	New variety
Capeiti	1964	Old improved variety
Ciccio	1996	New variety
Colosseo	1995	New variety
Cosmodur	1992	New variety
Creso	1970	Old dwarf variety
Crispiero	1992	New variety
Duilio	1984	Old improved variety
Fenix	1992	New variety
Fortore	1995	New variety
Gianni	1993	New variety
Grazia	1986	Old improved variety
Iride	1997	New variety
Messapia	1985	Old improved variety
Norba	1988	Old improved variety
Nudura	1993	New variety
Ofanto	1992	New variety
Platani	1996	New variety
Radioso	1992	New variety
Russello	–	Landrace
Rusticano	1997	New variety
Salentino	1995	New variety
Simeto	1988	Old improved variety
Svevo	1997	New variety
Tavoliere	1992	Old improved variety
Timilia	–	Landrace
Trinakria	1970	Old improved variety
Valbelice	1993	Old improved variety
Valnova	1975	Old improved variety

Source: Developed with data from Statistiche Agrarie, ISTAT
Note: A new variety is typically of medium or short stature, and has been released during the past decade. An old improved variety is a tall variety released up to 50 years ago. A landrace is a farmers' variety

Table 4 Number of agricultural cooperatives in southern Italy, by region, by decade

Year	Abruzzi Molise*	Campania	Puglia	Basilicata	Calabria	Sicilia	Sardegna
1951	8	34	85	31	36	155	86
1961	60	111	190	102	86	438	361
1971	194	430	547	146	192	1161	686

Source: Annuario dell' Agricoltura Italiana, INEA
* Abruzzi and Molise was one single region up to 1973

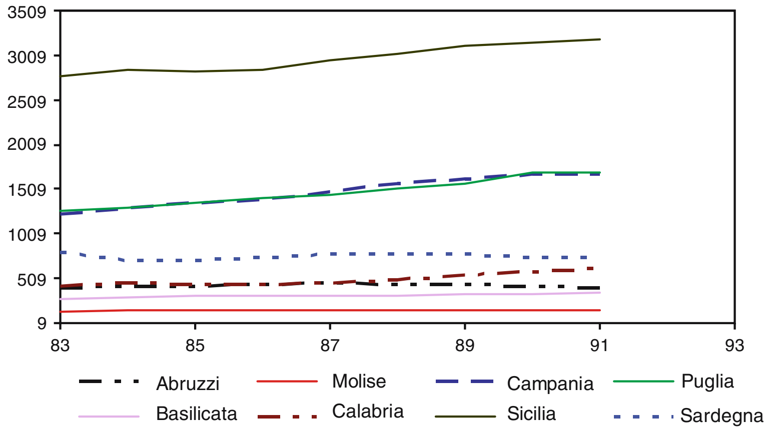

Fig. 1 Number of agricultural cooperatives by region, 1983–1991. Source: Annuario dell' Agricoltura Italiana, INEA

developed areas of southern Italy, cooperatives enable individual producers to (a) capture more of the value of the final product through processing it locally, and (b) better exploit local market opportunities by reducing per unit marketing costs.

4 Empirical approach

Estimation was conducted in two stages. To assess the effect of cooperatives on wheat diversity, a diversity index was regressed against the density of cooperatives in the region. To test the effect of diversity on long-run productivity, a production function was estimated in the second stage. The predicted values from the first-stage regressions were used as explanatory variable in the production function, along with conventional inputs and a variable for weather conditions. The next subsection describes the data source, followed by econometric specifications corresponding to each stage of analysis, and the approach used to handle stochastic structure.

4.1 Data

Data were obtained from ISTAT, the Italian National Institute of Statistics and the INEA, the National Institute for Agricultural Economics. The series are drawn from the *Statistiche Agrarie* and *Annuario* for the South of Italy (Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia and Sardegna), including the years 1980 to 1993.[2]

The regional level of aggregation is driven primarily by the structure of the secondary data that was available for analysis. Still, an understanding of the distribution of variety diversity and its determinants at the regional level is important for the design of programs to support sustainable management of plant genetic resources on farms.

[2] The time span was determined by data availability. Data on wheat varieties are available up to 1993. Indeed, after 1993 the ISTAT did not record anymore this information. While instead, data on cooperatives are available from the early 80s.

Table 5 Variables definition

Variables	Definition
Durum wheat yield	Durum wheat output (tons/ha), by region and year
Pesticides	Pesticides use (100 kg/ha), by region and year
Rainfall	Rainfall (mm/year), by region and year
Labour	Labour units (no/ha), by region and year
Cooperative density	Number of cooperatives per ha, by region and year
Wheat diversity	Simpson index over durum wheat area allocated among varieties, by region and years

In southern Italy, regions are administrative units that implement and coordinate policy intervention in agriculture.

Table 5 lists the definitions of the variables used in our empirical analysis. The quantity of hard wheat produced is in tons per hectare. Pesticide applications per hectare and labour force participation are conventional inputs. The quantity of rainfall per year captures the meteorological impact on productivity. The density of cooperatives expresses the extent of localized cooperative power. Density was calculated as the number of agricultural cooperatives in the region divided by the land allocated to agriculture in that region. The majority of agricultural cooperatives (around 70%) are devoted to arable production, and most have been involved in durum wheat production, during the time period considered.

4.2 Diversity index

In terms of diversity measurement, the analysis conducted by Heisey et al. (1997) and Smale et al. (1998) focused on modern varieties, since most (but not all) varieties grown in the higher potential growing environment of the Punjab are modern varieties. Diversity indices were constructed from the coefficients of parentage, based on pedigree data. Pedigree data is available only for modern varieties. The analysis of Meng et al. (2003) also focused on modern wheat. The authors constructed diversity indices from a combination of ecological concepts, trial data, genealogies, and a statistical model.

The biological and ecological literatures have developed many metrics to represent diversity concepts and methods for calculating them. No single index is superior for all purposes, and in any given empirical setting, more than on may be appropriate for the analysis (Meng et al. 1998; Smale et al. 2003). In agricultural systems, one of the most commonly employed measures of diversity is spatial diversity. Spatial diversity refers to the amount of diversity found in a fixed geographical area. Typically, spatial diversity refers to concepts of richness (the count or number of species) and evenness (the distribution of the species). These indices treat each species as genetically equal, although the evenness indices weight them by their abundance in the landscape. Crop scientists and resource economists have advanced other metrics that express distinctness or the degree of genetic distance among populations (Weitzman 1992; Solow et al. 1993; Souza et al. 1994).

In this study, we chose a spatial diversity index. We hypothesize that the density of cooperatives in a region affects the spatial distribution of varieties. The cooperatives play no role in purchasing seed or plant breeding. To the extent that cooperatives enable farmers to better match varieties to localized market demand, greater density could positively influence the evenness of different varieties cultivated across a region. Even if consumer tastes were uniform and product qualities similar across varieties, differential performance of varieties in environmental niches could still explain spatial evenness. However, in that case, we would not expect the density of marketing cooperatives to have an effect on diversity levels.

Among spatial indices, we selected Simpson's index of proportional abundance to measure the diversity of durum wheat. The formula for the Simpson index is:

$$S = 1 - \Sigma p_i^2.$$

P_i is the population share of the ith species in a reference region (Magurran 1988). In applications to cultivated cereals with constant seeding rates, the Simpson index has been expressed as the sum of squared shares of crop area planted to each variety (Meng et al. 1998). Area shares represent population shares. Here, p_i is the share of the area in durum wheat planted to the i th variety. The index of variety diversity encompasses both landraces and modern varieties, spanning improvement status. As S increases, diversity increases. An index value close to zero indicates that almost all of the crop area is allocated to one single variety. When the index is close to one a large number of varieties are planted on very small area shares. While Simpson's index expresses both richness and evenness, it is "heavily weighted toward the most abundant species in the sample while being less sensitive to species richness" (Magurran 1988: p. 40). This means that the underlying spatial distribution is important in determining whether the index has a high value or not.

Stage 1: Agricultural cooperatives and wheat diversity

To select an appropriate specification for the wheat diversity—cooperative density relationship, different models were estimated. The Reset test, the Akaike test and A-memiya test were used to compare alternative model specifications.[3] As in the case of the adjusted *R* squared, Akaike and Amemiya tests incorporate the trade-off between parsimony and goodness of fit.

The linear model exhibited the better statistics. Let C represents the cooperative density:

$$D = a_0 + a_1 C + v_{it}. \tag{1}$$

Stage 2: Wheat diversity and productivity

In agricultural productivity analysis, a range of mathematical representations of the production technology has been invoked (Mundlak 2001). Here, a standard Cobb-Douglas production function has been applied. Along with a set of conventional inputs and a control variable for rainfall, spatial diversity of durum wheat was added separately as an explanatory variable.

Let y = f(x) denote the production function, where y is quantity of durum wheat and x is a n x 1 vector of inputs. In the single output case, the Cobb-Douglas production function is written as:

$$y = A\Pi_{i=1}^{n} x_i^{\alpha_i} \text{ where } \alpha_i > 0, \forall\, i = 1, \ldots, n$$

[3] We also tested a quadratic and a cubic relationship.

By taking logarithms we have an expression that is linear in parameters,

$$\ln(\mathrm{y}) = \alpha_0 + \alpha_i \Sigma_i \ln(\mathrm{x}_i) \tag{2}$$

where $\alpha_0 = \ln(\mathrm{A})$

This implies that $((\partial \mathrm{Y}/\partial \mathrm{x}_i)/(\mathrm{Y}/\mathrm{x}_i)) = \alpha_\mathrm{i}$. The estimated *i*th coefficient can be readily interpreted as the marginal productivity of the *i*th input. The Cobb-Douglas specification imposes unitary elasticity of substitution between inputs. In order to relax this property an interaction term was added. Since the fit of the model was not more robust in the more flexible case than it was with the standard specification, the assumption of unitary elasticity did not constrain the estimation.

4.3 Analysis

The data set is a cross-sectional time series, suggesting that the use of panel analysis is appropriate. Panel data analysis improves reliability of estimates, and can control for individual heterogeneity and unobservable or missing values (Baltagi 2001). Fixed and random effects eliminate problems arising from stochastic trends that are specific to a variable, but cannot eliminate those related to specific regions (Hsiao 1986). In order to eliminate regional stochastic trends in the variables, a First Difference Estimator was used. Let Y_{it} be the dependent variable and X_{it} a set of explanatory variable, hence

$$\mathrm{Y}_{it} = \mu_i + \mathrm{X}_{it}\beta + \mathrm{v}_{it}.$$

Taking the first difference, the equation becomes,

$$\Delta \mathrm{Y}_{it} = \beta \Delta \mathrm{X}_{it} + \Delta \mathrm{v}_{it} \tag{3}$$

Assuming that $\Delta \mathrm{v}_{it}$ are uncorrelated with $\Delta \mathrm{X}_{it}$, Eq. (3) may be estimated with OLS. This transformation eliminates the individual effects (Baltagi 2001) and reduces serial correlation. Moreover, if there are omitted integrated variables the First Differences Estimator is consistent. The approach does induce residual autocorrelation. Estimated models should therefore be tested for autocorrelation to control for this potential source of bias.

Different estimating procedures were tested. For instance, a dynamic panel data estimator (Arellano Bond 1991) was estimated, allowing for a lagged dependent variable and introducing instruments to address the potential endogeneity of processes affecting variety diversity and yield. In general, we found that the qualitative findings reported below were robust to this alternative estimation procedure. To save space, here, we present only the approach with two stages. The system results are available upon request.

5 Results

Table 6 reports the estimates of both Eqs. (1) and (2). The overall significance of each estimated equation is good. Cooperative concentration is correlated positively and significantly with regional levels of variety diversity in durum wheat. In regions where cooperative organizations are denser, levels of spatial diversity in durum wheat are also higher. Predicted levels of spatial diversity in durum wheat are positively and significantly related to productivity over the time period considered. Conventional inputs

Table 6 The effect of cooperative concentration on spatial diversity of durum wheat

Variables	Coefficent	Std. Error
First stage: Eq. (1)		
Constant	0.4	0.28
Cooperative Density	1.2***	0.22
Second stage: Eq. (2)		
Constant	−0.49***	0.12
Spatial diversity of durum wheat[a]	1.2***	0.18
Rain	0.0003	0.078
Pesticide	0.21***	0.092
Labour	0.15**	0.071

R^2: 0.4; F-test: 47.9* – R^2: 0.73; F-test = 31.27 * – Significance code:*** = 1%; ** = 5 %
White's standard errors were used
[a] Fitted value from the first-stage regression

such as labour and pesticide show the expected positive signs and are both statistically significant. Rainfall, although not statistically significant, has a positive impact on production. Heteroscedasticity was identified in both models, and was treated with White's standard errors. A Durbin Watson test was used to test for presence of autocorrelated errors. In the first step, the test score was 1.3, while in the second step, the test score was 2.1. Scores imply that the level of autocorrelation is not serious in the second stage while the test is inconclusive in the first.

6 Conclusions

This paper has considered the impact of cooperative of production on the diversity of durum wheat in regional crop productivity in southern. Given the aggregate nature of the data, first differencing techniques have been used to eliminate regional stochastic trends and improve the estimation.

Findings demonstrate two very important points regarding sustainable management of crop genetic resources on farms and economic change. First, our analysis supports the idea that one type of institution, a processing and marketing cooperative, has an effect on the diversity of varieties grown at a regional scale in an economically marginalized region of a high income country. The conservation of durum wheat diversity in a major crop-producing region of southern Italy (and the European Union, for that matter) is an increasing function of cooperative density. Second, the strong and positive marginal effect of evenness in the spatial distribution of varieties (including both landraces and modern varieties) on the regional productivity of durum wheat from 1980 to 1993 is a salient finding.

We explain these findings in the following way. These cooperatives enable individual farmers to capture more of the value of the final product and better meet the demand of local consumers through reducing the costs of transactions. Local consumers, unlike distant consumers, prefer bakery products made from durum wheat. Different wheat varieties are used and mixed to produce various, locally preferred products. Though farmers do not purchase seed through their cooperative, localized production and marketing contributes to a more even pattern of varieties distributed across the wheat-producing landscape. Since most farmers in this region have grown wheat for many years and a number of the varieties are older and well-known, it is likely that farmers are also maximizing yields under local conditions. These two factors—localized demand and localized production environments—explain, in turn, the positive relationship of variety evenness to regional yields.

Although our study is based on data from southern Italy, findings have more general interest. In marginalized regions of the world where a cooperative structure would enable farmers to gain revenues and reduce marketing costs, and consumer demand is localized, promoting cooperatives might also generate a positive externality of maintaining variety diversity. To the extent that variety diversity also improves overall yield performance through genetic processes, it may also contribute to sustaining regional yield levels.

In any region of the world, whether marginal or not, the findings lead to two general hypotheses. One is that "buying local" can support diversification at a regional level, to the extent that production conditions and/or consumer tastes continue to be heterogeneous. A second is that even where demand is less localized but the tastes of distant consumers remain heterogeneous, given that product differentiation also reflects variety diversification, markets can support the maintenance of diversity. Of course, differentiation of consumption attributes and quality may not always be associated with other genetic differences that are of significance for farming system sustainability or resilience. Demand for differential agronomic traits depends on the production environment of farmers and the extent to which they rely on genetic traits, rather than purchased inputs, to combat biotic and abiotic pressures.

Nonetheless, if either of these two hypotheses is borne out, the implication is that economic change and market development does not necessarily cause the loss of diversity in a crop. Policies that serve to enhance cooperative formation, reduce the cost of membership of cooperatives, or the cost of coordination have encouraged the cultivation of a diversity set of durum wheat varieties over the time period studied. This result is of particular interest in the light of the reformed CAP. For instance, because of reduced price supports, farmers will need to implement strategies that create added value and increase their competitiveness. Cooperatives or association of producers allow farmers to process and market their product under conditions that would be not possible for a single producer.

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