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WILL ROMANIAN CROP FARMS BE AFFECTED DIFFERENTLY BY LOW-INPUT FARMING?

ABSTRACT

We use farm-level panel data from FADN Romania for three years (2016–2018) and estimate Cobb-Douglas production function to document the effect of low-input farming on production. We find that there are substantial differences in measuring values for capital, crop protection and fertilizers in the database that pose problems in estimating a uniform function for farms of all sizes and also for comparing the results. The estimations show the effect of fertilizers is larger for very small farms and of similar magnitude for the other farms. However, the estimator of the impact of reducing the use of crop protection materials is larger for farms with total utilized area larger than 10 hectares.

Key words: productivity, European Green Deal, crop farms, Romania.

JEL Classification: Q12, Q18, O47.

1. INTRODUCTION

The European Green Deal is an important part of the Commission's priorities for the period 2019–2024. It aims to transform Europe into "the first climate-neutral continent by becoming a modern, resource-efficient economy". The Farm to Fork Strategy lies at the core of the Green Deal, which aims at developing a healthy, equitable and environment friendly agricultural system by 2030. In order to achieve the above objectives, it is necessary to reduce the use of pesticides, antibiotics, chemical fertilizers, boost organic production, improve animal welfare and reduce biodiversity loss. In figures, the strategy can be summarized as follows (targets for 2030): reduce the use of pesticides by 50% by the year 2030; reduce the loss of soil nutrients by 50% and the use of chemical fertilizers by 20%; increase the set-aside area to 10% in order to maintain biodiversity; increase organic farming to 25% of total agricultural land.

The application of the restrictions proposed by the Farm to Fork Strategy and the Biodiversity Strategy produces four large categories of effects: at farm level, at sectoral level, at the European Union level and at global level. All the actors in the supply chains are affected, starting with farmers, input producers, processors, consumers and finally the whole population (taxpayers), due to the changes in the structure and level of agricultural supply, agricultural prices, agri-food trade balance, consumer prices and food demand implicitly. Less evaluated so far are the expected effects on the environment, human health, biodiversity and animal and plant welfare in agricultural areas. In this context, several scientific and academic institutions have developed studies to evaluate the impact of the implementation of the two above-mentioned strategies on agriculture in the European Union and globally. The studies approached this issue differently, emphasizing and giving priority to one or the other of the provisions and targets of the two strategies. The methodologies used were different, using econometric models developed in the European space or within the ERS (USDA).

The main conclusions of these studies are diversified and quite nuanced because it seems that the evaluation of the effects of the implementation of the European Green Deal targets is quite difficult to forecast at this moment, due to the insufficient information for estimating the effects generated by the climate and environmental measures on agricultural production, consumers and general welfare of society. There are assessments based on partial equilibrium models that estimate the impact on markets and prices, at European, regional and global level, but it is unclear to what extent climate and environmental interventions will have the intended (expected) effects in terms of improving climate conditions, increasing biodiversity, air, water and soil quality, and finally to what extent they will affect people's lives, in terms of improving health, nutrition and quality of life throughout the ecosystem.

This paper presents a case study that attempts to evaluate the sensitivity of farm production in relation to the use of chemical inputs, namely chemical fertilizers and crop protection products, for farms specializing in field crops. It aims to ascertain the effect that the Green Deal will have on Romanian crop farms, but takes into account only two aspects of the strategy, namely the reduction in fertilizer use and reduction in pesticide use. We have used the production function methodology that establishes a relationship between outputs and inputs, and included fertilizers and pesticides among determinants. In the literature, there are numerous types of dependency between inputs and outputs, and we have selected a Cobb-Douglas approach. The correct estimation of total factor productivity is an important issue in the works of applied economy and at the same time a difficult problem because the endogeneity and identification of parameters must be taken into consideration. Thus, productivity determines the optimal choice of inputs by the production unit, giving rise to an endogeneity problem known in the literature as “transmission bias” (Griliches and Mairesse, 1998).

There are several solutions to the above-mentioned problem, fixed effect models that require that a component of the productivity be fixed over time, instrumental variable estimation that requires an instrument correlated with the variable input but uncorrelated with the productivity shock. Oiley and Parker (1996) developed a new approach for controlling the correlation between input and productivity by using investment. Levinsohn and Petrin (2000) showed that intermediate consumption can play a similar role to that played by investment. Moreover, investment is a good instrument only for firms with non-zero investment, making it ineffective for a large number of firms. On the other hand, all firms report intermediate consumption expenditure each year, making it a better instrument for correcting the correlation. Both Oiley and Parker and Levinsohn and Petrin methods are two-step estimation procedures.

Wooldridge (2009) developed a method that is a one-step procedure implementing the generalized method of moments (GMM) that accounts for serial correlation or heteroskedasticity of errors (Wooldridge, 2009).

In this paper, we estimate a Cobb-Douglas production function for a representative sample of Romanian crop farms in the period 2016–2018 using Wooldridge method.

2. MATERIAL AND METHOD

We use a relatively large farm-level panel database for Romania for 8 regions and three years (2016–2018) and all TF8 specializations, but the analysis is limited to the farms that have declared field crops as their main activity. The series contains regional and farm size information about the representative farms in that size category. It includes information on production, costs, inputs, labour, assets, liabilities, etc. *We divided the farms into 4 groups according to the size of total utilized agricultural area (SE025, denoted as land). The variable* ***c_land*** *takes the value:* ***1****, for 1342 very small farms with land<10 hectares;* ***2****, for 2832 small farms with land>=10 and land<100;* ***3****, for 2383 medium-sized farms with land>=100 and land<500; and* ***4****, for 1185 large farms with land>500. The reasons for selecting these limits are related to the heterogeneity of farms and the common characteristics depending on size.* There are inconsistencies in measuring values for capital, crop protection and fertilizers in the database. These measurement problems can lead to inaccurate estimates if farm heterogeneity is not taken into account. In Table 1 we show the value of crop specific costs per hectare expressed by: total seeds, fertilizers and crop protection. We notice almost the twice as high average value of crop specific costs for very small farms.

Table 1

Statistics per hectare. Percentages (total seeds, fertilizers, crop protection) in crop specific costs

	Crop specific costs	Total seeds (%)	Fertilizers (%)	Crop protection (%)
c_land=1				
Mean	463.0621	41.07	32.52	20.50
P25	192.9512	31.07	23.04	13.97
P50	256.7806	39.51	32.68	18.98
P75	449.8042	48.36	40.62	25.64
c_land=2				
Mean	269.0034	38.53	37.49	21.05
P25	187.931	30.59	31.57	15.78
P50	230.2899	37.20	37.01	19.91
P75	273.6804	45.14	43.59	26.53
c_land=3				
Mean	241.2777	37.13	39.40	21.79
P25	203.4228	29.42	33.86	16.77
P50	232.6937	35.53	38.62	20.45
P75	262.9439	44.25	44.14	27.54
c_land=4				
Mean	244.2842	36.64	39.36	23.28
P25	205.3649	28.71	34.03	17.34
P50	239.1052	34.73	38.15	21.85
P75	273.0504	44.88	43.98	28.90
Total				
Mean	308.0623	38.54	36.99	21.42
P25	196.5242	29.80	31.03	15.96
P50	236.1198	36.99	36.94	20.01
P75	284.4814	45.52	43.17	27.11

Note: Mean, P25, P50 and P75 represent the mean value, and the 25^{th} 50^{th} and 75^{th} percentile.

However, the percentages in crop specific costs for total seeds, fertilizers and crop protection are smaller for these farms. This demonstrates that very small farms use less inputs and the abnormal values are due to the higher prices these farms pay for these inputs as they pay more due to purchasing smaller quantities.

In Table 2 we show the value of capital per hectare expressed by: total assets, machinery and equipment, land, buildings. The very high values for very small farms are highlighted: more than twice the average for assets and land value; more than three times for the average value of buildings; more than 1.4 times for the value of machinery and equipment.

Table 2

Statistics per hectare. Variables that express capital

c_land	Machinery and equipment (SE455)	Total assets (SE436+SE437)/2	Value of land (SE446)	Buildings (SE450)	Total assets – Value of land - Buildings
c_land=1					
Mean	962.2869	8741.061	2167.615	4534.751	2038.695
P25	0	3335.707	779.4602	845.7596	430.7306
P50	76.86453	5632.481	1763.551	2180.138	967.29
P75	910.8896	9339.072	2717.056	4330.231	2197.222
c_land=2					
Mean	663.0708	2682.179	926.8326	644.7031	1110.644
P25	57.33332	900.1254	0	113.2689	253.2461
P50	280.2658	1760.164	342.919	335.6298	537.8004
P75	696.0629	3243.299	1407.317	785.3402	1064.176
c_land=3					
Mean	505.8426	1314.307	334.8423	138.5759	840.8884
P25	102.0977	489.6115	0	25.09686	254.4702
P50	312.9925	957.076	18.71001	63.91569	590.082
P75	647.814	1697.83	265.0245	156.3668	1105.995
c_land=4					
Mean	563.8559	1567.301	370.3327	141.9762	1054.992
P25	151.7474	645.9947	0	19.17635	357.7661
P50	395.8858	1206.632	37.50098	48.53904	840.1815
P75	791.8557	1997.293	321.3715	123.5119	1457.278
Total					
Mean	683.2851	3715.839	1007.303	1440.391	1268.145
P25	41.71453	836.4087	0	53.50255	308.8342
P50	287.3229	1790.672	281.2423	225.0791	671.9304
P75	726.7358	3937.643	1516.968	1028.889	1335.581

Note: Mean, P25, P50 and P75 represent the mean value, and the 25th 50th and 75th percentile.

The framework in which we present the analysis allows the integration of imperceptible productivity shocks that inevitably correlate with the level of inputs. Thus, from an estimation point of view, we are dealing with the endogeneity of the regressors, which makes the OLS estimators biased and inconsistent.

Contributions in this area include Olley and Pakes (OP) (1996), Levinsohn and Petrin (LP) (2003) and Ackerberg *et al*. (2015). According to these studies, the variables that define the problem of maximizing profits are divided into: (i) x_{it} state variables (usually capital) that are not affected by productivity shocks at time t because they were already subject to the choice at a previous time t-k; (ii) free variables w_{it} (usually labor inputs) affected by the productivity shocks; (iii) control variables.

The generic model is as follows:

$$y_{it} = \alpha + \beta w_{it} + x_{it}\gamma + \omega_{it} + \eta_{it} \qquad (1),$$

$$\log(A_{it}) = \alpha + \varepsilon_{it}.$$

$$\varepsilon_{it} = \omega_{it} + \eta_{it}$$

$$\Phi_{it}(i_{it}, x_{it}) = x_{it}\gamma + h(i_{it}, x_{it}) = x_{it}\gamma + \omega_{it}.$$

where y_{it} is the output, w_{it} is the vector of free variables and x_{it} is the vector of state variables w_{it}.[1].

ω_{it} is an unknown variable representing the productivity or technical efficiency estimated as a random effect, ε_{it} is the error variable that represents the shocks that are supposed to evolve as a Markov process.

$$\omega_{it} = E(\omega_{it} \mid \omega_{it-1}) + u_{i,t} = g(\omega_{it-1}) + u_{i,t}\,,$$

where $u_{i,t}$ is the component that represents the random shocks considered uncorrelated with the state variables x_{it} and the lags of the free variables w_{it}. The function g(.) is usually left unspecified and approximated by an n-th order polynomial.

Output (cropout, SE135) is defined as the value (€) of total output crops and crop production, total labour (totallb, SE010) is measured by the total labour input of holding expressed in annual work units, farm capital (asset, SE436+SE437)/2) is total value (€) of fixed assets + current assets measured as average value at opening and closing valuation, which include the value of agricultural land, farm machinery and equipment, buildings, forest capital, breeding livestock, intangible assets and total current assets.

Fertilizers (fert, SE295) is the value (€) of purchased fertilizers and soil improvers and crop protection (cropprot, SE300) represents plant protection products, traps and baits, bird scarers, anti-hail shells, frost protection, etc. (excluding those used for forests).

In this application we have selected total assets as a proxy for capital as state variable[2] and total labour as free variable[3].

In order to determine productivity, we consider that the (optimal) decision to establish crop protection will affect the future level of profit and capital. Thus, in the model we use the level of crop protection as a proxy for productivity: the demand function $cropprot_{it} = f(x_{it}, \omega_{it})$ is considered invertible, so the productivity could be measured by the inverse function $\omega_{it} = h(i_{it}, x_{it})$.

To control for production heterogeneity due to regional and annual differences in farm output we include dummy variables.

[1] All variables used in the model are represented by logarithm and are denoted by prefix l.

[2] The state variables are those that are not affected by contemporary productivity shocks (they are fixed in the short term) at the time of the shock.

[3] Free variables (w_{it}) represent the set of inputs whose level is set by the farm after the productivity shocks ω_{it} are realized/observed (that are potentially observed or predictable).

We use the Wooldridge method, which is a one-step procedure that implements the generalized method of moments (GMM) that accounts for serial correlation or heteroskedasticity of errors (Wooldridge, 2009).

3. RESULTS AND CONCLUSIONS

Due to the European Green Deal strategy for the reduction in fertilizer and pesticide use, we are interested in estimators for the effects of these inputs on crop production. In particular, the question is whether Romanian crop farms will be affected differently by low-input farming. Table 3 presents a summary of the results. In the Appendix we present full results (Tables 4 to 7) for the 4 groups of farms by land use size.

The estimations show that the effect of fertilizers is larger for very small farms and of similar size for the other farms. However, the estimator of the impact of reducing the use of crop protection materials is larger for farms with total utilized area larger than 10 hectares. However, it should be taken into consideration that these results could be affected by other characteristics of farms that were not taken into account, such as production diversity, prices, type of agriculture (organic or not).

Table 3

Average elasticities of inputs. Synopsis

	c_land = 1	c_land = 2	c_land = 3	c_land = 4
ltotallb	0.1986***	0.2923***	0.1203***	0.1808***
lasset	0.2758*	0.1395***	0.0016	0.1101**
lfert	0.1802***	0.0770***	0.0810***	0.0643**
_Iregion_841	4.3151	-3.9249***	-1.1901	0.3067
_Iregion_842	-0.6265	-4.3999***	-6.7220	-14.4114***
_Iregion_843	-0.3156	0.2711***	0.0306	-0.2867**
_Iregion_844	0.0025	-0.0064*	-0.0050**	0.0019
_Iregion_845	0.0489**	-0.0079	0.0187**	0.0225*
_Iregion_846	-0.5613**	0.2613	0.2008	0.5715*
_Iregion_847	-0.0400**	-0.0070	-0.0383***	-0.0545***
_IYEAR_2017	0.5824***	0.4217***	0.6155***	0.9200***
_IYEAR_2018	-0.0052	-0.0143***	-0.0044	-0.0037
lcropprot	0.1107***	0.3138***	0.3303***	0.3336***

Note: *, **, *** represent significance at 10%, 5%, 1%

Our empirical analysis demonstrates that output value can generate productivity heterogeneity by size.

We highlighted the significant positive impact of variables that represent inputs (total labor, capital, fertilizers, crop protection).

For future research we can consider a specific impact of crop farm characteristics, which would put more emphasis on the extent to which capital, labour and intermediate inputs lead to increased productivity and also nuance the effect of the proposed measures of Farm to Fork Strategy on agricultural production, which proposes reducing the use of pesticides, antibiotics and chemical fertilizers.

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APPENDIX

Table 4

Average elasticities of inputs. Estimates for very small farms (c_land=1)

lcropout	**Coef.**	**Std. Err.**	**Z**	**P>z**	**[95% Conf. Interval]**	
ltotallb	0.1986	0.0364	5.46	0.0000	0.1273	0.2698
lasset	0.2758	0.1659	1.66	0.0960	-0.0493	0.6009
lfert	0.1802	0.0316	5.71	0.0000	0.1183	0.2420
_Iregion_841	4.3151	2.7828	1.55	0.1210	-1.1391	9.7692
_Iregion_842	-0.6265	1.3036	-0.48	0.6310	-3.1815	1.9285
_Iregion_843	-0.3156	0.2649	-1.19	0.2340	-0.8347	0.2036

Table 4 (continued)

_Iregion_844	0.0025	0.0093	0.27	0.7860	-0.0156	0.0207
_Iregion_845	0.0489	0.0170	2.87	0.0040	0.0155	0.0822
_Iregion_846	-0.5613	0.2720	-2.06	0.0390	-1.0944	-0.0281
_Iregion_847	-0.0400	0.0136	-2.95	0.0030	-0.0666	-0.0135
_IYEAR_2017	0.5824	0.1254	4.64	0.0000	0.3366	0.8282
_IYEAR_2018	-0.0052	0.0051	-1.02	0.3060	-0.0153	0.0048
lcropprot	0.1107	0.0268	4.14	0.0000	0.0583	0.1631
Wald test on Constant returns to scale: Chi2 = 1.28 p = (0.26)						

Note: variables with prefix _I are dummy variables for the specific region or year.

Table 5

Average elasticities of inputs. Estimates for small farms (c_land=2)

lcropout	**Coef.**	**Std. Err.**	**Z**	**P>z**	**[95% Conf. Interval]**	
ltotallb	0.2923	0.0216	13.5200	0.0000	0.2499	0.3347
lasset	0.1395	0.0541	2.5800	0.0100	0.0334	0.2456
lfert	0.0770	0.0192	4.0000	0.0000	0.0393	0.1147
_Iregion_841	-3.9249	1.2235	-3.2100	0.0010	-6.3229	-1.5269
_Iregion_842	-4.3999	1.0037	-4.3800	0.0000	-6.3672	-2.4326
_Iregion_843	0.2711	0.0932	2.9100	0.0040	0.0883	0.4538
_Iregion_844	-0.0064	0.0033	-1.9300	0.0540	-0.0130	0.0001
_Iregion_845	-0.0079	0.0094	-0.8400	0.4010	-0.0262	0.0105
_Iregion_846	0.2613	0.1661	1.5700	0.1160	-0.0643	0.5869
_Iregion_847	-0.0070	0.0083	-0.8400	0.3990	-0.0232	0.0092
_IYEAR_2017	0.4217	0.0741	5.6900	0.0000	0.2765	0.5668
_IYEAR_2018	-0.0143	0.0031	-4.6600	0.0000	-0.0203	-0.0083
lcropprot	0.3138	0.0168	18.7100	0.0000	0.2809	0.3466
Wald test on Constant returns to scale: Chi2 = 19.51 p = (0.00)						

Table 6

Average elasticities of inputs. Estimates for medium-sized farms (c_land=3)

lcropout	**Coef.**	**Std. Err.**	**Z**	**P>z**	**[95% Conf. Interval]**	
ltotallb	0.1203	0.0151	7.99	0.0000	0.0908	0.1498
lasset	0.0016	0.0380	0.04	0.9660	-0.0730	0.0762
lfert	0.0810	0.0197	4.12	0.0000	0.0425	0.1196
_Iregion_841	-1.1901	1.5092	-0.79	0.4300	-4.1481	1.7680
_Iregion_842	-6.7220	1.3100	-5.13	0.0000	-9.2895	-4.1545
_Iregion_843	0.0306	0.0837	0.37	0.7140	-0.1333	0.1946
_Iregion_844	-0.0050	0.0021	-2.33	0.0200	-0.0092	-0.0008
_Iregion_845	0.0187	0.0074	2.53	0.0110	0.0042	0.0332
_Iregion_846	0.2008	0.1693	1.19	0.2360	-0.1310	0.5326
_Iregion_847	-0.0383	0.0059	-6.52	0.0000	-0.0498	-0.0268
_IYEAR_2017	0.6155	0.0941	6.54	0.0000	0.4310	0.8000
_IYEAR_2018	-0.0044	0.0031	-1.40	0.1620	-0.0105	0.0018
Wald test on Constant returns to scale: Chi2 = 11.26 p = (0.00)						

Table 7

Average elasticities of inputs. Estimates for large farms (c_land=4)

ltotallb	0.1808	0.0207	8.74	0.0000	0.1403	0.2214
lasset	0.1101	0.0540	2.04	0.0410	0.0043	0.2159
lfert	0.0643	0.0348	1.85	0.0650	-0.0040	0.1326
_Iregion_841	0.3067	2.1981	0.14	0.8890	-4.0014	4.6148
_Iregion_842	-14.4114	3.3074	-4.36	0.0000	-20.8937	-7.9291
_Iregion_843	-0.2867	0.1171	-2.45	0.0140	-0.5162	-0.0572
_Iregion_844	0.0019	0.0044	0.42	0.6720	-0.0068	0.0105
_Iregion_845	0.0225	0.0122	1.85	0.0640	-0.0013	0.0464
_Iregion_846	0.5715	0.3145	1.82	0.0690	-0.0449	1.1879
_Iregion_847	-0.0545	0.0104	-5.25	0.0000	-0.0749	-0.0341
_IYEAR_2017	0.9200	0.2377	3.87	0.0000	0.4542	1.3858
_IYEAR_2018	-0.0037	0.0060	-0.63	0.5310	-0.0155	0.0080
lcropprot	0.3336	0.0255	13.09	0.0000	0.2836	0.3835
Wald test on Constant returns to scale: Chi2 = 9.94 p = (0.00)						