WHEAT PRODUCTION IN FASCIST PERIOD. A COMPARISON BETWEEN HIGH FARMING, LATIFUNDIUM AND SHARECROPPING USING THE CATASTO AGRARIO OF 1929

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Abstract. In the mid-1920s, the Kingdom of Italy was a strong importer of wheat; In order to reverse this deficit in the trade balance, the fascist regime decided to implement an agrarian policy aimed at achieving, within a few years, full self-sufficiency. This policy is remembered as the "battle for the wheat", which began in 1925 and was mainly directed by Arrigo Serpieri. The measures were aimed to increase the yields per hectare of wheat. The factors that had a positive impact were the progressive spread of mechanization in the countryside, the use of chemical fertilizers, the widening of land credit and the use of selected seed. The present work will analyze the effects of the fascist politics in the first period using the data coming from the *Catasto Agrario* of 1929; the second experience of this kind after that of 1910. In this case, three case studies (Lombardy, Tuscany and Puglia) will be considered corresponding to three geographical areas of the country (Northern, Central and Southern) and three different forms of land management (high farming, sharecropping and latifundium). After an initial descriptive analysis with provincial data, the focus will be shifted on the yields per hectare by comparing the values of 1929 with the average values of 1923-28 using the data at the municipal level. It will try to understand if there is a link between the yield of wheat and its spread on the territory in the three different forms of conduction and, with different models of linear regression, it will go to identify which explanatory variables had a greater influence on crop productivity levels in different provinces.
Keywords: Agriculture, Fascism, Battaglia del Grano

INTRODUCTION

The literature has clearly defined how advanced agriculture is the prodrome for the start of an industrial take-off[1]. If for the northern-European states the start of a new economic cycle took place following the Industrial Revolution for the Italian case, recognized as a late comer, it was necessary to wait for the conclusion of the unitary process. On how and when industrialization began, the literature offers different methodologies of approach and finish points. After the spread of the quantitative methodology, the cliometry, the results of Fenoaltea appear to be the most satisfactory[2]. If the economist anticipated the Italian take-off at the end of the 1880s of the 19th century, however, it seems indispensable the thesis that sees in the period of the "belle epoque" the true and substantial growth of Italian agriculture; at least if it wants to compare it with the European standards[3]. As it has been widely demonstrated, the contingencies of the Great War led to slowing this process of expansion. Therefore, it seems more correct to talk about a slowing down than a real shutdown for the agrarian class managed to maintain a certain efficiency, which allowed it to start again decisively at the end of the Conflict, as recent territorial studies have shown.

The years following the end of the war were particularly heated and pervaded by strong social tensions and led the ruling class to reflect on how action could be taken to find a viable solution in relation to the demands of the agrarian population. The failure in the lands' re-distribution had fostered the increase of disagreements that during the conflict had been calmed by the contingencies of the war economy. At the end of the "Biennio Rosso" and with the rise to power of fascism, it was inevitable not to focus on the world of agriculture. In this regard, also through the use of propaganda, a series of policies were initiated that should ruralize Italy[4]. Mussolini was flanked by highly qualified technicians; and probably fascism benefited from the most dynamic and proactive minds in all those areas related to technical progress; this can also be found in the agricultural sector[5]. Regardless of the results, it is irrefutable that the fascist agrarian policies were aimed at promoting the development of highly specialized agriculture. In this perspective, there is the so-called "Battaglia del Grano" whose purpose was the increase of the yields per hectare of cereal through the use of new techniques and the use of methodologies proper to applied sciences.

In this regard the goal of this paper is to analyze the effects of the wheat battle in three sample regions on a municipal scale: Lombardy, Puglia and Tuscany, as representing the different geographical areas of the peninsula and, at the same time, also of the three main forms of management characterizing the different "Agricultural Italie": high farming, latifundium and sharecropping[6].

[1] Clark. G. Agricultural and Industrial Revolution, 1700-1850. In Mokyr. J., eds., The british revolution. An economic perspective. Buelder: Westview Press; 227-266; 1993.
[2] Fenoaltea. S. L'economia italiana dall'Unità alla Grande Guerra. Roma: Laterza; 2006.
[3] Federico. G. Le nuove stime della produzione agricola italiana, 1860-1910: primi risultati e implicazioni. Rivista di storia economica, 19 (3): 359-382; 2003.
[4] Preti. D. La politica agraria del fascismo. Note introduttive. Studi storici. 14 (4): 803-869; 1973.
[5] Zanibelli. G. Scienza e sviluppo in agricoltura durante il fascismo. Physis. 1: 223-236; 2017
[6] Sereni. E. La questione agraria nella rinascita nazionale italiana. Torino: Einaudi; 1974.

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Through a predominantly quantitative approach, but in harmony with the traditional historical methodology, it will descend into the territorial microhistory to acquire additional elements in order to deepen the national dimension.
The contribution presents the following structure: a continuation of the contextualization of the historical period, a reconstruction and presentation of the used dataset, an analysis on the evolution of yields and finally some models will be presented to offer an economic and historical interpretation of the case study.
If, as we introduced, on the one hand, fascism really bet on the wheat battle, on the other, the historians always looked at the battle a traumatic phenomenon for the Italian agrarian economy[7], in particular by focusing on the slowdown in investment, economics and wood crops that made Italy a significant competitor in the international market for quality products. A process that had seen its take-off in the Giolitti's decade. Between 1891 and 1911 there had been an increase in agricultural production, in particular for some specialized products such as citrus fruits (116.75% lemons; 76.85% oranges). These must be added to the increase in potatoes (131.46%) and rice (54.86%); products such as wheat (31.08%) and corn (36.68%) and wine (61.34%) also showed a markedly positive increase, excluding oil that, instead, has a decrease (-11.61%). It treated about, then, a very prosperous scenario, also due to improvements, which are essential for shifting from an extensive to an intensive agriculture[8] system. This was also possible in land settling operations that led to an increase in arable land.
If, as it has been anticipated, the Great War slowed down agriculture by favoring traditional crops such as wheat, it must also say that the post-war situation was not flourishing for any of the countries involved, particularly Germany, whose economy came out destroyed by conflict. Notwithstanding its official victory in the war and the institutions' interventions in the attempt to contain the inflation always in rise since the beginning of the conflict, Italy did not present an economic situation of great prosperity. In addition, the instability of the "Biennio Rosso" years prevented *de facto* the propulsive climate of the propulsive period of the years before the First World War from reoccurring.
Once fascism came to power, it had to decide which way to go to try to revive agriculture, and the technocrats chose what seemed to be most viable one at that time, even on the basis of the echo these initiatives would have had all over the peninsula. Hence the idea of ruralizing Italy, but how could this process have taken place in a time frame useful to the propaganda machine? Agriculture in relation to other production sectors has a significant variable within the production function, the natural cycle; if, on the one side the natural cycle can be beneficial for the cultivations, on the other side, it often lengthens the times of an agricultural specialization process. It was therefore decided to invest in a crop that, thanks to the use of chemical fertilizers and scientific experiments, could soon bring the desired results to show that Italian agriculture had taken a significant step forward. Reducing the imports of wheat and increasing its production was also part of that classic "ruralismo" from the myth of Romanism that always influenced Fascism, and which was useful in promoting the spread of a newly found prosperity.
Whilst much has been looked at the "Battaglia del Grano" and its effects in the agrarian economy in relation to other crops, much remains to be seen on the variation in yields and variables that contributed most to the results which, although in good shape sample, have emerged from this work. These allow us to observe some aspects related to technical progress that would otherwise remain buried in the mists of a predominantly historical and political reconstruction of the case study.

DATA: THE *CATASTO AGRARIO* OF 1929

The source used for the research is the *Catasto Agrario* of 1929, a survey edited by ISTAT in the period 1928-1930 (ISTAT, 1933-1936)[9]. A volume for each province of the Italian Kingdom was published with detailed descriptive data of the agricultural situation. The 1929 *Catasto* is the second example of such detection, after the similar one in 1910, both essential sources for the study of the Italian agriculture in the first thirty years of the 20th century. The *Catasto* presents itself as a real inventory of all the areas and productions of the Italian agriculture providing, at a municipal level or agricultural area, a series of data on agricultural and forest area, area dedicated to individual crops, yield average per hectare of crops, number of farms and others[10].
For the purposes of this study, the volumes of the *Catasto* of the provinces of three regions were taken into account: Lombardy, Tuscany[11] and Puglia; The consultation took place on the online versions of the original printed publications on the website of the ISTAT digital library. The variables detected, at a provincial and municipal level, are as follows:

1. REGION
2. PROVINCE
3. AGRICULTURAL AND FORESTRY SURFACE
4. WHEAT SURFACE
5. YIELD PER HECTARE WHEAT IN 1929
6. YIELD PER HECTARE AVERAGE WHEAT 1923-1928

Data from 23 provinces and about 1.900 municipalities were collected.

[7] Profumieri. P. L. "La battaglia del grano": costi e ricavi. Rivista di Storia dell'Agricoltura. XI. 2: 53-72; 1971.
[8] Zanibelli. G. Le politiche agrarie e l'andamento della produzione nella Toscana meridionale durante la Grande guerra. Il caso della provincia di Siena. Storia Urbana. 162: 63-80; 2019.
[9] ISTAT (1933-1936). Catasto Agrario 1929. Roma.
[10] Albertario, P. Il nuovo catasto agrario. Giornale degli Economisti e Rivista di Statistica. 73: 349-370; 1933.
[11] Pazzagli. C. Per la storia dell'agricoltura toscana nei secoli XIX e XX. Dal catasto particellare lorenese al catasto agrario del 1929: Firenze; Olschki; 1973.

Table 1.
Wheat agrarian surface and yield per hectare from Catasto Agrario 1929

Type of management	Region	Province	Agrarian Surface (hectars)	%	Yield per hectar 1929	Yield per hectar 1923-1928	Var. %
CLatifundium	PUGLIA	BARI	71.486	*14,3*	12,9	9,5	*36,7*
		BRINDISI	31.136	*17,4*	13,3	8,0	*66,3*
		FOGGIA	192.954	*28,6*	16,8	13,5	*24,5*
		LECCE	18.474	*6,9*	9,6	6,5	*47,7*
		TARANTO	33.511	*14,2*	9,8	6,7	*47,6*
		TOTAL	**347.561**	***18,7***	**14,4**	**10,9**	***32,4***
High farming	LOMBARDIA	BERGAMO	24.148	*9,8*	24,9	17,7	*40,7*
		BRESCIA	44.053	*11,1*	24,3	18,1	*34,3*
		COMO	12.555	*7,4*	21,8	19,1	*14,1*
		CREMONA	32.239	*20,0*	31,5	25,2	*25,0*
		MANTOVA	50.169	*23,2*	23,4	17,6	*33,0*
		MILANO	52.681	*21,0*	24,5	20,8	*17,8*
		PAVIA	45.902	*16,8*	25,1	22,1	*13,6*
		SONDRIO	363	*0,2*	19,5	19,9	*-2,0*
		VARESE	6.539	*6,5*	20,8	17,9	*16,2*
		TOTAL	**268.649**	***13,3***	**25,0**	**20,1**	***24,6***
ShaecroppingC	TOSCANA	AREZZO	55.928	*18,3*	11,5	11,7	*-1,5*
		FIRENZE	67.951	*18,5*	12,5	12,3	*1,6*
		GROSSETO	58.649	*13,5*	11,6	10,7	*8,4*
		LIVORNO	16.315	*14,2*	13,5	10,9	*23,9*
		LUCCA	14.035	*8,6*	13,2	11,9	*10,9*
		MASSA CARRARA	6.365	*6,3*	9,1	8,2	*11,0*
		PISA	41.992	*18,3*	13,0	10,9	*19,3*
		PISTOIA	9.425	*10,4*	13,0	12,5	*4,0*
		SIENA	70.941	*19,7*	11,7	11,1	*5,4*
		TOTAL	**341.601**	***15,8***	**12,1**	**11,4**	***6,6***

Source: our elaborations on data of ISTAT, Catasto agrario 1929

3. Provincial data

In **Tab. 1**, the data on the agricultural area for wheat cultivation are shown in absolute value and as a percentage impact on the whole agricultural area. Only the integral surface, i.e., the one invested in the main crop, was taken into account, while the repeated surface was left out. Wheat has a fairly similar spread the territory of the three regions, with 18,7% for Puglia, 15,8% for Tuscany and 13,3% for Lombardy. At a provincial level, the highest incidence of wheat cultivation is found in Foggia (28,6%), Mantua (23,2%), Milan (21%) and Cremona (20%), while the lowest percentage incidences are in the province of Sondrio (0,2%, respectively), (the province is characterized by a predominantly mountainous territory furred by longitudinal valleys), Massa Carrara (6,3%) (also that province it has a predominantly mountainous and hilly territory), Varese (6,5%, province with predominantly hilly and mountainous territory) and Lecce (6,9%, although it is a province with essentially flat territory, is characterized by the spread only of the hard grain, being completely absent the tender one). It should be pointed out that, while in Puglia it finds diffusion both soft and hard wheat (the latter particularly widespread in *Capitanata* and *Salento*, and, in the Terra di Bari, in some common *Murge*), in the other two regions only soft wheat is cultivated.

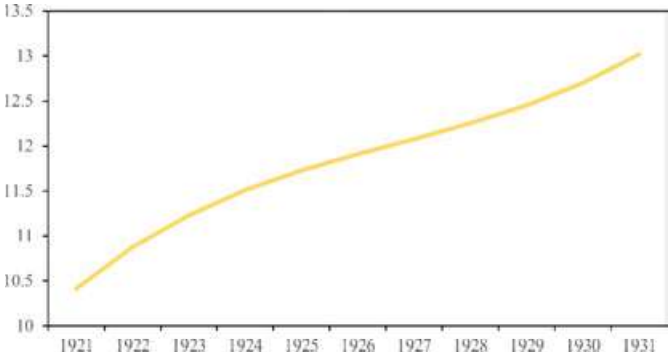
Surely the most important crop, both because it is present in a significant way in all regions, but also from an economic point of view, is that of wheat. The gap between Lombardy, with its intensive agriculture, Puglia with the latifundium and Tuscany with the sharecropping is quite obvious, the yields per hectare are respectively: 25, 14.4 and 12.1, while the interprovincial differences appear almost irrelevant. The fascist autarchic policy was determined to achieve self-sufficiency in the wheat production through a propaganda and a series of interventions starting in 1925 (c.d. battle of the wheat). Serpieri's policies brought considerable dynamism, also by promoting the dissemination of agricultural knowledge through prizes and exhibitions on a territorial scale. The food self-sufficiency thus became the workhorse of fascism[12]. To this, it must also

[12] Vaquero Piñerio. M. Rastrellare il Grano. Gli ammassi obbligatori in Italia da Fascismo al dopoguerra. Studi Storici. 148: 257-292; 2015.

be added that it was necessary to reduce the imports of cereals, which had a significant impact on the trade balance[13]. The measures were aimed at increasing production not so much with the expansion of the area to be allocated to wheat, but above all with an improvement in yields per hectare. Factors that had a positive impact, as often reported in the provincial volumes of the *Catasto Agrario*, were the progressive spread of mechanization in the countryside, the increase in the use of chemical fertilizers, the enlargement of land credit and selected seeds[14]. If we look at the productivity trend per hectare of wheat (Fig. 1) in the decade 1921-1931 it immediately notices a growing trend going from the initial 10.5 to the end 13. The agrarian policy of the fascist regime, in the short term, seemed to be successful, but it resulted in a significant reduction in the yields of other crops such as olive and vine. **Tab. 2** shows data of a linear regression in wheat production and imports in Italy on the *WheatBatt* dummy variable is 1 in the years following the "Battaglia del Grano" and 0 in previous years. As it can see in both cases, the model is significant, especially in terms of production, highlighting the positive effects of the fascist agricultural policy in the short term. **Figure 2** shows the graph of the yield per hectare of wheat in some European countries between 1889 and 1939[15]; it immediately emerges that the yield in Italy was significantly lower than in other more developed countries such as England, France and Germany, but surely higher than a country almost similar in agriculture and development process types, such as Spain. This confirms to us how it seems more significant to compare the Italian case with those realities having strong similarities with those of the Peninsula in respect to advanced agriculture types, such as those in Northern Europe.

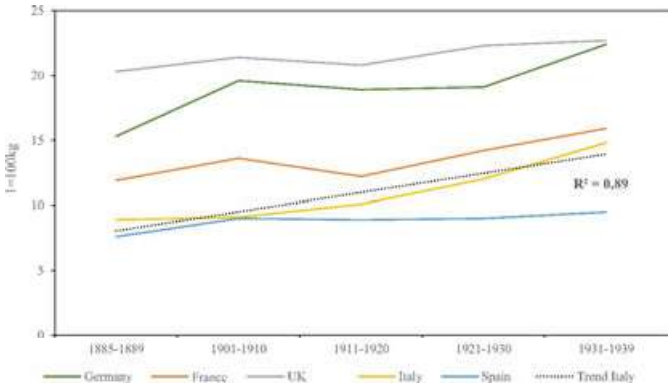
The average production of wheat per hectare is reported as growing in all the three regions: 32,4% in Puglia, where yields continue to remain low compared to intensive agriculture such as Lombardy (24,6% in Lombardy and only 6,6% in Tuscany); this is because, as it was well emphasized by Galassi, the sharecropping already had a form of efficiency within it, and it seemed difficult to increase the yields for the structure of the system itself[16]. It is during this period that it is interesting to study the Tuscan agricultural system, in order to see the various stages of the introduction of mechanization in the territory; in two provinces only, there is a decline in yields: Sondrio (-2%), characterized by a predominantly mountainous territory, and Arezzo (-1,5%). In Puglia the largest increases occur in the provinces of Salento.

Figure 1.
Trend of wheat yield per hectar *in Italy from 1921 to 1931*



Source: our elaborations on data of ISTAT, http://seriestoriche.istat.it/

Figure 2.
Wheat yield per hectare in some European Countries 1889-1939



Source: Our elaboration on Pinilla (2004).

Table 2.
Wheat production and import in Italy: before and after the "Battaglia del Grano"

	Production	Import
(Intercept)	46.735***	20.123***
	(2.241)	(1.848)
Dummy WheatBatt	20.958***	-7.004**
	(3.068)	(2.531)
R^2	0,62	0,21
R^2 adjusted	0,61	0,18
F statistic	46,45***	7,659**
N. obs	30	30

Source: our elaboration on dati of ISTAT, *Catasto agrario* 1929. Notes. Signif. codes: 0 '***' 0,001 '**' 0,01 '*' 0,05 '.' 0,1 ' ' 1.

[13] Segre. L. La battaglia del grano. Depressione economica e politica cerealicola fascista: Milano; Unicopli; 2012.
[14] Bertini, F. La Confederazione degli agricoltori dal 1930 alla Repubblica di Salò. In S. Rogari., eds., La Confagricoltura nella storia d'Italia: dalle origini dell'associazionismo agricolo nazionale ad oggi. Bologna: IlMulino; 1999: 277-402.
[15] Pinilla. V. Sobre la agricultura y el crecimiento económico en España (1800-1935). Historia Agraria. 34: 137-162; 2004.
[16] Galassi. F., Cohen, J.S. La agricultura italiana 1860-1930: tendencias de la producción y diferencias en la productividad regional. In L. Prados de la Escosura and V. Zamagni., eds., El desarrollo económico en la Europa del sur España e Italia en prospectiva histórica. Madrid: Alianza; 1992: 140-170.

The yield per hectare: an analysis

The present paragraph is dedicated to a specific topic in the field regarding the wheat yields per hectare. The reasons for such a specific choice are to be found in the importance of the cultivation under an economic perspective. First, it needs to remind that the fascist regime, through the so-called "Battaglia del Grano" implemented an agrarian policy aimed at achieving cereal self-sufficiency in our country[17]; in addition, wheat is the only crop, among those examined here, to be present to a significant extent in all the three regions, also allowing to assess the effects of the three different forms of agricultural management.

The localization quotients[18] were calculated by comparing some size (number of farms per municipality, average agrarian area per farm, percentage incidences of crops and yields per hectare) at a municipal level (i) with the corresponding at the level regional (j):

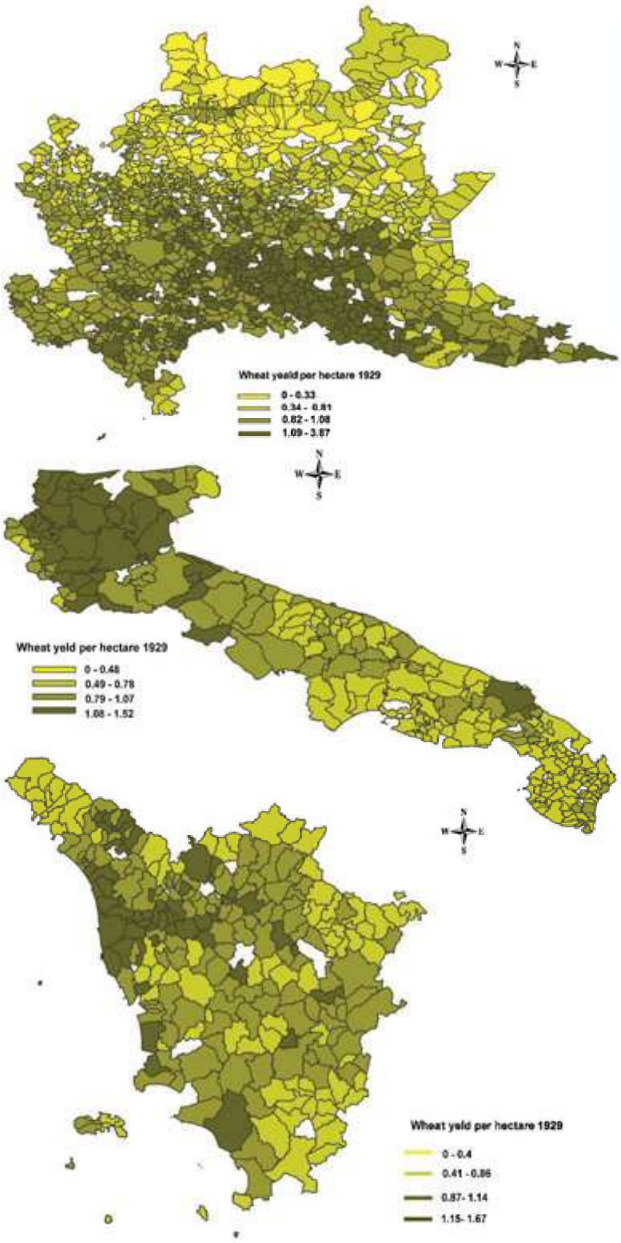
$$Q_i^j = \frac{A_i^j \; B_i}{A^j \; B}$$

These indicators allow to measure and identify those municipalities which, within a region, present a particular concentration of the phenomenon and, therefore, are far from the average regional profile; they can also be interpreted as a measure of specialization. In the event that Qij>1 the municipality i.esmo of the j.th region presents a specialization with respect to the overall regional context for the variable examined. Moreover, as they are pure numbers and the effect of the different average value at a regional level is eliminated, I allow for a better comparison. From the cartograms, (**Fig. 3**) it emerges that the provinces specialized in the cultivation of wheat are Foggia, the Padane provinces of Lombardy: Cremona, Mantua, Milan and Pavia, which are all flat areas and historically characterized by wheat production; In Tuscany, provinces specializing in the cultivation in question do not seem to emerge.

Analyzing the provincial data, it has already been seen that yields per hectare between 1923-28 and 1929 increased. Here it wants to use the data at a municipal level, comparing in a scatterplot the yields of the two historical periods (**Fig. 4**).

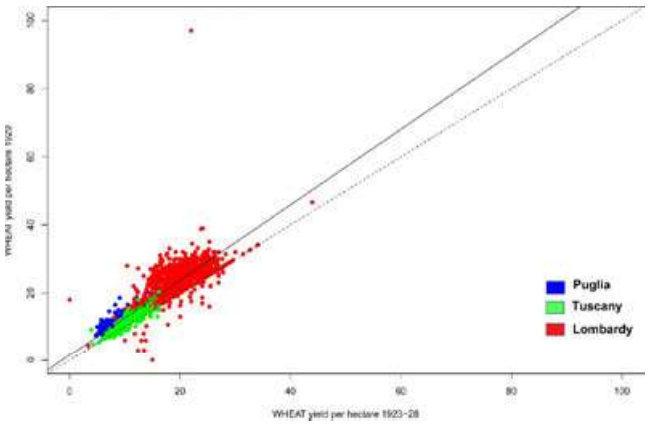
On the axis of the *x* it is reported the yield of the initial period (1923-28), while on the orderly axis that of the final period (1929); In blue are indicated the municipalities of Puglia, in green the Tuscan ones and in red the Lombardy ones. There are also two lines: the dotted one is the bisector, the points that are above this indicate that an improvement in yield for the municipality, while the continuous one is the regression line expressing an indication of the average growth between the two periods with an angular coefficient of 1,189546, from which an average growth of 18,9% can be retrieved; the points above the regression are those pertaining to those municipalities for which the yield has increased more than the average of the data of the three regions. The increase in municipal yields is not uniform in the

Figure 3.
Wheat yield per hectare 1929 in Lombardy, Puglia and Tuscany, municipal level



Source: our elaboration on data of ISTAT, *Catasto agrario* 1929

Figure 4.
Wheat yield per hectare average 1923-28 vs 1929.

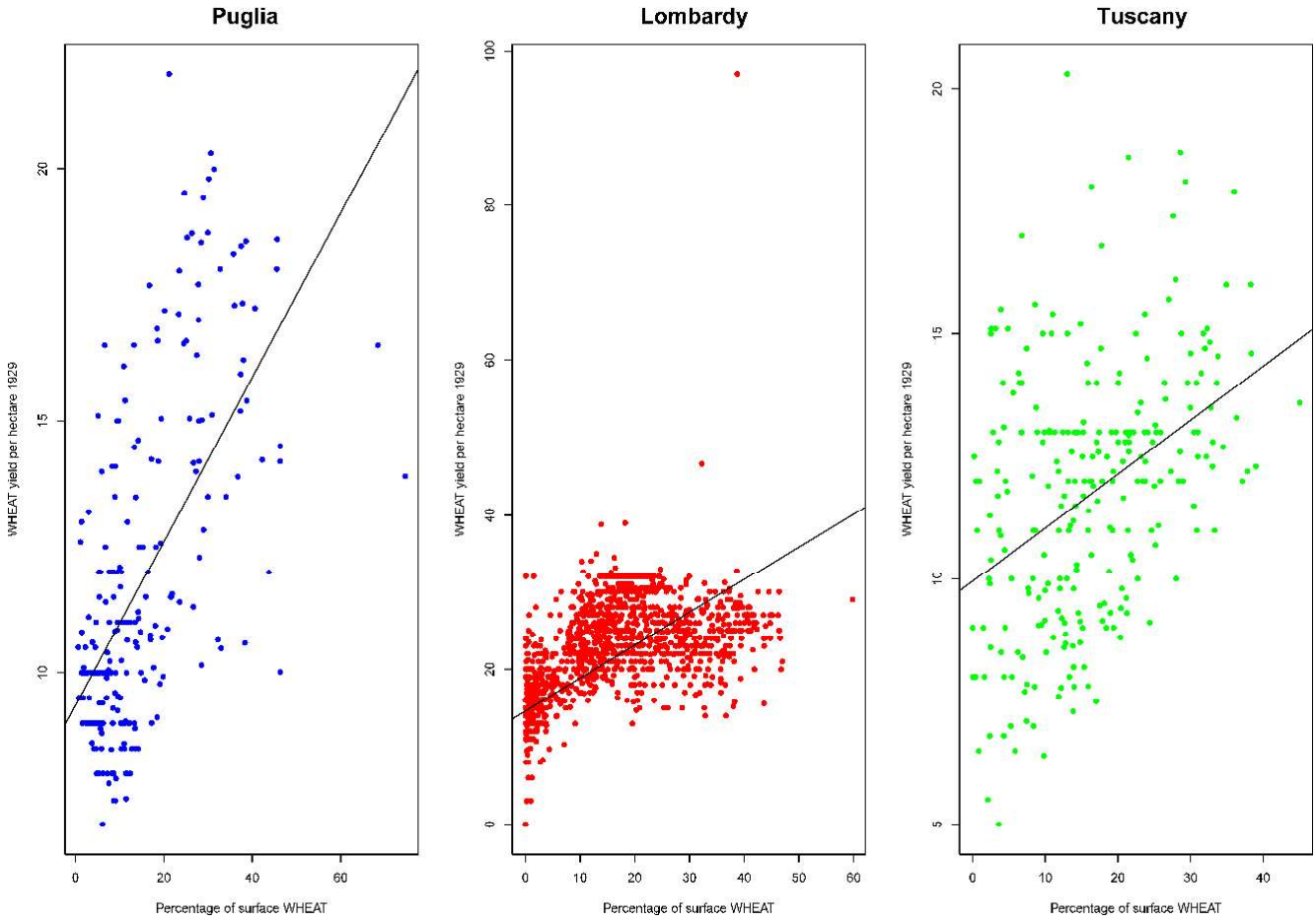


Source: our elaboration on data of ISTAT, *Catasto agrario* 1929

[17] Nützenadel. A. Economic Crisis and Agriculture in Fascist Itay, 1927-1935. Some New Considerations. Rivista di Storia Economica. 17 (3): 289-312; 2012.

[18] Marbach, G. Statistica economica: Torino; UTET; 1991.

Figure 5.
Wheat yield per hectare vs wheat percentage agrarian surface in Puglia, Lombardia and Toscana



Source: our elaborations on data of ISTAT, *Catasto agrario* 1929

three regions: in Puglia in 98,8% of municipalities there is an improvement in productivity per hectare, whilst in Lombardy this percentage is lower and equal to 85,7% and in Tuscany to 79,7%. The Puglia case is symptomatic, for it shows a good response to rural policies, and the same reasoning can be extended to Lombardy. Although the Tuscan case has its own peculiarities, already stated above, it is noted that the percentage change is significant and this allows us to say, that, even if the sharecropping soured by nature an efficiency within it, there was a rural sector's effort to enhance cereal farming by showing a similarity to the national trend. However, if it examines how many municipalities have grown more than the average, it is that they are 91,7% for Puglia, 46,5% for Lombardy and only 18,1% for Tuscany. These percentages show that the increase in yields per hectare of wheat was particularly strong for Puglia, a region presenting the lowest average yield in the period 1923-28 and, therefore, with better room for improvement.
Another aspect of yields that has been addressed is the verification of, whether or not, there is a link between the percentage incidence of the area destined for wheat and the yield of the same crop per hectare, i.e. whether or not the largest or least spread over the territory of the crop affects yield levels. Figure 5 shows the scatterplots of the regions under examination.
In **Tab. 3**, it is reported the regression data between the two variables. It can immediately observe that there is a positive relationship between the spread of culture and productivity per hectare in all the regions examined, albeit with some differences. Before proceeding with the analysis of the models, it is important to remember, that the incentive to grow yields could also be attributable to the prizes of the various competitions on productivity[19]. In particular, by examining the parameters of the regression lines, a different value is found in the intercept reflecting the different value of yield per hectare in the regions; The highest regression coefficient is recorded for Lombardy, where an increase of 1% in the cultivated area averages (0,425) tons in yield, while Puglia (0,163) and Tuscany (0,110). If, on the other hand, it intends to measure the intensity of the bond through the R^2 determination coefficient, the highest value is for Puglia, with 0,392, slightly lower than that of Lombardy (0,339), while that of Tuscany is almost completely irrelevant. It can admit, therefore, that there is a direct link between the two variables, and it has a level of intensity of a certain importance, although below the 0.5 threshold, for regions characterized by extensive and intensive agriculture, while the bond is practically negli-

[19] Cohen, J.S. Fascism and agriculture in Italy: Policies and consequencies. Economic History Review. 32 (1): 70-87; 1979.

gible in the case of the Tuscan sharecropping. This is because Tuscany had a defined and consolidated territorial connotation over the time. The regression also confirms that productivity was still linked to typical characteristics that prevented a momentum comparable to that of other systems; to this must be added the peculiarity of the work factor. It is therefore clear that in this first phase of the verification of the effects of ruralism, the sharecropping system, notwithstanding the improvements seen above, was already efficient, and such a model of conduct could hardly lead to the hypothesis of a yields' exponential growth.

Table 3.
Estimates of parameters of linear regression wheat yield per hectare vs wheat percentage agrarian surface in 1929 per region

Predictors	Lombardia	Puglia	Toscana
(Intercept)	14,604***	9,351***	9,951***
	(0,3166)	(0,250)	(0,290)
% wheat surface	0,425***	0,163***	0,11***
	(0,0162)	(0,013)	(0,015)
Observations	1351	241	160
R^2	0,339	0,392	0,166
R^2 adjusted	0,338	0,389	0,162

Source: our elaborations on data of ISTAT, Catasto agrario 1929;
Note. Signif. codes: 0 '***' 0,001 '**' 0,01 '*' 0,05 '.' 0,1 ' ' 1

The Linear regression analysis was also used with the provincial data, using the 1929 wheat yield per hectare as a response variable together with some explanatory variables that can affect yield levels at a provincial level. It has already been seen in a previous paragraph how the determinants that positively influenced, as often reported in the provincial volumes of the *Catasto Agrario*, were the progressive spread of mechanization in the countryside, the greater use of fertilizers enlargement of land credit, the use of selected seeds. Among these variables, the only one for which data are available for all the provinces is the amount of chemical fertilizers used; A number of inputs have been taken into account: agricultural workers and livestock, the latter, at the time, was also an important workforce on many farms; only at an example level, it is found that in 1929 in the province of Foggia there were 5,482 agricultural vehicles, instead in the Padane provinces of Cremona and Pavia this figure was around 18,000, in the Tuscan provinces (Siena, Pisa, Grosseto) was slightly lower and 10- 13,000 units. The explanatory variables have been properly normalized to make them homogeneous: the use of chemical fertilizers has been compared to the agrarian surface, thus having the figure per hectare (Fertilizer); the number of agricultural workers has been compared to the number of companies, thus having the average number of workers per company (Workers); the population with head of the agricultural family was compared to the present population (AgrPop), in order to obtain an index measuring the degree of dependence of the provincial economy from agriculture; the number of cattle (cattle and equines) was divided by the number of farms, obtaining the average number of cattle per farm (Livestock). Tab 4 shows the average values of the variables used in linear regression for the three regions. The main differences, in addition to the wheat yield, are found in the average amount of chemical fertilizer per hectare used, and the number of livestock per farm; in high farming in Lombardy the amount of chemical fertilizers used is twice as high as Tuscany and four times that of Puglia, while the number of animals per company is 2,82, compared to 0,99 in Puglia and 2,07 in Tuscany. There are no significant differences, however, with regard to the number of employees per farm, which is around 2,5, and the impact of the agricultural population on the present: for both Puglia and Lombardy it is about 26%, in Tuscany the level is slightly lower (23,4%).

Table 4
Mean values of the variable used in linear regression per region

Region	Yield per hectare	AgrPop	Workers	Fertilizer	Livestock
Puglia	14,39	26,45	2,48	0,37	0,99
Lombardia	25,02	26,31	2,68	1,59	2,82
Toscana	12,11	23,44	2,65	0,7	2,07

Source: our elaborations on data of ISTAT, Catasto agrario 1929

The parameters of the different linear regression models (Tab. 5) have been estimated using the OLS method[20]. The linear model in matrix form is as follows:

$$\boldsymbol{Yield = X\beta + \varepsilon}$$

Yield is the response variable; *X* is the matrix of regressors, which is variable depending on the pattern used; β is the vector of the regression coefficients, and ε is the vector of the error.
All proposed models presented the significant F-test, with an adjusted R^2 ranging from a minimum of 0,3857 for Model A to a maximum of 0,592 for model F, excluding geographical variables. Models A and B, both with the exclusion of the Fertilizer variable, highlight the significance of the Livestock variable, or how the different contribution of the livestock workforce has some impact on wheat yields. If the fertilizer variable is introduced between the regressors, it results as highly significant (models C and E, while in model D neither Fertilized nor Livestock are significant, while the model as a whole appears to be). The F model is the one with all the variables, it is the one with the highest adjusted R^2 value and therefore has the best degree of adaptation in explaining the relationship between the response variable and the predictors. In this model the only non-significant variable is the Livestock,

[20] Ricci, V. Principali tecniche di regressione con R. R documentation; 2006.Url: https://cran.r- project.org/doc/contrib/Ricci-regression-it.pdf

Table 5.
Parameters estimation of linear regression models OLS

	A	B	C	D	E	F	G
Predictors							
(Intercept)	12,55***	11,05***	11,08***	11,51***	8,73***	8,79***	-209,8***
	(2,1911)	(2,1906)	(2,1295)	(1,5544)	(0,2198)	(2,0876)	(50,36)
Workers	0,410	-2,61.	0,310			-2,63*	-0,413
	(0,7750)	(1,3401)	(0,6404)			(1,1663)	(0,9129)
Livestock	2,16**	2,71***		0,600		0,560	0,009
		(0,6296)		(0,9090)		(0,9745)	(0,676)
AgrPop		0,22.			0,09977.	0,29**	0,070
		(0,1112)			(0,05507)	(0,1006)	(0,0818)
Fertilizer			5,04***	3,95.	5,31***	5,79*	4,086*
			(1,2145)	(2,2213)	(1,08128)	(2,1764)	(1,509)
Longitude							1,926**
							(0,5699)
Latitude							4,551***
							(1,02)
Observations	23	23	23	23	23	23	23
R^2	0	0,535	0,506	0,511	0,571	0,666	0,865
R^2 adjusted	0,386	0,461	0,457	0,462	0,528	0,592	0,815
F statistic	7,906**	7,282**	10,26***	10,46***	13,31***	8,982***	17,1***
Moran Test	9,7888***	7,9736***	9,1497***	9,6471***	8,4226***	6,3463***	5,2769***

Source: our elaborations on data of ISTAT, Catasto agrario 1929, Notes. Signif. codes: 0 '***' 0,001 '**' 0,01 '*' 0,05 '.' 0,1 ' ' 1

while the *AgrPop* variable takes on a certain role, always not significant in the other models.
With regard to the number of employees we can observe that the coefficient always assumes negative values, except that in equation C, and is never significant except in model F. This would demonstrate the problems of marginal labour productivity which would lead to an already full distribution of the labour factor within the production process, and this would let emerge some critical issues in relation to the ruralization of the countryside to encourage the decongestion of cities. There aren't still any significant effects on labour policies in the countryside. In the G model, the geographical variables of longitude and latitude of provincial capitals have been introduced; these highly significant variables remarkably increase the correct R^2 level from 0,59 of model F to 0,81 of the G model. The latter regression model shows that, of course, wheat yields affect the number of fertilizers used per hectare, but above all the geographical element, i.e., the socio-economic and business-run diversities is the one affecting the wheat yields for the most. The Geographical variables become particularly explanatory in the case study; in this research perspective, it does not seem wrong to assume that, in addition to the different forms of conduction, regional differences between North and South also influenced the yields, as it is also confirmed by the angular coefficient of the Latitude variable in the G model.

For all the linear regression models estimated with the OLS method, it emerges the presence of spatial self-correlation of residues, a fairly frequent feature in the case of using the geographical data for the estimation of the models, resulting in the Moran test always very significant[21]. The OLS estimates in this circumstance are incorrect. This particular one leads to the use of spatial models, such as the self- regressive spatial models (SAR)[22]:

$$\boldsymbol{Yield} = \rho \boldsymbol{WYield} + \boldsymbol{X\beta} + \boldsymbol{\varepsilon}$$

In this model we introduce the matrix W (spatial weights matrix) that takes into account the geographical element, in our case by using longitude and latitude, to eliminate the effect of spatial self-correlation of residues, while ρ the relative parameter being estimated and it measures the spatial effect, or spatial lag. In Tab. 6, the A-F models were estimated using the SAR model and the maximum likelihood method. In all models, the parameter was always very significant, confirming the presence of a spatial effect. In addition, the model adaptation indicator (godness of fit) Nagelkerke pseudo-R-squared is always higher than 0,7, showing a good adapting spatial regression models. With regard to the significance of the re-

[21] Moran, P. A. Notes on Continuous Stochastic Phenomena. Biometrika. 37 (1): 17–23; 1950
[22] LeSage J.P. An Introduction to Spatial Econometrics. Revue d'économie industrielle. 123 (3): 19-44; 2008

Table 6.
Parameters estimation of linear regression models SAR with maximum likelihood method

	A	B	C	D	E	F	G
Predictors							
(Intercept)	-0,713	-0,627	-1,733	-1,215	-2,123	-1,370	173,5345***
	(2,40418)	(2,63377)	(2,22467)	(2,11134)	(2,41074)	(2,71504)	(47,9509)
Workers	-0,182	-0,710	0,252			-0,857	-0,248
	(0,47365)	(0,85555)	(0,37649)			(0,784481)	(0,75586)
Livestock	1,37549***	1,5316***		0,265		0,143	0,040
	(0,36784)	(0,41245)		(0,5408)		(0,645308)	(0,55264)
AgrPop		0,051			0,046	0,113164.	0,050
		(0,07264)			(0,03414)	(0,067869)	(0,06819)
Fertilizer			3,36529***	2,96255*	3,60711***	3,970361**	3,6941**
			(0,71525)	(1,3198)	(0,67289)	(1,434887)	(1,25184)
Longitude							1,7121***
							(0,4767)
Latitude							3,655***
							(1,06146)
Rho	0,85657***	0,82815***	0,85721***	0,8533***	0,82837***	0,77082***	0,345
	(0,09143)	(0,10762)	(0,08999)	(0,092294)	(0,10515)	(0,13225)	(0,32016)
Log-likelihood	-59,787	-59,565	-57,481	-57,583	-56,855	-56,323	-51,395
AIC	129,570	131,130	124,960	125,170	123,710	126,650	120,790
Nagelkerke pseudo-R- squared	0,722	0,733	0,778	0,776	0,789	0,799	0,869
Observations	23	23	23	23	23	23	23

Signif. codes: 0 '***' 0,001 '**' 0,01 '*' 0,05 '.' 0,1 ' ' 1; Notes. Source: our elaborations on data of ISTAT, Catasto agrario 1929

gressors, the same indications are essentially given to the OLS model, confirming the important role played by the Fertilizer and Livestock variables, and geographical variables. Estimates of regression coefficients obtained with the SAR model are undistorted (unbiased), as opposed to those obtained with the OLS method.

The **figure 6** shows scatterplots between yield per hectare and four explanatory variables used in models; in all cases a positive bond is observed, it has a greater intensity for the variables Fertilized and Livestock.

Using the same data already used for regression, with the exception of geographical variables, the DEA analysis (Data Envelopment Analysis) was conducted to estimate the frontier of the production function and calculate the production efficiency of the wheat yields for each province examined[23]. It was decided to use the DEA to observe the efficiency of the provinces, in order to identify further confirmations of what emerged from this study regarding the development of wheat yields in the three sample regions. In Tab. 7, the efficiency indexes at a provincial level are presented, whilst in Tab. 8 the frequency distribution (absolute and percentage) of these indices is reported, and in Tab. 8 the percentage impact of the provinces with an efficiency index of 1 on the provinces, to obtain an efficiency assessment for the different types of agricultural management examined.

The efficiency analysis shows no diverging results in respect to those previously emerged. One striking fact is that the average efficiency is 0,858, a particularly high value showing how the battle for wheat was also aimed at achieving agricultural efficiency. The most efficient region is Lombardy, followed by Puglia and Tuscany, which would be inefficient if placed in a wider context. What it has emerged from the DEA, however, must not divert the attention from the fact that it seems difficult to carry out comparative analyses of such different production realities, but it allows to observe that the agricultural land settling policies in Puglia, in particular in the captaincy area, had brought most of the provinces into a full efficiency condition. It has also verified whether the efficiency affected the change in yields between 1923-28 and 1929. This analysis also confirms that Tuscany is below the growth of other regions. The only exceptions were the provinces of Massa Carrara and Livorno, probably due to a greater small farms presence that favoring an increase in efficiency compared to the other provinces. The DEA analysis allows to confirm what it emerged from the sharecropping literature, i.e. the comparison of the sharecropping system with other realities doesn't seem to be so coherent, and this would also be confirmed by the Sienese situation, which is in a position of countertrend towards the real conditions of the Sienese agriculture.

[22] LeSage J.P. An Introduction to Spatial Econometrics. Revue d'économie industrielle. 123 (3): 19-44; 2008

Figure 6.
Scatterplot wheat yield in 1929 vs predictors used in linear regressions per province

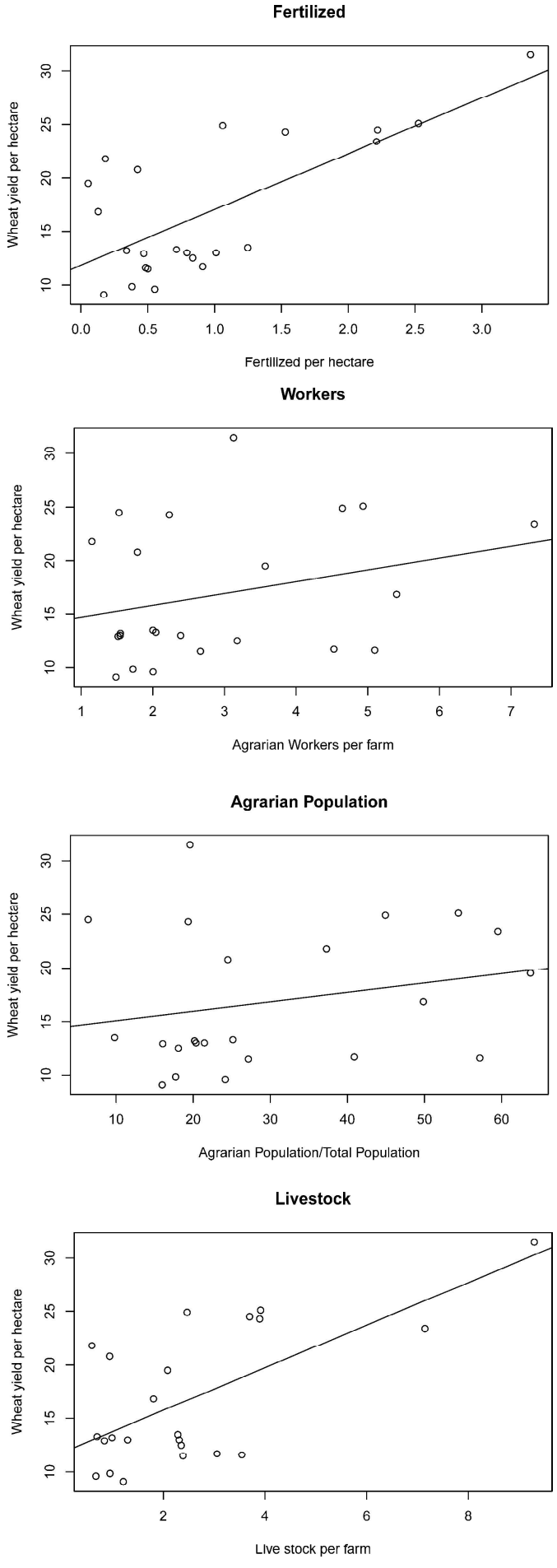


Table 7.
Wheat yield efficiency indicators according the province

Province	Efficiency
BARI	1,000
BRINDISI	1,000
FOGGIA	0,887
LECCE	1,000
TARANTO	0,975
BERGAMO	1,000
BRESCIA	1,000
COMO	1,000
CREMONA	1,000
MANTOVA	0,452
MILANO	1,000
PAVIA	0,754
SONDRIO	1,000
VARESE	1,000
AREZZO	0,614
FIRENZE	0,761
GROSSETO	0,356
LIVORNO	1,000
LUCCA	0,954
MASSA CARRARA	1,000
PISA	0,657
PISTOIA	0,931
SIENA	0,396
Mean Efficiency	0,858

Source: our elaborations on data of ISTAT, *Catasto agrario* 1929

Table 8
Distribution of wheat yield efficiency indicators among provinces

Efficiency range	N.	%
0,31-0,4	2	8,7
0,41-0,5	1	4,3
0,51-0,6	0	0,0
0,61-0,7	2	8,7
0,71-0,8	2	8,7
0,81-0,9	1	4,3
0,91-0,99	3	13,0
1	12	52,2
Total	23	100,0

Source: our elaborations on data of ISTAT, *Catasto agrario* 1929

Table 9
Distribution of province with wheat yield efficiency indicator ugual to 1 among regions

Regione	N. efficiency=1	Total	%
PUGLIA	3	5	60,0
LOMBARDIA	7	9	77,8
TOSCANA	2	9	22,2

Source: our elaborations on data of ISTAT, Catasto agrario 1929

CONCLUSIONS

In this contribution, the data from the *Catasto Agrario* of 1929 were examined limited to three Italian regions (Lombardy, Tuscany, Puglia), which are expression of different forms of conduction (high farming, sharecropping and latifundia) related to wheat cultivation. The analysis took place at a provincial level through representations in tabular form, while at a municipal level, cartograms with GIS software were made. The data showed that there were significant differences between the three forms of agricultural management. With regard to wheat yield, the outcomes of the so-called "Battaglia del Grano" were different in the three regions, for which different levels of growth were found between 1923-28 and 1929, with the best performance for Puglia in terms of improvement, although this region was the one with the lowest yield in 1923-28. The Analysis of regression, with municipal data, showed a positive link between the wheat yield and the percentage impact of this crop on the agricultural area; however, this link was not particularly intense (R^2<0.4) and was more characteristic in intensive and extensive agriculture, irrelevant in the sharecropping. The parameters of the different provincial linear regression models were estimated using the OLS method first; the presence of spatial self-correlation of residues suggested the use of SAR models. Although there are differences in the values of the regression coefficient estimates between OLS and SAR, the significance of the regression coefficients appears quite similar. Factors that have affected wheat yield include the use of chemical fertilizers, the number of livestock used as a labour force, and, to a lesser extent, the impact of the agricultural population on the present population. The introduction of geographical variables (latitude and longitude of provincial capitals) increases the determination index, showing how the spatial factor plays an important role in explaining the different levels of yield per hectare, as well as the form of conduct. The result is a rather delineated picture in which the use of chemical fertilizers has been affected in agriculture, thus also showing the initiation of specialization and the enhancement of technical progress in the agricultural field. It also emerges once again, thanks to the DEA analysis, the need to approach the Italian case through a micro vision, in order to reconstruct the macro dimension. This is confirmed by the results of Tuscany, for which it is increasingly evident that the interpretative model of the sharecropping proposed by Galassi is the one that best suits the region: the sharecropping for its intrinsic structure already has a level efficiency that will remain constant over time and is unlikely to change in the longer run. From this perspective, it becomes more significant to compare it with regions having the same form of agricultural conduct