On the Role of Agricultural Institutions in Sustaining Wheat Biodiversity: The Case of Cooperative in Southern Italy

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Abstract

This paper presents an empirical study of the role of agricultural cooperatives in sustaining regional levels of crop biodiversity in southern Italy, a mega-diversity spot and centre of diversity for durum wheat. Institutional structures, such as agricultural cooperatives, can influence aggregate levels of crop biodiversity through food processing and marketing functions. Crop varieties differ in qualitative characteristics. These qualitative differences can create a farmer demand for differentiated seed types, derived from processor and consumer demand for differentiated products. The diversity of crop varieties can affect the productivity of a cropping system. These hypotheses are tested using 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 higher levels of wheat diversity, and that wheat diversity is positively correlated with medium run productivity.

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This paper presents an empirical study of the role of agricultural cooperatives in sustaining regional levels of crop biodiversity in southern Italy, a mega-diversity spot and centre of diversity for durum wheat. Institutional structures, such as agricultural cooperatives, can influence aggregate levels of crop biodiversity through food processing and marketing functions. Crop varieties differ in qualitative characteristics. These qualitative differences can create a farmer demand for differentiated seed types, derived from processor and consumer demand for differentiated products. The diversity of crop varieties can affect the productivity of a cropping system. These hypotheses are tested using 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 higher levels of wheat diversity, and that wheat diversity is positively correlated with medium run productivity.
Keywords: Crop Biodiversity, Productivity, Agricultural Institutions

Introduction

Agricultural biodiversity is defined as a component of biodiversity, referring to all diversity within and among species found in crop and domesticated livestock systems, including wild relatives, interacting species of pollinators, pests, parasites, and other organisms (Qualset et al., 1995; Wood and Lenné, 1997; Convention on Biological Diversity). Genetic diversity is the genetic information that is contained in the genes of individuals of plants, animals and micro-organisms. Species diversity is the diversity of species within which gene flow occurs under natural conditions.

Different components and levels of agricultural biodiversity are interlinked. For instance, the narrow genetic base of major crops, and the concentration on a small number of crops can increase vulnerability to pests and pathogens, contributing to yield variability (National Research Council, 1972). This is because the greater is the diversity between or within species and functional groups, the greater is the tolerance or resistance to pests. Pests have more ability to spread through crops with the same genetic base or genetic sources of resistance (Priestley and Bayles, 1980; Sumner, 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 and ensures that "whatever the environmental conditions there will be plants of given functional types that thrive under those conditions" (Heal, 2000).

Few studies have investigated the relationship between crop yields and genetic diversity using standard production, cost, or profit function analyses. In a study of the Punjab of Pakistan, Smale et al. (1998) related wheat productivity to several indicators of genetic diversity 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 productivity. 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). They 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 the number of planted varieties reduced both the mean and the variance of yields, although the effect on variance was not statistically significant.

Meng et al. (2003) modeled 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 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 probably one of the driving forces of diversity loss or conservation. 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, formal agreements, but also of informal constraints, such as more general customs or codes of conduct.

In this paper we use a formal econometric modelling of diversity-productivity relationships, but we also address the role of one type of institution—agricultural cooperatives—in sustaining regional levels of crop biodiversity. We use an analysis conducted at the regional level to test 1) the relationship of cooperative organization of production and marketing to levels of crop biodiversity, and 2) the relationship of crop biodiversity to productivity. Data are drawn from southern Italy, an important area for cereal production in Europe. 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 crops.

The following section presents the conceptual background to this study, explaining the research interest in cooperative behaviour. This is followed by a site description, presenting the historical context of cooperatives and cereals production in southern Italy. The empirical approach used to investigate the relationship of cooperatives to cereal biodiversity levels, and the relationship of diversity to productivity, is summarized. Analysis is based on regional, time-series data. Findings are then discussed, and conclusions are drawn in the final section.

Conceptual background

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, using district-level data. 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 in that lower income nation.

The analysis by Heisey et al. assumed that each farmer acted without the knowledge of other farmers' actions or the interests of other farmers in mind. In contrast, this analysis asks the question: does the institutional structure that conditions farmers' choices affect the genetic diversity of the crop they cultivate? Genetic diversity is a club good (a type of impure public good), for which the level is determined by the actions of the members of agricultural cooperative.

A cooperative is a voluntary group of individuals who derive mutual benefit from the coordination of production decisions, shared access to inputs, enhanced market power and more effective lobbying capacity. The cooperative can process the crop and market the product in order to create added value and to distribute the revenues to members. From the cooperative perspective, having crop biodiversity implies capability to produce different products. Crops are the raw material for food processing. Variety diversity can imply product diversification.

In the case of wheat, the members gather their harvests at the end of the season and transfer the crop to the cooperative. Wheat constitutes the raw material for a wide range of bakery products. The cooperative can process the wheat and market the final products, distributing the revenues to members. Different wheat varieties have different qualitative characteristics, such as protein content, colour, and grain moisture, or humidity. These qualitative differences can create a demand at the farm level for differentiated seed types, derived from processor and consumer demand for differentiated products. Therefore, institutional structures such as cooperatives or producer associations might play an instrumental role in influencing crop biodiversity levels within a region.

In turn, the level of crop biodiversity may positively affect crop productivity in that region over the medium and longer-term. Maintaining crop biodiversity in crops can affect the sustainability of a cropping system. 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). This reasoning leads to the hypothesis that, under certain market conditions, agricultural cooperatives can represent a viable way to internalize some of the economic and ecological benefits of biodiversity.

In terms of diversity measurement, the analysis conducted by Heisey et al. 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. Here, genetic diversity is captured by the Simpson index, measuring the proportional abundance of durum wheat varieties grown in southern Italy. The index of genetic diversity encompasses both landraces and modern varieties, spanning improvement status.

Site description

Economic, cultural and climatic characteristics make agriculture an important sector in southern Italy. Agriculture accounts for 8% of overall European Union agricultural land (in the 8 southern Italian regions) and the average ratio of added value in agriculture against added value in industry is 0.4 from 1960 to 1993. During the time span considered here, the study regions were all designated “Objective 1” for development by the European Union. 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, warm weather in southern 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 nation's staple food, pasta. 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 Sicilia, for example, farmers often grow more than one durum wheat variety at a time, driven by a combination of heterogeneous agro-ecological 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 to food processors. Table 3 lists some of the varieties of durum wheat grow in the study regions from 1970 to 2000 by improvement status. Although the adoption of newer varieties (e.g. Ciccio, Gianni, Colosseo) is increasing rapidly, some farmers' varieties (e.g. Russello, Timilia) are 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 found that genetic variability in Italian durum wheat have been constant through the breeding process in the last century (Martos et al.).

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. 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 have a common property regime for some fixed capital, such as threshing machines. Each cooperative can market the harvest as a monopsonist vis-à-vis its members. In some cases, the cooperative mediates with respect to its members in a bargaining process with the agri-food industry; in others, the cooperative processes the crop. When cooperatives intermediate with the agri food industry, they influence the payoff to members because the price paid by the industry to the farmers is determined by the cooperative's bargaining power. The bigger the cooperative, the bigger is its marketing and negotiating power. Potential for market power is amplified if one considers that because of tariffs in the European Union and protection, the food industry is unable to buy cereals from non-EU countries.

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.

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[1]. Though the regional level of aggregation is driven primarily by the structure of the secondary data that was available, data on wheat diversity is recorded only at regional level.

This level of aggregation is also defined by the nature of the problems presented in this book. Understanding differences in levels of biodiversity, and the way that explanatory factors influence these levels as the scale of observation and analysis changes from farmer, to village, district, and region, is important for the design of programs to support sustainable management of plant genetic resources. In the 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 cooperative power at the regional level. 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.

The ecological literature has developed many metrics to represent diversity concepts and methods for calculating them. In agricultural systems, one of the most commonly adopted measures of diversity is spatial diversity. Spatial diversity refers to the amount of diversity found in a fixed geographical area. In this study, the Simpson index of proportional abundance has been used to measure the diversity of durum wheat. The Simpson index formula is generally given by:

$$S = \Sigma\, p_i^{\,2}$$

where p_i is the population share of the *i*th species in a reference region. In applications to cultivated cereals with constant seeding rates, the Simpson index can be expressed as the sum of squared shares of crop area planted to each variety. Area shares represent population shares. Here, p_i is the area in durum wheat planted to the *i* th variety. An index value close to one indicates that almost all of the crop area is allocated to one single variety. Instead, when the index is close to zero a large number of varieties is planted on very small area shares. To simplify its interpretation, the Simpson index can be expressed as D = 1/S.

The Simpson index is "heavily weighted toward the most abundant species in the sample while being less sensitive to species richness" (Magurran, 1988: p. 40). In our database, however, no single variety dominates crop area. Farmers grow a large number of wheat varieties in each region, each year.

Stage 1: Crop biodiversity and cooperatives

To select an appropriate specification for the wheat diversity – cooperative density relationship, different models were estimated and tested. The Reset test, Akaike and Amemiya tests were used to compare alternative model specifications. 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 :

$D = a_0 + a_1 C + v_{it}$ (1).

Stage 2: Crop biodiversity 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, crop biodiversity 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:

$$y=A\Pi^{n}_{i=1} x_i^{\alpha_i} \text{ where } \alpha_i>0, \forall\ i=1,...,n$$

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

$$\ln(y) = \alpha_0+\alpha_i\Sigma_i \ln (x_i) \quad (2)$$

where $\alpha_0 = \ln(A)$

This implies that $((\partial Y/\partial x_i)/(Y/x_i))=\alpha_i$. 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.

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

$$Y_{it}=\mu_i+ X_{it}\,\beta + v_{it}.$$

Taking the first difference, the equation becomes,

$$\Delta Y_{it} =\beta\, \Delta X_{it} + \Delta v_{it} \quad (3)$$

Assuming that Δv_{it} are uncorrelated with ΔX_{it}, equation (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) allowing for a lagged dependent variable and instrumeting biodiversity to control for potential endogeneity was set up. In general, we found that the qualitative findings reported below were robust to this alternative estimation procedure. However, the estimated coefficient of wheat diversity was consistent with the first in difference method. To save space, here, we present only the approach with two stages. The system results are available upon request.

Results

Table 4 reports the effects of cooperative concentration on wheat diversity of durum wheat measured at the regional level in the southern Italy. The overall significance of the model 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 biodiversity in durum wheat are also higher.

Table 5 reports the result of the production function estimation in the second stage. The overall fit of the second-stage regression model is also good. Predicted levels of durum wheat diversity are positively and significantly related to productivity over the time period considered. Conventional inputs 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 found in both models, and was treated with White's standard errors. Autocorrelation was tested using a Durbin Watson test. In the first step, the test score was 1.3, while in the second step, the test score was 2.1. This implies that the level of autocorrelation is not serious in the second steps while the test is in the incoclusiveness region in the first step.

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 that in areas of Italy that are economically more marginal, such as southern regions, cooperatives can play a role in maintaining variety diversity in a major crop. This finding likely reflects the role of cooperative production and marketing in highly differentiated industry for the food staple, durum wheat. Durum wheat varieties have characteristics that relate to quality in end-use, such as protein content, colour, and grain moisture content, or humidity. These qualitative differences are related in turn to product differentiation. Consumer demand for a range of wheat-based food products drives the food processing industries to acquire several varieties of crops, each having a slightly different combination of properties. In Italy, the agri-food industry can require diversity in durum wheat and other cereals to satisfy diversified consumer demand for quality food.

Although our study is based on data from southern Italy, findings have more general interest. Indeed, as consumer demand for differentiated products increases and is transmitted through markets, to the extent that product differentiation reflects variety diversification, economic development can have a beneficial impact on crop 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. Clearly, organizations that are involved in processing and marketing, such as cooperatives or producer associations, can be unintended but important determinants of crop diversity levels

It is important to recognize that this finding reflects the well-articulated (in market prices) consumer demand for food products found in advanced industrial economies with high incomes. The cost of the market infrastructure that supports this differentiation is borne by consumers, and in this case study, has the positive externality of supporting regional diversity levels. In less industrialized agricultural economies, and countries with lower incomes, such market infrastructure does not yet exist and it would be costly to construct solely for the purposes of maintaining crop biodiversity on farms.

Furthermore, keeping crop biodiversity appears to positively affect medium-to-long run productivity, at least at the aggregate level. Agricultural cooperatives could be a viable way to internalize some of the economic and ecological benefits of biodiversity. In other words, the cooperative can "internalise" the public good externalities of individual variety choice decisions, such as the genetic diversity that results on farms scattered across a crop-producing region. To test this hypothesis fully, relationships to yield stability or resilience would need to be investigated.

The policy implications of this case study are transparent. The conservation of durum wheat diversity in an important crop-producing region of southern Italy (and the European Union, for that matter) is an increasing function of cooperative density.

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.

In addition, the strong and positive marginal effect of variety diversity (including both landraces and modern varieties) on the long run productivity of durum wheat is a salient finding. The study contributes to the ongoing debate on biodiversity conservation by providing an empirical example from a high income, developed European country situated in a Vavilov mega-diversity spot and centre of diversity for durum wheat.

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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 – 1990

	% Cereals	% Durum Wheat
Abruzzi	0.37	24.42
Molise	0.44	38.89
Campania	0.36	28.23
Puglia	0.55	46.62
Basilicata	0.54	35.13
Calabria	0.38	20.24
Sicilia	0.45	38.36
Sardegna	0.28	23.71

Source: Authors' calculations using ISTAT data

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

Table 5. Variables definition

Variables	Definition
Durum wheat yield	Durum wheat output (tons/ha), by region and year
Cereal yield	Cereals output (tons/ha), by region and year
Pesticides	Pesticides use (100kg./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

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

Variables	Coefficent	Std. Error
Constant	0.4	0.28
Cooperative Density	1.2*	0.22

R^2: 0.4; F – test : 47.9* Significance code:

* = 1 % ; ** = 5 % with one tailed test

Table 7. Contribution of variety diversity and conventional inputs to durum wheat productivity

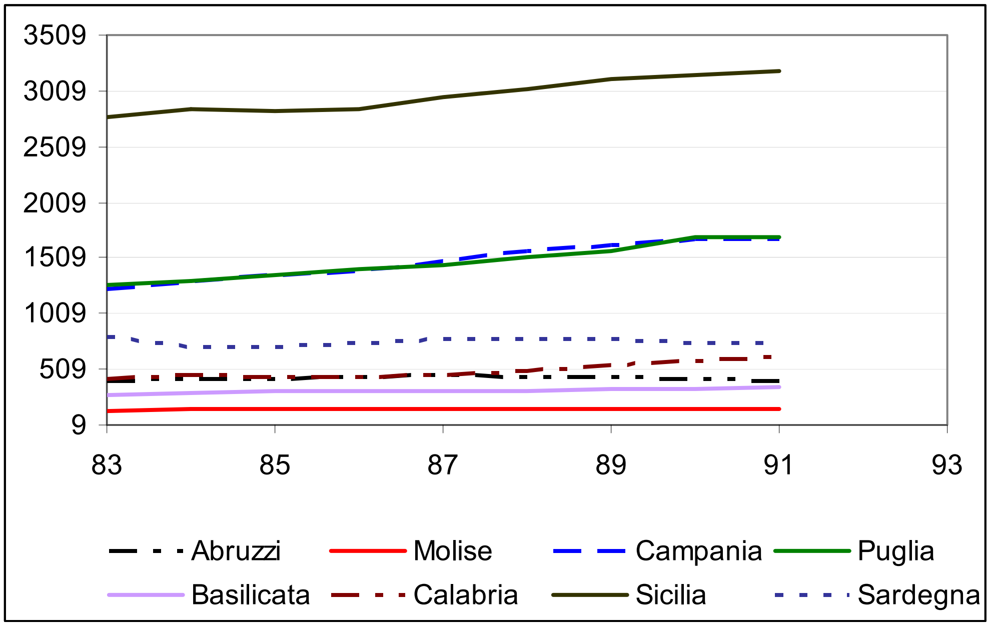
Variables	Coeffs	Std. Errors
Constant	- 0.49*	012
Variety diversity	1.2*	0.18
Rain	0.0003	0.078
Pesticide	0.21*	0.092
Labour	0.15**	0.071

R^2: 0.73; F-test = 31.27 *

Significance: *= 1 % ; ** = 5 % with one tailed test

Note: Variety diversity is the fitted value from the first-stage regression.

Figure 1. Number of agricultural cooperatives by region, 1983-1991



Source: Annuario dell' Agricoltura Italiana, INEA

[1] 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.