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Campus Luigi Einaudi, Lungo Dora Siena 100/A, 10153 Torino (Italy)
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THE PRODUCTION GENDER GAP AMONG ITALIAN FARM OPERATORS

ALESSANDRO CORSI and ROBERTA MISURACA

UNIVERSITÀ DEGLI STUDI DI TORINO

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The production gender gap among Italian farm operators

Alessandro Corsi[1] – Roberta Misuraca[2]

[1]Dept. of Economics and Statistics "Cognetti de Martiis", University of Torino
[2]Dipartimento di Scienze Politiche - Università degli Studi di Bari Aldo Moro

Abstract

The wage gender gap in the industry and services sectors is a highly debated and researched issue. In agriculture, the main issue related to male-female diversities has been the diversity of yields in male vs female-operated plots, with a focus on Sub-Saharan Africa. In this paper, we assess whether there is an overall gap in economic output between farms managed by male or female operators in a developed country (Italy) and we analyse if it is due to different endowments in production factors and natural resources and/or in different productivity in specific factors. The data are drawn from the Italian section of the European Farm Accounting Data Network. The results suggest that Total Output (TO) in male-operated farms exceeds by around 50 percent on average TO of female-operated farms. Female- and male-operated farms have different endowments of primary inputs and human capital and belong differently in Types of Farming and areas of different productivity, generally disfavouring women. The largest part of the gap (between 50 and 60%, as assessed through an Oaxaca-Blinder decomposition) is explained by the different endowments, as female-operated farms have less capital of all types, less labour, and generally operate in unfavourable physical conditions. A lower, and more variable, share of the gap (30-40%) is due to the different productivity of the production factors.

Keywords: gender gap; agriculture; Total Output; productivity; FADN

JEL codes: J16; J24; Q12

1 Introduction

Farming has traditionally been a male business in developed countries. The share of farms operated by women remains a minority, especially among farm operators. In Italy, according to the last Agricultural Census, in 2020 68.5% of the operators are male vs 31.5% of females, a small change relative to the 2010 Census, when they were 69.3% and 30.7%, respectively. The sociological literature (Brandth, 2002) underlines the traditional

gender roles in farming, with men as the head of the family farm and women in subordinate roles. However, a traditional economic explanation of the male prevalence has been the different productivity, particularly in traditional agriculture, due to the different physical strength. The question of the different productivity of female farmers has been widely debated over the years (Peterman and al., 2011; Peterman et al., 2014; Doss, 2018), especially in the development literature. The overwhelming majority of the recent literature shows that female-managed farms have lower yields than those managed by males. Nevertheless, large differences penalizing women have also been found in input use, access to productive resources, and individual farmers' attributes. When estimating productivity differentials between men and women controlling for the factor endowment, the results are mixed. In some studies, when controlling for the different endowments, the differentials vanish (e.g., Quisumbing, 1996; Gilbert et al., 2002; FAO, 2011), in other they persist or even become larger (e.g., World Bank, 2014; Kilic et al., 2015). While there is a considerable abundance of studies on the role played by the constraints encountered by women in accessing resources, such as fertilizer, labor, higher level of education, technologies, market, and credit access, these findings prohibit every generalization, relegating the debate to an unresolved issue (Slavchevska, 2015; Doss, 2018).

The bulk of studies on gender differences in agricultural productivity focuses on sub-Saharan Africa and physical yields. It typically considers two different approaches: (1) Inter-household analysis, which studies the gender gap in productivity between female-owned and male-owned firms, and (2) the intra-household approach that moves the investigation within the firm, by focusing the analysis on female and male-managed plots in the same firm. However, while the first approach allows exploring whether the gender gap is mostly driven by differences in allocative and/or technical efficiency, simply

estimating the gender gap in mean, the second one forces to restrict the analysis to only households in which both male and female-managed plots are present, taking into account all unobserved variables, at household and plot level, able to confound the main results. Despite the widespread use of these approaches in the literature, several limitations, such as the inconclusiveness of gender findings due to limited geographic coverage, lack of representative data, and questionable empirical aspects, bring to the fore the problem of the robustness and the external validity of the results.

Moreover, the existing literature does not deal with agricultural sectors in developed countries. In these countries, the crucial issue is not the one of differences in physical yields, also given the high level of mechanization that offsets the gender differences in physical strength. Rather, the issue is one of economic productivity and, of course, of inter-gender justice. Our study intends to explore the existence of a gender gap in agriculture as to differences between male and female farm operators in the ability of generating farm economic output in a developed country, Italy. To this purpose, using a data set constructed from the Farm Accountancy Data Network (FADN) of farms observed from 2012 to 2017, we analyse the determinants of farm output between male and female farm operators. Farm output is assumed to depend, in addition to basic factors (land, capital, and labour), on productivity shifters and on the human capital endowment of the operators. Both basic factors and human capital endowment can differ between male and female operators, which is a reason for differences in output. Another reason for the differences can be gender-based idiosyncratic technical and managerial skills, or gender discrimination, which renders factors' productivity higher or lower. For instance, the traditional cultural concept that women are less able in technical matters can leave a track both in their self-confidence and in the trust of the other operators (workers, buyers, advisors, i.e.) with whom they are in a relationship, thus affecting the relevant factor

productivity. We nevertheless do not investigate these reasons. Our goal is simply to assess whether there is an overall gender gap in production and, if so, if it lies in the different endowments in production factors and natural resources and/or in different productivity in specific factors.

To disentangle these different components, we proceed in successive steps. After illustrating the data in the following Section 2, we examine the differences in the endowment of production factors and of other variables affecting production between female- and male-operated farms (Section 3 Differences in factor endowments). The second step is estimating separate models of production determinants for female- and male-operated farms and testing the differences in the relevant parameters, to shed light on the possible different productivity of the factors (Section 4 Differences in factor productivity). The final step is employing a formal Oaxaca-Blinder decomposition (OBD) of the gender gap economics (Oaxaca, 1973; Blinder, 1973), a technique widely used in labor economics, especially in the analysis of the gender gap within the labor market. Following the main literature on the gender gap estimation across sub-Saharan Africa, we extend the Oaxaca-Blinder decomposition to the Italian case, by decomposing the average gender difference in agricultural productivity into two parts: one part driven by differences in the levels of available and observable endowments (i.e. endowment effects), and a second part, driven from returns' differences between male-managed and female-managed farms in the same set of attributes (i.e. structure effects). The OBD technique has been extensively utilized in analyzing the productivity gender gap in Sub-Saharan Africa (e.g., Osemi et al., 2015, among many others). This allows us to provide a detailed picture of the gender gap in the Italian agriculture sector, identifying the contribution of each available factor. Some conclusions close the paper.

2 Data and variables

Our data are from the "Rete di Informazione Contabile Agricola" (RICA), the Italian part of the Farm Accounting Data Network (FADN) established by the European Union. It is an annual survey, based on the common European methodology, of the characteristics and of the economic performances of professional and market-oriented farms. The RICA sample is representative of these farms over three dimensions, namely region, economic size, and type of farming. The farm operator's gender is recorded. From the RICA general data of years 2012 to 2017, after eliminating observations with missing or inconsistent variables, we extract two panel datasets. The first one is an unbalanced panel, comprising all observations for all years, regardless of their presence in different years. It comprises 54,205 observations, distributed over 6 years, as shown in Table 1. The number of farms declines from the first years onward. The balanced panel includes 17,244 observations, i.e., 2,874 farms each year. The choice of also considering such a panel is to explore whether the loss in terms of observations can be compensated for in terms of the homogeneity of the observed farms. We will therefore analyse in parallel both datasets.

Tab 1 – Observations by year in the unbalanced panel

Year	Freq.	Percent
2012	10,222	18.86
2013	10,072	18.58
2014	9,013	16.63
2015	8,003	14.76
2016	8,384	15.47
2017	8,511	15.7
Total	54,205	100

The variable of interest we take as an indicator of production is Total Output (TO) in value (Euro) as defined in FADN (European Commission, 2014). We intend to explore the determinants of differences in TO based on operators' gender. The differences can be due to different endowments of production factors and/or to different productivity of the factors. The main production factors we consider are as follows. Land-associated capital (*Capitale Fondiario* in the Italian RICA terminology) is the sum of values of land, permanent crops & quotas, and buildings. Fixed capital (*Capitale Agrario Fisso*) is the sum of machinery and breeding and non-breeding livestock. Circulating capital (*Capitale Agrario Circolante*) is the sum of stocks of agricultural products and other circulating capital. Labour inputs (in hours) are distinguished between family labour and waged Labour. Other variables are assumed to affect the human capital of farmers: age (a proxy for experience); age squared (to test the possibility of a curvilinear relationship); education levels, represented by dummies for elementary school, junior high school, high school, and university; and a dummy for having inherited the farm, which may affect experience and idiosyncratic skills. Some controls are needed, that can affect the relationship between factors and output. Some are related to the quality of land, namely the altitude (plains, hills, and mountains), and the farm being located in Less Favourite Areas (LFA). Others concern the production mix, represented by the type of farming (TF) according to the FADN classification[1], the share of irrigated land over total Utilized Agricultural Area and the farm being organic.

[1] The EU Farm Accounting Data Network (FADN) defines the TF of a farm based on the composition of its Standard Output (SO) from the different productions (European Commission, 2009). SOs are obtained multiplying the farm area (number of heads) of a crop (livestock) by the area-specific (livestock-specific) standardised output. TFs are defined as specialised in if the SO for the particular production covers more than two-thirds of the total SO.

3 Differences in factor endowments

As a first analysis, we examine the gender differences in Total Output and the first reason for the gender gap, i.e., different factor endowments, through the descriptive statistics of the variables. Table 2 reports the descriptive statistics for the unbalanced panel, both for the whole sample and for women-operated and male-operated farms. It also reports the t-test results for the differences of group averages.

Table 2 - Descriptive statistics of the variables and t-test of the differences of female-male averages- Unbalanced panel

			Female		Male		t-test for mean differences
Variable	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	
Female operator (yes=1)	0.185	0.389					
Total Output (€)	143902.7	461736.1	117023.2	617440.6	150024.4	418015.7	-5.10***
Log (Total Output)	10.91831	1.256818	10.57958	1.210774	10.99546	1.25436	-30.88***
Land-associated capital (€)	444508.2	2598349	376731.5	5071558	459944.1	1558986	-1.63
Fixed capital (€)	49234	144554.3	36996	138361.7	52021.1	145785.9	-9.73***
Circulating capital (€)	34365.4	266059.8	26867.1	222421.3	36073.1	275005.6	-3.57***
Waged labour (hrs)	1051.7	4437.4	879.6	3362.8	1090.9	4646.6	-5.26***
Family labour (hrs)	2833.5	1693.1	2610	1545.9	2884.4	1720.8	-15.72***
Inherited (0/1)	0.511	0.5	0.483	0.5	0.518	0.500	-6.33***
Primary school education or lower	0.161	0.367	0.151	0.358	0.163	0.369	-3.02***
Junior high school education	0.371	0.483	0.366	0.482	0.373	0.484	-1.31
High school education	0.407	0.491	0.413	0.492	0.406	0.491	1.29
University education	0.061	0.239	0.071	0.256	0.059	0.235	4.31***
Less Favourite Area (0/1)	0.534	0.499	0.588	0.492	0.522	0.5	12.10***
Operator's age (yrs)	54.6	13.6	54.1	13.2	54.7	13.6	-4.09***
Share irrigated/total UAA	35.5	42.5	29.2	40.3	36.9	42.9	-17.08***
Organic (0/1)	0.124	0.33	0.143	0.35	0.120	0.325	6.02***
Mixed livestock (0/1)	0.007	0.084	0.007	0.084	0.007	0.084	0.00
Mixed cropping (0/1)	0.064	0.244	0.075	0.263	0.061	0.240	4.89***
Mixed crops – livestock (0/1)	0.047	0.211	0.051	0.219	0.046	0.209	2.08**
Specialist grazing livestock (0/1)	0.222	0.416	0.202	0.402	0.227	0.419	-5.58***
Specialist granivores (0/1)	0.049	0.217	0.040	0.195	0.052	0.221	-5.43***
Specialist horticulture (0/1)	0.064	0.244	0.080	0.271	0.060	0.237	6.83***
Specialist field crops (0/1)	0.256	0.437	0.245	0.430	0.259	0.438	-2.94***
Specialist permanent crops (0/1)	0.29	0.454	0.300	0.458	0.288	0.453	2.38**
Mountain	0.227	0.419	0.243	0.429	0.223	0.416	4.24***
Hill	0.445	0.497	0.506	0.500	0.431	0.495	13.60***
Plain	0.328	0.469	0.251	0.434	0.345	0.475	-19.25***
Observations	54,205		10,055		44,150		

*** p<0.01, ** p<0.05, * p<0.010

Female operators represent 18.5 percent of the total. The average Total Output (TO) in this panel of male operator farms (150,000 Euro) is 28.2 percent higher than the average of female-operated farms (117,000 Euro), a statistically significant difference. Though, the gap is larger (61.3%) when confronting the medians (55,300 vs 34,300 Euro). If the gap is measured as the difference in log (TO), it amounts to 0.416, which equally translates to 61.3%.

Nevertheless, there are significant differences in factor endowment and other variables affecting the output. Female-operated farms have significantly lower fixed and circulating capital (€ 37,000 vs € 52,000 and € 27,000 vs € 36,000, respectively), while the difference in land-associated capital, although in favour of male farms (€ 377,000 vs € 460,000), is not statistically significant, due to the large variation in both groups. On average, female-operated farms also employ less waged and family labour (880 vs 1090 and 2610 vs 2884 hours, respectively). Among human capital variables, female operators are slightly younger and more educated (lower share of low grades and a higher one for University) and have inherited their farm in a lower percentage relative to their male counterparts. Their farms are located in mountains and hills, and in Less Favoured Areas, in a significantly higher share than the corresponding male-operated farms. The share of irrigated land is also significantly lower. The distribution in the TFs of female and male farms is also different. The share is higher for female farms in Specialist Horticulture, Specialist permanent crops, Mixed cropping and Mixed crops-livestock, while the opposite holds for Specialist grazing livestock, Specialist granivores, and Specialist field crops.

The balanced panel shows a somewhat different picture (Table 3).

Table 3 - Descriptive statistics of the variables and t-test of the differences of female-male averages - Balanced panel

	All		Female		Male		
Variable	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	t-test for mean differences
Female operator (yes=1)	0.164	0.370					
Total Output (€)	140501.8	497486.4	141,130.2	971,584.2	140,378.4	332,958.1	-0.04
Log (Total Output)	11.002	1.170	10.654	1.152	11.071	1.161	-17.56***
Land-associated capital (€)	437873.1	865491.2	363,547.7	1,132,846.0	452,459.8	801,877.9	-3.98***
Fixed capital (€)	46783.8	123999.1	39,576.5	174,109.1	48,198.2	111,507.0	-2.53***
Circulating capital (€)	36336.4	231964.1	44,225.3	372,856.7	34,788.2	192,555.1	1.31
Waged labour (hrs)	804.5	4172.2	724.8	2912.9	820.2	4376.9	-1.45
Family labour (hrs)	3027.1	1710.4	2833.1	1637.2	3065.2	1721.9	-6.83***
Inherited (0/1)	0.530	0.499	0.463	0.499	0.544	0.498	-7.90***
Primary school education or lower	0.131	0.337	0.110	0.312	0.135	0.342	-3.90***
Junior high school education	0.415	0.493	0.414	0.493	0.415	0.493	-0.14
High school education	0.408	0.491	0.432	0.495	0.403	0.491	2.87***
University education	0.046	0.210	0.044	0.206	0.046	0.211	-0.54
Less Favourite Area (0/1)	0.537	0.499	0.592	0.492	0.526	0.499	6.54***
Operator's age (yrs)	55.3	12.7	55.0	12.2	55.4	12.8	-1.44
Share irrigated/total UAA	41.9	43.8	34.0	42.4	43.4	43.9	-10.76***
Organic (0/1)	0.097	0.296	0.105	0.307	0.095	0.293	1.57*
Mixed livestock (0/1)	0.006	0.079	0.005	0.073	0.006	0.080	-0.71
Mixed cropping (0/1)	0.060	0.237	0.059	0.235	0.060	0.238	-0.29
Mixed crops – livestock (0/1)	0.049	0.216	0.054	0.227	0.048	0.214	1.41
Specialist grazing livestock (0/1)	0.214	0.410	0.183	0.387	0.220	0.414	-4.62***
Specialist granivores (0/1)	0.045	0.207	0.044	0.206	0.045	0.207	-0.20
Specialist horticulture (0/1)	0.075	0.263	0.113	0.317	0.067	0.250	7.27***
Specialist field crops (0/1)	0.255	0.436	0.235	0.424	0.259	0.438	-2.71***
Specialist permanent crops (0/1)	0.297	0.457	0.306	0.461	0.295	0.456	1.25
Mountain	0.273	0.445	0.277	0.448	0.272	0.445	0.59
Hill	0.387	0.487	0.465	0.499	0.372	0.483	9.14***
Plain	0.340	0.474	0.258	0.437	0.356	0.479	-10.80***
Obs	17,244		2,829		14,415		

The share of female-operated farms is slightly lower (16.4%). The Total output is almost identical between female- and male-operated farms (140,130 and 140,378 Euro, respectively). Though, the gap is positive and strong (45%) when confronting the medians (29,140 vs 20,076 Euro). This is due to few very high TOs in the highest decile of the

female-operated farm distribution. When measured as the difference in log (TO), the mean gap is 0.420, i.e., 52%.

Land-associated capital and Fixed capital means are significantly lower for female farms (€ 364,000 vs € 452,000 and € 40,000 vs. € 48,000, respectively), while the difference in average Circulating Capital is not significant, although higher for female farms (€ 44,000 vs. € 35,000). On average, female-operated farms also employ significantly less family labour (2833 vs. 3065 hours) and (not significantly) less waged labour (725 vs 820 hours). The share of Female operators is significantly higher for Primary school and High school education, but not significantly different for the other education levels. Female operators have inherited the farm in a significantly lower percentage than their male counterparts. The share of female farms is significantly lower in Plains, and higher in Hills and Mountain areas (although not significantly for the latter), and significantly higher in Less Favourite areas. The share of irrigated areas is also significantly lower. Among Types of farming, the share of female farms is significantly lower in Specialist field crops and Specialist grazing livestock, and higher in Specialist horticulture. Organic farming is a slightly higher share in female-operated farms, though the difference is only marginally significant.

The different statistics between the unbalanced and balanced panels suggest some caution in interpreting the results. Nevertheless, some common features emerge. Female- and male-operated farms have different endowments of primary inputs and human capital and belong differently in Types of Farming and areas of different productivity. In particular, female-operated farms are relatively more numerous in locations (Mountains and Hills, Less Favourite Areas) and TFs (Specialist permanent crops, Mixed cropping and Mixed crops-livestock) that are expected to be less productive. Nevertheless, their performance can be higher or lower than the corresponding male operators in specific locations and

TFs. To analyse the latter point, the average Total Output in the different TFs, separately for female and male farms, is shown in Table 4 for the unbalanced and balanced panels.

Table 4 - Mean Total Output by Type of Farming and operator gender

	All			Female			Male			t-test for mean differences
	Mean	Std.Dev.	Freq.	Mean	Std.Dev.	Freq.	Mean	Std.Dev.	Freq.	
					Unbalanced panel					
Mixed livestock	138033.9	278979.6	389	94809.2	189729.8	72	147851.4	294877.1	317	-1.91*
Mixed cropping	86216.2	232162.1	3,457	411973.9	1168080.0	400	106992.3	182901.6	2,020	5.21***
Mixed crops – livestock	98070.6	177750.6	2,530	62733.7	150736.5	510	509646.3	1187976.0	2,279	-17.35***
Specialist grazing livestock	186779.2	624765.8	12,060	69011.7	190834.5	754	209419.9	593290.9	2,642	-10.42***
Specialist granivores	495062.9	1185322	2,679	113510.8	308184.9	805	91015.4	242250.5	2,703	1.90*
Specialist horticulture	187021.6	541824.2	3447	201249.8	1198701.0	2036	183840.1	421705.3	10,024	0.65
Specialist field crops	107894.3	192966	13,899	80316.5	183962.0	2459	113822.0	194344.5	11,440	-8.11***
Specialist permanent crops	93830.5	229325.8	15,744	73668.2	183704.6	3,019	98614.0	238630.3	12,725	-6.31***
Total			54,205			10,055			44,150	
					Balanced panel					
Mixed livestock	132139.5	183698.9	107	284739.4	354526.6	15	107259.0	124525.5	92	1.92*
Mixed cropping	79979.3	165380.3	1,032	74326.8	123860.1	166	81062.8	172237.4	866	-0.6
Mixed crops – livestock	102281.0	144537.6	845	56259.1	90569.6	154	112537.7	152173.7	691	-6.04***
Specialist grazing livestock	215958.6	914483.1	3,687	337733.4	2150566.0	517	196098.2	465653.2	3,17	1.49
Specialist granivores	380928.6	849427.2	774	432128.5	1219968.0	125	371067.3	758488.2	649	0.54
Specialist horticulture	147853.7	273590.6	1,289	112760.3	238225.3	320	159442.9	283465.2	969	-2.89***
Specialist field crops	115057.7	198243.2	4,396	75524.0	126762.1	665	122104.0	207649.3	3,731	-7.79***
Specialist permanent crops	88434.2	207983.6	5,114	68112.2	165629.0	867	92582.8	215391.0	4,247	-3.75***
Total			17,244			2,829			14,415	

The average Total Output of female operators is significantly lower for all TFs except for Mixed cropping, Specialist grazing livestock, and Specialist granivores for which the difference is not significant and, in the balanced panel, for Mixed livestock, higher in female-operated farms. As to location (Table 5), the female average Total Output is significantly lower (about 2/3 of the male average) in Mountain and Hill areas, in which the share of females is also higher. It is higher, but not significantly, in Plain areas, and is not significantly different in Less Favourite Areas.

Table 5 - Mean Total Output by location and operator gender

	All			Female			Male			t-test for mean differences
	Mean	Std.Dev.	Freq.	Mean	Std.Dev.	Freq.	Mean	Std.Dev.	Freq.	
Unbalanced panel										
Mountain	83699.41	193359.60	12,303	57116.8	86376.0	2,443	90285.7	211153.9	9860	-12.05***
Hill	107584.00	346182.00	24,136	80717.2	269471.1	5,088	114760.5	363616.9	19,048	-7.39**
Plain	234934.50	670235.80	17,766	248194.4	1158539.0	2,524	232738.7	548984.9	15,242	0,66
LFA	105402.30	426664.10	28,972	104470.2	724446.9	5,914	105641.3	306827.6	23,058	-0,12
Total			54,205			10,055			44,150	
Balanced panel										
Mountain	81062.6	94572.8	4,701	56705.3	55757.7	784	85937.8	99852.3	3,917	-11.46***
Hill	95005.0	199884.8	6,677	69962.8	145737.1	1,316	101152.3	210620.5	5,361	-6.31***
Plain	239923.0	812344.6	5,866	360396.9	1886875.0	729	222826.4	496552.6	5,137	1.96**
LFA	109988.2	548318.6	9,255	146756.7	1205624.0	1,675	101863.3	213749.0	758	1,52
Total			17,244			2,829			14,415	

*** p<0.01, ** p<0.05, * p<0.010

4 Differences in factor productivity

Following the literature on the gender gap in agriculture we adopt a Cobb-Douglas production function. Though, it should be noted that the relevant literature frequently modelled production in terms of physical yields, while our function is in value terms. Overall, we estimate the following model:

$$\log(y_{it}) = \beta_1 \log(LandCap_{it}) + \beta_2 \log(FixCap_{it}) + \beta_3 \log(CircCap_{it}) + \beta_4 \log(FamLab_{it}) + \beta_5 \log(WagLab_{it}) + \beta_6 X_{it} + \beta_7 Z_i + \sum \beta_8 yr_t + \sum \beta_9 R_i + \varepsilon_{it}$$

where y_{it} is Total Output; LandCap, FixCap, CircCap, FamLab, and WagLab are Land-associated capital, Fixed capital, Circulating capital, Family labour, and Waged labour; X_{it} are time-variant controls; Z_i are time-invariant controls; *yr* are year dummies and *R* are Region dummies. Following Battese (1997) dummy variables were added to cope with the problem of zero values of the explanatory variables in Cobb-Douglas functions.

A first OLS naïve model is estimated in which a dummy variable indicating female operation is added, which implies that the parameters are constrained to be equal for female- and male-operated farms, and no account is taken for the correlations induced by the panel nature of the data. The OLS model is then estimated separately for female- and male-operated farms on the pooled sample. The following step is estimating fixed effect (FE) models that cope with the panel nature of the data. Since all time-invariant variables collapse in the fixed effect, but location time-invariant variables have arguably an effect on TO, we interacted them with the main factors (LandCap, FixCap, CircCap, FamLab, WagLab).

Table 6 reports the estimates of the different models, as well as the results of the t-tests of the differences between variables of the male and female models. All models are overall significant, with R-squared ranging 0.64 to 0.68 for OLS models and 0.10 to 0.13 for FE models. All basic inputs exhibit the expected sign and are inelastic. The output elasticity is highest for family labour, followed by waged labour and by circulating capital, while fixed and land-associated capital elasticities are the lowest. It can also be noted that the relevant estimates are lower in the FE models than in the OLS models, which could suggest that the idiosyncratic components included in the fixed effects play an important role.

Table 6 - Production functions estimates and t-test of the differences of female-male parameters

Models	OLS unbalanced			OLS balanced			FE unbalanced			FE balanced		
Variables	Female	Male	t-test	Female	Male	t-test	Female	Male	t-test	Female	Male	t-test
Land-associated capital (€)	0.0740***	0.0974***	-297.60	0.0720***	0.0958***	-70.51	0.0378	0.0198	47.04	0.0293	0.0244	3.37
	(0.00765)	(0.00400)		(0.0175)	(0.00905)		(0.0235)	(0.0108)		(0.0319)	(0.0148)	
Fixed capital (€)	0.0987***	0.105***	-77.98	0.109***	0.101***	25.06	0.0192	0.0205***	-7.23	0.0287	0.0215***	10.25
	(0.00786)	(0.00411)		(0.0166)	(0.00809)		(0.0111)	(0.00461)		(0.0155)	(0.00603)	
Circulating capital (€)	0.175***	0.177***	-21.08	0.172***	0.178***	-17.90	0.0528***	0.0730***	-108.96	0.0374**	0.0739***	-49.15
	(0.00925)	(0.00467)		(0.0173)	(0.00975)		(0.0114)	(0.00511)		(0.0163)	(0.00735)	
Waged labour (hrs)	0.417***	0.357***	329.71	0.386***	0.326***	93.49	0.128***	0.118***	32.85	0.127***	0.102***	20.64
	(0.0179)	(0.00743)		(0.0334)	(0.0159)		(0.0187)	(0.00854)		(0.0264)	(0.0138)	
Family labour (hrs)	0.611***	0.646***	-124.26	0.613***	0.642***	-25.14	0.211***	0.246***	-49.35	0.229***	0.247***	-6.55
	(0.0275)	(0.0135)		(0.0601)	(0.0280)		(0.0437)	(0.0187)		(0.0602)	(0.0283)	
Inherited (0/1)	-0.0426	-0.109***	259.17	-0.0442	-0.0620**	17.82	0.0358	-0.0641**	107.01	0.205**	-0.0455	65.80
	(0.0250)	(0.0124)		(0.0519)	(0.0257)		(0.0574)	(0.0258)		(0.0822)	(0.0502)	
Junior high school education	0.115***	0.0607***	131.13	0.118	0.0735	24.23						
	(0.0404)	(0.0201)		(0.0953)	(0.0486)							
High school education	0.154***	0.0938***	136.11	0.0943	0.0879	3.34						
	(0.0431)	(0.0219)		(0.0990)	(0.0540)							
University education	0.117**	0.147***	-51.02	0.0134	0.154**	-56.26						
	(0.0572)	(0.0300)		(0.129)	(0.0723)							
Operator's age	-0.0154***	0.0125***	-474.44	-0.0278	0.0140**	-144.62	0.0139	0.0175***	-15.35	0.00680	0.0238***	-19.64
	(0.00575)	(0.00274)		(0.0151)	(0.00651)		(0.0146)	(0.00459)		(0.0192)	(0.00598)	
Operator's age squared	0.000134**	-0.000138***	506.60	0.000239	-0.000153**	152.64	-0.000141	-0.000169***	14.49	-3.17e-05	-0.000229***	24.48
	(5.25e-05)	(2.50e-05)		(0.000134)	(5.98e-05)		(0.000120)	(4.15e-05)		(0.000179)	(5.20e-05)	
Less Favourite Area	-0.0478	-0.0244	-72.03	0.0955	0.0164	60.17						
	(0.0316)	(0.0166)		(0.0680)	(0.0368)							
Share irrigated/total UAA	0.00246***	0.00287***	-113.33	0.00158**	0.00268***	-82.96	0.00174***	0.000836***	131.10	0.00170***	0.000320	46.83

	(0.000354)	(0.000166)		(0.000690)	(0.000329)		(0.000425)	(0.000181)		(0.000647)	(0.000290)	
Organic	0.00975	-0.00951	58.70	0.0414	-0.0416	67.49	0.0438	-0.0219	78.66	0.0600	-0.0492	39.73
	(0.0319)	(0.0169)		(0.0633)	(0.0372)		(0.0514)	(0.0227)		(0.0601)	(0.0295)	
Mixed livestock	-0.380***	-0.429***	59.90	-0.248	-0.357**	31.90	0.278***	0.148***	85.33	0.445***	0.110	42.95
	(0.0763)	(0.0631)		(0.170)	(0.145)		(0.0918)	(0.0564)		(0.169)	(0.0979)	
Mixed cropping	-0.244***	-0.268***	59.74	-0.199**	-0.300***	60.33	0.0330	-0.0789***	169.14	0.0117	-0.106***	38.92
	(0.0388)	(0.0227)		(0.0866)	(0.0468)		(0.0403)	(0.0214)		(0.0663)	(0.0308)	
Mixed crops – livestock	-0.440***	-0.442***	4.06	-0.516***	-0.433***	-43.39	0.134**	0.0495	88.23	0.200**	0.0196	42.25
	(0.0478)	(0.0262)		(0.0992)	(0.0511)		(0.0584)	(0.0305)		(0.0933)	(0.0465)	
Specialist grazing livestock	-0.300***	-0.334***	75.95	-0.452***	-0.392***	-32.34	0.151**	0.0859**	58.79	0.213**	0.0951	26.64
	(0.0437)	(0.0215)		(0.0966)	(0.0456)		(0.0674)	(0.0362)		(0.0957)	(0.0573)	
Specialist granivores	-0.430***	-0.272***	-122.39	-0.730***	-0.411***	-65.65	0.441***	0.220***	89.66	0.698**	0.0715	47.45
	(0.127)	(0.0525)		(0.253)	(0.119)		(0.150)	(0.0808)		(0.292)	(0.104)	
Specialist horticulture	-0.0575	-0.0291	-48.71	-0.0300	-0.0418	6.36	0.0710	0.0731	-1.16	0.209	-0.0241	24.34
	(0.0565)	(0.0315)		(0.0942)	(0.0668)		(0.112)	(0.0434)		(0.213)	(0.0573)	
Specialist permanent crops	-0.177***	-0.226***	149.64	-0.0811	-0.201***	83.45	-0.0799	-0.167***	83.26	-0.106	-0.193***	17.28
	(0.0319)	(0.0163)		(0.0748)	(0.0353)		(0.0637)	(0.0340)		(0.111)	(0.0446)	
Mountain	-0.225***	-0.247***	41.92	-0.314***	-0.296***	-8.45						
	(0.0510)	(0.0272)		(0.110)	(0.0607)							
Hill	-0.120***	-0.127***	16.90	-0.181**	-0.205***	14.40						
	(0.0405)	(0.0193)		(0.0865)	(0.0440)							
Land-capital x Mountain							-0.00180	0.0153	-46.21	0.0600	0.0341	16.14
							(0.0228)	(0.00978)		(0.0347)	(0.0207)	
Land-capital x Hills							-0.0232	0.00538	-78.57	-0.0267	0.000386	-19.48
							(0.0226)	(0.00764)		(0.0309)	(0.00867)	
Fixed-capital x Mountain							-0.0112	0.00308	-64.46	-0.0256	0.00183	-29.47
							(0.0137)	(0.00537)		(0.0206)	(0.00717)	
Fixed-capital x Hills							-0.0124	-0.00913**	-18.77	-0.0125	-0.0109	-2.21
							(0.0108)	(0.00393)		(0.0160)	(0.00558)	
Circ-capital x Mountain							0.0234**	-0.000234	139.04	0.0300	-0.00778	52.52
							(0.0104)	(0.00514)		(0.0158)	(0.00702)	
Circ-capital x Hills							0.0131	0.00659	45.91	0.0181	0.00966	13.12

					(0.00864)	(0.00457)		(0.0141)	(0.00660)		
Waged Labour x Mountain					-0.0156	0.00751	-112.81	-0.0179	0.0199	-49.94	
					(0.0125)	(0.00646)		(0.0163)	(0.0103)		
Waged Labour x Hills					0.000283	-0.00711	35.41	0.0139	-0.00191	19.72	
					(0.0129)	(0.00518)		(0.0176)	(0.00789)		
Family Labour x Mountain					-0.0322	-0.0319	-0.31	-0.0261	-0.0130	-3.28	
					(0.0593)	(0.0243)		(0.0876)	(0.0411)		
Family Labour x Hills					-0.00177	-0.0167	16.58	-0.0484	0.0254	-20.58	
					(0.0561)	(0.0171)		(0.0793)	(0.0282)		
Constant					7.099***	7.127***	-3.33	6.996***	6.856***	4.49	
					(0.519)	(0.209)		(0.683)	(0.317)		
Zero capital or labour dummies	yes			yes			yes			yes	
Year dummies	yes			yes			yes			yes	
Region dummies	yes			yes							
Observations	10,055	44,150		2,829	14,415		10,055	44,150		2,829	14,415
R-squared	0.648	0.674		0.682	0.653		0.099	0.115		0.132	0.126
N. farms							3,969	16,071		502	2,434

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.010

Among human capital variables, the farm being inherited has a generally negative effect on Total Output, though in FE models it is positive for females. Education (only included in the OLS models) has the expected positive sign, with the highest values (relative to the reference, the lowest grade) for High School. The age parameter is always positive and significant for males, is negative or insignificant for women. When age is significant, so is also age squared, suggesting a curvilinear relationship. The farm being located in a Less Favourite Area is never significant. By contrast, the share of irrigated over total area exhibits a significant positive sign. Organic production has never a significant effect on Total Output but, interestingly, the parameter is always positive for females and negative for males. Location of the farm in Mountain or Hill areas, according to the OLS models, significantly reduces TO, more so for the former. When introduced as interaction with the primary inputs, though, the relevant parameters are almost invariably insignificant, the effect of TFs probably being captured by the fixed effects.

The effects of the Types of farming (as measured with reference to Specialist field crops) are mixed and often contingent on the specific model. Specialist permanent crops are negative in both OLS and FE models, and so is Mixed cropping for males. The other TFs are generally significantly negative in the OLS models and positive or insignificant in the FE models. It is therefore difficult to find consistent conclusions and, again, the idiosyncratic components of the fixed effect may absorb part of the effect of TFs, given the limited number of changes that they exhibit.

When comparing the male vs female estimated parameters, their differences are always highly significant, as shown by the t-values (just the mean differences in male-female parameters of Specialist horticulture and of Mountain interacted with Family labour in

the FE model for the unbalanced panel are insignificant). Among the primary inputs, the productivity of Circulating Capital and Family labour is lower for females in all models. By contrast, the parameter of Waged labour is higher for females in all models. The female parameters of Land-associated capital are lower in the OLS models, but higher, although not significant, in the FE models. As to Fixed capital, it is lower in the models of the unbalanced panel, and higher in the balanced one. Among human capital variables, women have an advantage in the Inherited variable, because their parameter is not significantly different from zero or positive while it is negative for men. Female parameters are also higher in Junior high school and High School education, while the opposite holds for University. Women are also at a disadvantage for age, a proxy for experience, since their parameters are insignificant or negative, unlike men. As to physical farm characteristics, the parameters for the share of irrigated land are significantly lower for female farms in the OLS models, while the opposite is true in the FE models. The parameters of Organic orientation are never significant, but the mean difference is in favour of women. According to the OLS models, location in Mountains or Hills brings a lower production relative to Plains, but less so for female than for male farms. The parameters of Less Favourite Areas are never significant. As to the production mix, three TFs (Mixed livestock, Mixed cropping, and Specialist permanent crops) show higher female parameters consistently for all models. In the other cases, the differences have opposite signs contingent on the model or are not significant.

5 Oaxaca-Blinder decomposition

The following step is performing a formal Oaxaca-Blinder decomposition (OBD) of the gender gap (Oaxaca, 1973; Blinder, 1973). The OBD is a well-known technique

performing a decomposition of the difference in the means of an outcome Y between two gender groups, in our case male and female-operated farms:

$$[E(Y_M) - E(Y_F)] \quad (1)$$

Estimating the outcomes of the two groups as:

$$Y_F = \beta_F X_F + \varepsilon_F \quad \text{and} \quad Y_M = \beta_M X_M + \varepsilon_M \quad (2)$$

the difference between the means can be decomposed as:

$$E(Y_M)-E(Y_F) = [E(X_M) - E(X_F)]'\beta_F + E(X_F)' (\beta_M - \beta_F) + [E(X_M) - E(X_F)]' (\beta_M - \beta_F) \quad (3)$$

The first right-hand component represents the contribution to the gap of the difference in endowments; in other words, the part of the gap that is due to group differences in the determinants. The second component is the contribution to the gap by the differences in the coefficients. The third term represents the interaction due to the fact that differences in endowments and coefficients coexist in the groups.

The OBD has been performed on both the unbalanced and the balanced panel. Since for categorical explanatory variables the results of the detailed decomposition depend on the choice of the omitted base category, in the detailed decomposition the effects of those variables (education, location, region) have been "normalized", i.e. the effects are expressed as deviation contrasts from the grand mean (Yun 2005). Table 7 shows the results for both pooled datasets. The difference in the log Total Output is 0.416 for both the unbalanced and the balanced panel, corresponding to a 52% advantage for the male-

operated farms. On the unbalanced panel, 58% of the gap is attributed to differences in the endowments vs 34% due to the coefficients, the remaining 8% being due to the interaction. The results for the balanced panel are a lower share for the endowments (50%), a slightly higher for the coefficients (36%), and for the interaction (14%). Overall, the results are quite consistent across the different databases.

Tab. 7 - Oaxaca-Blinder decomposition of the gender gap in Total Output

	Unbalanced panel		*Balanced panel*	
Males	11.00***	(0.00597)	11.03***	(0.0250)
Females	10.58***	(0.0121)	10.63***	(0.0560)
Difference	0.416***	(0.0135)	0.400***	(0.0613)
Endowments	0.240***	(0.0117)	0.165***	(0.0560)
Coefficients	0.143***	(0.00828)	0.145***	(0.0395)
Interaction	0.0334***	(0.00511)	0.0896***	(0.0312)
M/F Total Output ratio	1.52		1.52	
	Percentage shares			
Endowments	57.7		50.2	
Coefficients	34.3		35.8	
Interaction	8.0		14.0	
Difference	100.0		100.0	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.010

Table 8 - Oaxaca-Blinder decomposition of the gender gap in Total Output by variables

	Unbalanced panel			Balanced panel		
VARIABLES	Endowment	Coefficients	Interaction	Endowment	Coefficients	Interaction
Land-associated capital (€)	0.0469***	0.257***	0.0148***	0.0504***	0.265**	0.0166**
	(0.00382)	(0.0593)	(0.00349)	(0.00740)	(0.111)	(0.00713)
Fixed capital (€)	0.0562***	0.0492	0.00353	0.0603***	-0.0632	-0.00437
	(0.00490)	(0.0449)	(0.00324)	(0.00933)	(0.0763)	(0.00532)
Circulating capital (€)	0.0497***	0.00936	0.000431	0.0345**	0.0410	0.00124
	(0.00790)	(0.0395)	(0.00182)	(0.0134)	(0.0693)	(0.00216)
Waged labour (hrs)	0.153***	-0.135***	-0.0221***	0.150***	-0.115***	-0.0233***
	(0.0163)	(0.0291)	(0.00525)	(0.0269)	(0.0400)	(0.00905)
Family labour (hrs)	0.0539***	0.271	0.00309	0.0486***	0.221	0.00223
	(0.00387)	(0.152)	(0.00174)	(0.00697)	(0.271)	(0.00276)
Inherited (0/1)	-0.00147**	-0.0321***	-0.00229***	-0.00358	-0.00825	-0.00144

	(0.000579)	(0.00820)	(0.000691)	(0.00218)	(0.0134)	(0.00236)
Elementary school education	-0.00115***	0.00318	0.000252	-0.00144	-0.00246	-0.000573
	(0.000448)	(0.00323)	(0.000269)	(0.000982)	(0.00438)	(0.00103)
Junior high school education	0.000133	-0.0122**	-0.000238	8.61e-05	-0.0276**	-9.35e-05
	(0.000136)	(0.00529)	(0.000206)	(0.000622)	(0.0109)	(0.000676)
High school education	-0.000415	-0.0162***	0.000283	-0.00111	-0.0124	0.000840
	(0.000328)	(0.00625)	(0.000240)	(0.000785)	(0.0114)	(0.000825)
University education	-0.000240	0.00365**	-0.000613	-9.85e-05	0.00521**	0.000270
	(0.000281)	(0.00183)	(0.000338)	(0.000206)	(0.00212)	(0.000512)
Operator's age	-0.00992***	1.513***	0.0180***	-0.0101	2.299***	0.0153
	(0.00328)	(0.220)	(0.00487)	(0.00756)	(0.458)	(0.0110)
Operator's age squared	0.0109***	-0.842***	-0.0221***	0.0129	-1.247***	-0.0211
	(0.00348)	(0.114)	(0.00535)	(0.00770)	(0.234)	(0.0118)
Less Favourite Area	0.00315**	0.0138	-0.00154	-0.00633***	-0.0469**	0.00524**
	(0.00129)	(0.0126)	(0.00142)	(0.00238)	(0.0220)	(0.00258)
Share irrigated/total UAA	0.0189***	0.0119	0.00315	0.0149***	0.0373**	0.0104**
	(0.00215)	(0.00763)	(0.00202)	(0.00401)	(0.0148)	(0.00422)
Organic	-0.000220	-0.00275	0.000436	-0.000406	-0.00872	0.000814
	(0.000498)	(0.00349)	(0.000558)	(0.000459)	(0.00454)	(0.000669)
Mixed livestock	-0.000002	-0.000374	0.00000	0.0000367	-0.000656	-0.000134
	(0.000118)	(0.000477)	0.00005	(0.000128)	(0.000697)	(0.000233)
Mixed cropping	-0.000132	-0.00205	0.000377	0.000116	-0.00678**	-0.000162
	(0.000345)	(0.00214)	(0.000400)	(0.000406)	(0.00312)	(0.000564)
Mixed crops – livestock	0.000924**	-0.000287	0.00003	0.00152	0.00370	-0.000442
	(0.000468)	(0.00160)	(0.000157)	(0.00113)	(0.00305)	(0.000480)
Specialist grazing livestock	-0.00114**	-0.00767	-0.000930	-0.00633***	0.00822	0.00167
	(0.000574)	(0.00487)	(0.000614)	(0.00201)	(0.00796)	(0.00166)
Specialist granivores	-0.00209**	0.00615**	0.00183**	-0.000375	0.0134***	0.000254
	(0.000850)	(0.00274)	(0.000881)	(0.00190)	(0.00505)	(0.00129)
Specialist horticulture	-0.00396***	0.00199	-0.000503	-0.0116***	-0.00304	0.00123
	(0.000876)	(0.00294)	(0.000746)	(0.00265)	(0.00619)	(0.00252)
Specialist field crops	0.00369***	-0.000870	-0.0000518	0.00670***	-0.00354	-0.000358
	(0.00124)	(0.00534)	(0.000318)	(0.00260)	(0.00893)	(0.000912)
Specialist permanent crops	-0.000918**	-0.0158**	0.000634	-0.00238	-0.0415***	0.00160
	(0.000455)	(0.00674)	(0.000379)	(0.00195)	(0.0121)	(0.00136)
Mountain	0.00215***	-0.00307	0.000248	0.000804	0.00550	-0.000107
	(0.000602)	(0.00435)	(0.000356)	(0.00138)	(0.00886)	(0.000251)
Hill	0.000409	0.00151	-0.000223	0.00148	-0.0103	0.00206
	(0.000850)	(0.00643)	(0.000948)	(0.00190)	(0.0107)	(0.00215)
Plain	0.0108***	0.00243	0.000911	0.0163***	0.000582	0.000223
	(0.00177)	(0.00492)	(0.00185)	(0.00343)	(0.00891)	(0.00341)
Constant		-0.730***			-0.936**	
		(0.197)			(0.386)	
Zero capital or labour dummies	yes	yes	yes	yes	yes	yes
Year dummies	yes	yes	yes	yes	yes	yes
Region dummies	yes	yes	yes	yes	yes	yes
Observations	54,205	54,205	54,205	17,244	17,244	17,244

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.010

Table 8 presents the results with reference to the individual variables. Land-associated capital contributes positively to the gender gap for endowment, coefficients, and interaction according to both panels. This implies that not only do female-operated farms on average have lower Land-associated capital, but that it is also less productive. Endowment of Fixed capital increases the gender gap, but there is no significant difference in the coefficient nor in the interaction term, which implies that there is no significant difference in productivity. The endowment of Circulating capital too penalizes women but, again, no significant difference in coefficient nor interaction terms is detectable. As to waged labour, the lower average endowment contributing to the gender gap is countered by its higher productivity in female-operated farms and by the interaction term. The endowment of family labour is also lower in female farms, but the coefficients and the interactions are not significant.

The effect of the controls is much less defined. Among human capital variables, the Inherited variable significantly lowers the gender gap for all components in the unbalanced panel, but no component is significant in the balanced panel. The endowment of the lower education level is significant in the unbalanced panel and bears a negative sign, which means that fewer females have a lower education level. Junior high school education is more productive for women (both panels) as well as High school (unbalanced panel). By contrast, University education favours males' more than women's productivity. The coefficients of age are significant and positive for both panels (and age squared significant and negative), which could be interpreted as a lower effect of experience on female productivity.

Among the variables related to the physical characteristics of soils, for the share of irrigated over total area the endowment components are significant and positive for both panels, which indicates that female-operated farms are less endowed with irrigation. The coefficients and interaction components are significant and positive for the balanced

panel only. The results for Less Favourite Areas are inconsistent between the two panels. Location in Mountains significantly penalises women, but only for the endowment component in the unbalanced panel (no component is significant in the balanced panel). As to hills, no component is significant. Location in plains significantly increases the gap, but no significant effect in productivity differences is detected. Finally, few results concerning the Type of farming are consistent across panels. The only ones are the endowment of Specialist horticulture which lowers the gender gap; the endowment of Specialist field crops, which has the opposite effect; and the coefficient component of Specialist granivores, again increasing the gender gap.

As a robustness check, and especially to cope with the possible serial correlation of the panel data, we performed the OBD on each year's cross-section data. Table 9 presents the results of the overall decomposition of the difference in average Total Output among the three components, while Table 10 displays their percentage shares. The Male/Female ratio in mean Total Output, equal to 1.52 for both pooled datasets, ranges from 1.41 to 1.60 across years for the unbalanced panel, and 1.46 to 1.58 for the balanced one. There is therefore a variation in yearly results. The mean Total Outputs are statistically significantly different between each couple of years, for both male and female farms. However, this is not surprising given the high number of observations, and it is fair to state that the variation of the gender gap remains in a reasonably limited range, since the differences between each year's mean TO and the mean TO for the overall period is always below 1% for both genders and both panels. As to the components, the endowment, which makes up 57.7 and 50.2% of the gap for the overall unbalanced and balanced panels, ranges from 54.2-59.7% and 41.3-58.1%, hence with up to 5 and 17 percentage points difference. The coefficient component (34.3 and 35.8% for the overall unbalanced and balanced panels) ranges from 30.3-37.4% and 30.4-41.1%, and the

difference to the overall share is up to 7 percentage points in the unbalanced panel, and up to 11 p.p. in the balanced one.

Tab. 9 - Oaxaca-Blinder decomposition of the gender gap in Total Output by year

	2012-17	2012	2013	2014	2015	2016	2017
		Unbalanced panel					
Males	10.995	11.021	11.000	10.944	11.015	11.008	10.978
Females	10.579	10.548	10.562	10.548	10.588	10.610	10.634
Difference	0.416	0.473	0.438	0.396	0.427	0.398	0.345
Endowments	0.238	0.275	0.250	0.221	0.241	0.238	0.181
Coefficients	0.157	0.167	0.147	0.155	0.170	0.152	0.148
Interaction	0.021	0.031	0.041	0.020	0.017	0.007	0.017
M/F Total Output ratio	1.52	1.60	1.55	1.49	1.53	1.49	1.41
		Balanced panel					
Males	11.071	11.118	11.106	11.061	11.064	11.054	11.026
Females	10.651	10.713	10.664	10.640	10.681	10.591	10.622
Difference	0.420	0.405	0.442	0.421	0.384	0.463	0.404
Endowments	0.218	0.198	0.238	0.245	0.203	0.220	0.201
Coefficients	0.164	0.185	0.158	0.137	0.149	0.205	0.151
Interaction	0.038	0.022	0.046	0.039	0.032	0.038	0.053
M/F Total Output ratio	1.52	1.50	1.56	1.52	1.47	1.59	1.50

6 Gender gap by production mix

So far, in our setting location and Type of farming are treated as dummy variables shifting the origin but leaving the coefficients of the inputs unaffected. It is nevertheless quite possible that the coefficients vary between locations and especially Types of farming, and that the gender differentials in the coefficients differ across locations and TFs. We therefore checked our results by estimating the Oaxaca-Blinder decomposition for the most representative TFs, i.e., Specialist field crops (SFC), Specialist permanent crops (SPC), and Specialist grazing livestock (SGL).

The shares of these three TFs over the total number of farms are 25.6%, 29.1%, and 22.2%, respectively, for a total of 76.9% in the unbalanced panel. The corresponding

shares are 25.5%, 29.7%, and 21.4%, for a total of 76.5%, in the balanced panel. The shares of the TFs over the total of female- and male-operated farms are respectively 30.0% and 28.8% for SFC, 24.5% and 25.9% for SPC, and 20.2% and 22.7% for SGL in the unbalanced panel. In the balanced panel, they are 23.5% and 26.0% for SFC, 30.6% and 29.4% for SPC, and 18.3% and 21.9% for SGL. Overall, they represent a substantial part of the farms, and their weight is rather similar for female- and male-operated farms.

Restricting the analysis to single TFs, the number of farms in each year from the originally balanced panel becomes uneven, due to year to year changes of TF of some farms. In addition, there are no observations of female-operated farms in some Regions, which prevents the estimation, as Region dummies were used as controls. We therefore estimated the decomposition from the balanced panel dropping the farms in those regions. The year-by-year estimation of the decomposition was also prevented for the balanced panel for similar reasons. i.e., lack of female-operated farms of the TF in several years and Regions. By contrast, we could estimate the decomposition on the full TF unbalanced panel, as well as the year-by-year decomposition (with some exceptions). Hence, we will report for completeness the results for both panels, but we are more confident in the unbalanced one, and we will comment mainly on it.

Table 11 presents the decomposition for the three TFs, and Table 12 the percentage shares. There are important differences across TFs. The production gender gap, equal to 52% when estimated on the whole panels, is higher for SFC (57% and 62%, for the unbalanced and balanced panel, respectively), lower for SPC (37% and 33%, respectively), and intermediate for SGL (47% and 62%, respectively). The origins of the gender gap also differ across TFs. While for SFC the shares of endowments and coefficients are of comparable size (49.8% and 43.1% in the unbalanced panel, 42.3% and 39.4% in the balanced one), in SPC and in SGL the share of the endowment component is overwhelming. It is 61.1% and 63.8% vs 28.3% and 19.1% in the

unbalanced and balanced panel, respectively, for SPC, and 76.6% and 64.4% vs 15.6% and 21.3% in the SGL.

Tab. 11 - Oaxaca-Blinder decomposition of the gender gap in Total Output by TF

Specialist field crops

	Unbalanced panel			*Balanced panel*		
	Mean	S.E.	%	Mean	S.E.	%
Males	10.94***	(0.0108)		11.09***	(0.0179)	
Females	10.49***	(0.0232)		10.60***	(0.0401)	
Difference	0.450***	(0.0256)	100.0	0.485***	(0.0440)	100.0
Endowments	0.224***	(0.0225)	49.8	0.205***	(0.0427)	42.3
Coefficients	0.194***	(0.0157)	43.1	0.191***	(0.0305)	39.4
Interaction	0.0331***	(0.0104)	7.4	0.0884***	(0.0302)	18.2
M/F Total Output ratio	1.57			1.62		
Observations	13,899			4,197		

Specialist permanent crops

	Unbalanced panel			*Balanced panel*		
	Mean	S.E.	%	Mean	S.E.	%
Males	10.74***	(0.0102)		10.81***	(0.0166)	
Females	10.43***	(0.0204)		10.53***	(0.0326)	
Difference	0.314***	(0.0229)	100.0	0.282***	(0.0366)	100.0
Endowments	0.192***	(0.0204)	61.1	0.180***	(0.0364)	63.8
Coefficients	0.0890***	(0.0145)	28.3	0.0540**	(0.0244)	19.1
Interaction	0.0322***	(0.00985)	10.3	0.0482**	(0.0241)	17.1
M/F Total Output ratio	1.37			1.33		
Observations	15,744			4,969		

Specialist grazing livestock

	Unbalanced panel			*Balanced panel*		
	Mean	S.E.	%	Mean	S.E.	%
Males	11.35***	(0.0217)		11.27***	(0.0122)	
Females	10.87***	(0.0589)		10.88***	(0.0276)	
Difference	0.479***	(0.0628)	100.0	0.385***	(0.0302)	100.0
Endowments	0.309***	(0.0648)	76.6	0.295***	(0.0284)	64.4
Coefficients	0.111***	(0.0361)	15.6	0.0599***	(0.0159)	23.1
Interaction	0.0603	(0.0388)	7.9	0.0303**	(0.0118)	12.6
M/F Total Output ratio	1.47			1.62		
Observations	3,564			12,060		

Note: in the Balanced panels the following Regions were excluded: Calabria, Emilia-Romagna, Lazio, Trentino Alto Adige, Valle d'Aosta for Specialist Field crops; Emilia-Romagna, Lazio, Sardegna, for Specialist permanent crops; Calabria, Friuli-Venezia Giulia, Puglia, Emilia-Romagna for Specialist grazing livestock

Tab. 12 - Percentage shares of the Oaxaca-Blinder decompositions of the gender gap in Total Output by TF and year

	2012-17	2012-17	2012	2013	2014	2015	2016	2017
	Balanced panel	*Unbalanced panel*						
		Specialist field crops						
Endowments	42.4	49.6	57.0	48.7	48.2	46.1	44.0	56.2
Coefficients	39.4	43.0	36.0	36.9	44.7	46.5	46.5	39.9
Interaction	18.2	7.3	7.0	14.3	7.1	7.4	9.5	3.9
Difference	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
M/F TO ratio	1.62	1.57	1.54	1.59	1.51	1.64	1.58	1.54
		Specialist permanent crops						
Endowments	63.8	61.3	67.1	61.6	69.2	69.0	65.7	38.7
Coefficients	19.1	28.4	25.7	23.2	25.6	28.4	23.1	40.9
Interaction	17.1	10.3	7.2	15.2	5.2	2.6	11.2	20.4
Difference	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
M/F TO ratio	1.33	1.37	1.43	1.45	1.38	1.34	1.34	1.27
		Specialist grazing livestock						
Endowments	64.4	76.6	73.6	66.8	80.0	123.6	78.8	58.2
Coefficients	23.1	15.6	20.5	20.3	22.4	-13.8	8.6	12.5
Interaction	12.6	7.9	5.8	12.8	-2.4	-9.8	12.6	29.3
Difference	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
M/F TO ratio	1.62	1.47	1.86	1.56	1.41	1.29	1.32	1.34

Within the individual TF, there is year-to-year variation in the male-to-female ratio of average Total Output (Table 12), ranging from 51 to 64% for SFC, 27 to 43% for SPC, and 29 to 86% for SGL (unbalanced panel). The composition of the gender gap too exhibits year-to-year variation. The endowment component ranges from 44 to 57% for SFC; 61.6 to 69% for SPC (except for a 38.7% outlier in 2017); 58.2 to 80% for SGL[2]. The coefficient component ranges from 36 to 46.5% for SFC, 23.1 to 28.4% for SPC (except for an anomalous 40.1% again in 2017), and -2.4% to 12.8% for SGL.

[2] The 2015 endowment component for SGL is 123%, an anomalous datum. In that year, the coefficient component for SGL is -13.8%, the only case in which the coefficients contribute to decreasing the gender gap; the interaction is -9.8%.

The decomposition by individual variables (Tables 13, 14, and 15) suggests that female-operated farms of all three TFs are less endowed with Land-associated and Fixed capitals and with Family labour. They are also less endowed with Waged labour and Irrigated area in both SFC and SPC. In the case of SFC and SGL, also location in Mountain and Plain add to the gender gap. Education in Elementary school (for SFC and SPC), Junior high school (for SFC), High school (for SGL), and University (for SPC) decrease the gender gap. The coefficients concerning Waged labour and High school education indicate a higher female productivity, while age contributes to an increase in the gap, suggesting that experience is more productive for males. Junior high school is more productive for females in SFC, High school in SGL, and University in SPC. It can also be noted that only in SGL Circulating capital adds to the gender gap, for endowment, coefficient, and interaction components.

Table 13 - Oaxaca-Blinder decomposition of the gender gap in Total Output by variables - Specialist field crops

	Unbalanced panel			Balanced panel		
VARIABLES	Endowment	Coefficients	Interaction	Endowment	Coefficients	Interaction
Land-associated capital (€)	0.0468***	0.150	0.00593	0.0339***	0.484**	0.0181
	(0.00738)	(0.102)	(0.00410)	(0.0114)	(0.220)	(0.00938)
Fixed capital (€)	0.0501***	0.113	0.00910	0.0474**	-0.0210	-0.00119
	(0.00922)	(0.0601)	(0.00507)	(0.0209)	(0.116)	(0.00656)
Circulating capital (€)	0.0145	-0.0764	-0.00204	-0.000859	-0.0858	0.000119
	(0.00984)	(0.0617)	(0.00214)	(0.0163)	(0.127)	(0.00226)
Waged labour (hrs)	0.107***	-0.0917**	-0.0166	0.0717**	0.136	0.0533
	(0.0260)	(0.0427)	(0.00859)	(0.0329)	(0.0711)	(0.0311)
Family labour (hrs)	0.0589***	0.667**	0.00860**	0.0528***	0.846	0.0111
	(0.00735)	(0.285)	(0.00379)	(0.0126)	(0.575)	(0.00788)
Inherited (0/1)	0.00412	-0.0180	0.000808	0.000999	0.0430	-0.000339
	(0.00225)	(0.0151)	(0.000798)	(0.00610)	(0.0280)	(0.00208)
Elementary school education	-0.00371**	0.0159**	0.00191	-0.00689	-0.00207	-0.00175
	(0.00169)	(0.00727)	(0.00116)	(0.00607)	(0.00752)	(0.00635)
Junior high school education	-0.00266**	-0.0404***	0.00445***	0.000756	-0.0389	0.00952
	(0.00132)	(0.0113)	(0.00167)	(0.00655)	(0.0285)	(0.00717)
High school education	0.00147	-0.0272**	-0.00118	-0.000998	0.0648**	0.00117
	(0.00106)	(0.0116)	(0.000922)	(0.00290)	(0.0263)	(0.00340)
University education	0.0000987	0.00473	0.000392	0.00806	-0.00143	-0.00203
	(0.000265)	(0.00315)	(0.000511)	(0.00502)	(0.00345)	(0.00489)
Operator's age	-0.00934	2.774***	0.0207	0.00184	4.270***	-0.00299
	(0.00751)	(0.466)	(0.0154)	(0.0256)	(0.883)	(0.0416)
Operator's age squared	0.00946	-1.499***	-0.0248	-0.00191	-2.160***	0.00333
	(0.00699)	(0.241)	(0.0161)	(0.0231)	(0.449)	(0.0403)
Less Favourite Area	-0.000903	0.0102	-0.00225	-0.0169	-0.0475	0.0136
	(0.00431)	(0.0217)	(0.00479)	(0.0120)	(0.0451)	(0.0131)
Share irrigated/total UAA	0.0255***	0.0163	0.00576	0.0415***	0.00693	0.00266
	(0.00514)	(0.0144)	(0.00511)	(0.0126)	(0.0313)	(0.0120)
Organic	-0.000110	0.00417	0.000113	-0.00574	0.00728	0.00560
	(0.000337)	(0.00461)	(0.000349)	(0.00369)	(0.00474)	(0.00388)
Mountain	0.00573***	-0.00178	0.000611	0.00230	0.00242	-0.00123
	(0.00192)	(0.00589)	(0.00202)	(0.00554)	(0.0125)	(0.00638)
Hill	0.00287	0.00181	-0.000259	0.00420	-0.00941	0.00169
	(0.00152)	(0.0115)	(0.00165)	(0.00364)	(0.0214)	(0.00386)
Plain	0.0176***	0.00232	0.000821	0.0136	0.00324	0.00164
	(0.00453)	(0.0133)	(0.00473)	(0.0123)	(0.0270)	(0.0136)
Constant		-1.658***			-4.135***	
		(0.407)			(0.814)	
Zero capital or labour dummies		yes			yes	
Year dummies		yes			yes	
Region dummies		yes			yes	
Observations		13,899			4,197	

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.010

Table 14 - Oaxaca-Blinder decomposition of the gender gap in Total Output by variables - Specialist permanent crops

	Unbalanced panel			Balanced panel		
VARIABLES	Endowment	Coefficients	Interaction	Endowment	Coefficients	Interaction
Land-associated capital (€)	0.0300***	0.668***	0.0425***	0.0366***	0.592***	0.0471***
	(0.00624)	(0.105)	(0.00739)	(0.0119)	(0.168)	(0.0143)
Fixed capital (€)	0.0447***	-0.0309	-0.00287	0.0874***	-0.273**	-0.0355**
	(0.00738)	(0.0641)	(0.00597)	(0.0187)	(0.112)	(0.0155)
Circulating capital (€)	-0.0143	-0.0190	0.000537	-0.0322**	0.00645	-0.000441
	(0.00844)	(0.0460)	(0.00134)	(0.0138)	(0.0842)	(0.00575)
Waged labour (hrs)	0.299***	-0.217***	-0.0457***	0.359***	0.0197	0.00819
	(0.0350)	(0.0594)	(0.0135)	(0.0542)	(0.0808)	(0.0335)
Family labour (hrs)	0.0313***	0.0831	0.000558	0.0260	-0.797	-0.00368
	(0.00656)	(0.248)	(0.00167)	(0.0148)	(0.445)	(0.00293)
Inherited (0/1)	-0.00234	0.00792	0.00106	-0.00406	0.0163	0.00457
	(0.00171)	(0.0137)	(0.00184)	(0.00591)	(0.0233)	(0.00655)
Elementary school education	-0.00216**	0.0128**	0.00166	0.000194	0.0272***	-0.000371
	(0.00105)	(0.00518)	(0.000943)	(0.00139)	(0.00833)	(0.00265)
Junior high school education	-0.000141	0.000825	0.0000222	0.000683	-0.00762	-0.000586
	(0.000241)	(0.00765)	(0.000208)	(0.00109)	(0.0144)	(0.00117)
High school education	0.000049	-0.0234**	-0.0000472	-0.000595	-0.0119	0.000300
	(0.000559)	(0.0112)	(0.000540)	(0.00106)	(0.0178)	(0.000671)
University education	-0.00227**	-0.00476	0.00118	-0.000458	-0.0127**	0.00232
	(0.00108)	(0.00424)	(0.00108)	(0.000957)	(0.00569)	(0.00190)
Operator's age	-0.00412	0.733**	0.0151	-0.0396	2.155***	0.0830***
	(0.00667)	(0.357)	(0.00825)	(0.0232)	(0.636)	(0.0315)
Operator's age squared	0.00553	-0.560***	-0.0229**	0.0427	-1.426***	-0.101***
	(0.00706)	(0.189)	(0.00953)	(0.0231)	(0.336)	(0.0347)
Less Favourite Area	0.00102	0.0436**	-0.000846	0.00251	-0.0174	-0.00137
	(0.00108)	(0.0185)	(0.000925)	(0.00258)	(0.0343)	(0.00276)
Share irrigated/total UAA	0.0237***	0.00450	0.00212	0.00931	0.0161	0.0102
	(0.00529)	(0.0117)	(0.00553)	(0.0146)	(0.0249)	(0.0157)
Organic	-0.00123	-0.00188	0.000387	-0.00820**	-0.0237	0.00735
	(0.00161)	(0.00869)	(0.00179)	(0.00412)	(0.0133)	(0.00445)
Mountain	-0.00210	-0.00434	-0.00222	-0.00200	0.00153	0.00140
	(0.00244)	(0.00544)	(0.00278)	(0.0120)	(0.0146)	(0.0134)
Hill	0.00152	0.00216	-0.000489	0.0144	0.0246	-0.00741
	(0.00296)	(0.0147)	(0.00333)	(0.00754)	(0.0272)	(0.00826)
Plain	0.00258	0.00635	0.00174	-0.000591	-0.0143	0.000317
	(0.00192)	(0.00769)	(0.00212)	(0.00167)	(0.0156)	(0.000947)
Constant		-0.384			-0.199	
		(0.315)			(0.569)	
Zero capital or labour dummies	yes	yes	yes	yes	yes	yes
Year dummies	yes	yes	yes	yes	yes	yes
Region dummies	yes	yes	yes	yes	yes	yes

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.010

Table 15 - Oaxaca-Blinder decomposition of the gender gap in Total Output by variables - Specialist grazing livestock

	Unbalanced panel			Balanced panel		
VARIABLES	Endowment	Coefficients	Interaction	Endowment	Coefficients	Interaction
	0.0309***	0.0680	0.00324	0.0902***	-0.565**	-0.0372
	(0.00663)	(0.129)	(0.00616)	(0.0221)	(0.281)	(0.0194)
Fixed capital (€)	0.0751***	-0.347	-0.00956	0.0782***	-0.579	-0.0197
	(0.0123)	(0.222)	(0.00628)	(0.0249)	(0.380)	(0.0141)
Circulating capital (€)	0.144***	0.349**	0.0199**	0.194***	1.289***	0.113***
	(0.0176)	(0.174)	(0.0102)	(0.0351)	(0.340)	(0.0329)
Waged labour (hrs)	0.0203	-0.113**	-0.00403	-0.0549	-0.269**	0.0246
	(0.0244)	(0.0569)	(0.00523)	(0.0524)	(0.113)	(0.0252)
Family labour (hrs)	0.0394***	0.275	0.00281	0.0467***	-0.142	-0.00148
	(0.00673)	(0.338)	(0.00348)	(0.0149)	(0.727)	(0.00756)
Inherited (0/1)	0.000880	-0.0512***	-0.00564***	-0.00932	-0.00823	-0.00258
	(0.00166)	(0.0163)	(0.00216)	(0.0101)	(0.0335)	(0.0105)
Elementary school education	0.000713	8.10e-05	-5.99e-06	0.000658	0.0239	-0.000524
	(0.000688)	(0.00650)	(0.000481)	(0.00380)	(0.0129)	(0.00303)
Junior high school education	0.000304	0.00857	0.00140	-0.00474	0.0558	0.00710
	(0.00162)	(0.0109)	(0.00179)	(0.00434)	(0.0319)	(0.00501)
High school education	-0.00307**	-0.0241**	0.00247	-0.00112	-0.0454	0.00787
	(0.00143)	(0.0119)	(0.00142)	(0.00505)	(0.0310)	(0.00594)
University education	0.000234	0.00192	-0.000425	0.00534	-0.00201	-0.00358
	(0.000572)	(0.00279)	(0.000648)	(0.00291)	(0.00169)	(0.00276)
Operator's age	-0.00901	0.963**	0.00878	0.00747	1.677	-0.00766
	(0.00694)	(0.410)	(0.00694)	(0.0174)	(0.981)	(0.0178)
Operator's age squared	0.0113	-0.556***	-0.0106	-0.00146	-1.005**	0.00154
	(0.00791)	(0.209)	(0.00768)	(0.0192)	(0.510)	(0.0202)
Less Favourite Area	0.00339	-0.0557	0.00546	0.0122	0.0902	-0.0105
	(0.00380)	(0.0422)	(0.00419)	(0.00903)	(0.0825)	(0.00985)
Share irrigated/total UAA	0.00969	-0.00692	-0.00361	0.0268**	-0.0266	-0.0170
	(0.00495)	(0.00981)	(0.00512)	(0.0126)	(0.0198)	(0.0128)
Organic	-0.000726	-0.00852	0.00121	0.000411	-0.0114	0.00285
	(0.000876)	(0.00627)	(0.00103)	(0.00306)	(0.0130)	(0.00352)
Mountain	0.0191***	0.0291	-0.00579	0.0178	-0.0124	0.00284
	(0.00419)	(0.0192)	(0.00388)	(0.0129)	(0.0578)	(0.0133)
Hill	-0.000289	0.0146	0.000851	0.000241	-0.0101	-0.000706
	(0.000528)	(0.00921)	(0.000733)	(0.000988)	(0.0143)	(0.00133)
Plain	0.0168***	-0.0141**	-0.00840**	0.0139	0.00742	0.00820
	(0.00416)	(0.00676)	(0.00410)	(0.0117)	(0.0112)	(0.0124)
Constant		-0.158			0.268	
		(0.412)			(0.902)	
Zero capital or labour dummies	yes	yes	yes	yes	yes	yes
Year dummies	yes	yes	yes	yes	yes	yes
Region dummies	yes	yes	yes	yes	yes	yes
Observations	12,060	12,060	12,060	3,564	3,564	3,564

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.010

7 Conclusions

In this paper we assess the existence and the components of a gender gap in agricultural productivity, confronting Total Output production in female- and male-operated farms. As we have shown, there is some variation in the results, depending on the year and on the dataset composition. Nevertheless, summing up, some general conclusions seem fair and sufficiently robust: 1) a gender gap in agricultural production exists, with Total Output in male-operated farms exceeding by around 50 percent the TO of the female-operated farms; 2) the largest part of the gap (between 50 and 60%) is explained by the different endowments, as female-operated farms have less capital of all types, less labour, and generally operate in unfavourable physical conditions; 3) a lower, and more variable, share of the gap (30-40%) is due to the different productivity; 4) among the basic inputs, the productivity is higher in male-operated farms for Land-associated capital, while the reverse is true for waged labour. The results are mixed for the other inputs and controls; 5) the gender gap is different across Types of farming, but in all the endowment component is prevalent, and mainly concerns Land-associated and Fixed capitals, and Waged and Family labour; 6) the productivity component is more varied across TFs.

Drawing some conclusions from these results is not easy. Our goal was to assess the existence of a gender gap and to evaluate its components. Speculating on the reasons for the gender gap and its components was outside the scope of our analysis and, in any case, our general data do not allow for an analysis of these reasons. A more detailed analysis may shed light on this issue, which is left to further research.

This study has several limitations. The decomposition relies on the assumption of a Cobb-Douglas production function, and no other production function has been tested. The year dummies might not fully account for the climate or economic year-to-year differences.

Most importantly, the gender gap we analyse concerns farm revenue, and does not necessarily translate into a gap in profitability. Lower returns may be compensated for by lower costs, so that there may be no difference, or a positive difference, in profits, between female- and male-operated farms. This issue is also a direction for future research.

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