Centro Studi Sulle Politiche Economiche, Rurali e Ambientali

associazioneAlessandroBartola
studi e ricerche di economia e politica agraria

Paper prepared for the 122nd EAAE Seminar
"EVIDENCE-BASED AGRICULTURAL AND RURAL POLICY MAKING: METHODOLOGICAL AND EMPIRICAL CHALLENGES OF POLICY EVALUATION"
Ancona, February 17-18, 2011

Assessing the impact of future CAP reforms on the demand of production factors

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Abstract

The CAP reform process has been a central issue for agricultural economics research in recent years, and is gaining further attention in view of the post-2013 perspectives.
The objective of this paper is to assess ex-ante the effect of different post-2013 CAP and market scenarios on the demand of productions factors. The paper is based on the use of farm household dynamic programming models maximising the net present value with a time horizon until 2030. A representative model has been implemented for 18 different farming systems in 8 EU countries. Changes in marginal values of selected resource constraints (land, labour and capital) are used to assess the potential effect of different scenarios on farm-household demand of production factors.
Results highlight that both policy and market conditions change strongly the demand of productive factors.

Keywords: CAP reform, Investment behaviour, Farm Household model, Factor markets

JEL classification: Q12.

1. Introduction

The CAP reform process has been central to the European policy debate. The reform is driven by internal and external EU pressures, such as the review of the general budget and international negotiations (in particular WTO) calling for more market liberalisation. The relevance of past CAP instruments in affecting farm income, and on-farm and off-farm investments has been highlighted by the literature, concluding that the Single Farm Payment (SFP) has a relevant impact on investment decision, both on-farm and off-farm (Gallerani et al. 2008). In addition to the SFP, the second pillar provides, amongst others, (co-financed) payments targeted to support investments or the adoption of new technologies on-farm.

The objective of this paper is to assess ex-ante the effect of different post-2013 CAP and market scenarios on the demand of productions factors at the farm-household level.

Previous literature has used dynamic programming models to assess the impact of expected policy reforms on investment behaviour (Gallerani et al. 2008; Viaggi et al., 2010b; Viaggi et al., in press). Following this stream of research, a more recent set of evaluations using analogous models has been carried out. Results are presented in Viaggi et al., 2010a and Bartolini et al., 2010.

These studies focus on the simulation of scenarios effects on net investment by farms and related performance/sustainability indicators, but do not explore the effects on the shadow prices of resources. In this paper we use the same models to address the effects of policy scenarios on factor markets, building on such existing models and focusing on changing in marginal values of selected resources constraints.

The paper is structured as follows: in the next section we illustrate the methodology adopted. In section 3 we illustrate the case study, while in section 4 results are presented. The paper ends with a discussion.

2. METHODOLOGY

Following Gallerani et al. (2008), we use a dynamic household model to simulate the reaction of a sample of individual farm households to decoupling in the medium-long term.

The choice of a normative model is due to the difficulty of collecting ex post data related on very recent reforms, the need to represent innovative policy mechanisms and also due to the possibility of more easily simulating alternative scenarios. The dynamic approach is a straightforward requirement to deal with investment and is adopted by much of the research on this issue (Gardebroek and Oude Lansik, 2004). Finally, the choice of a household model is justified by the need to define investment choices as embedded in the overall objectives of the "social" decision making unit.

One of the challenges of this approach is to provide a good representation of the households' objective function, usually characterised by a mix of consumption and leisure objectives. This wider range of objectives can be captured through multi-criteria analysis. While multi-criteria models are broadly used, relatively few applications of multi-criteria analysis are combined with multi-period programming, except a few cases. For example, Wallace and Moss (2002) propose a multi-criteria model applied to strategic decisions of the farm household. In Gallerani et al. (2008) multi-criteria programming is used as alternative to NPV maximisation, through the adoption of two modelling options: a) a NPV-maximising, consumption constrained model; and b) a multi-objective recursive model.

Compared to Gallerani et al. (2008), we restrict our attention to net present value (NPV) maximising model formulation, in which, a consumption objective is incorporated through a constraint to the expected consumption level of the household. The main motivation for the choice to limit the multi-criteria component of the model is to simplify the computational part of the analysis, by maintaining the main information contents of the model.

One of the challenges with representing investment is that real investment behaviour implies discontinuities due to the indivisibility of capital goods. One way of taking this into account is to adopt dynamic integer programming as used, for example buy Asseldonk et al. (1999), who provide a programming approach to farm technology adoption, including technology change. This approach can be easily extended to investment behaviour. as adopted in our context, (excluding the representation of technology change).

The model used is a deterministic model, not suitable to address uncertainty and risk, which are major components of investment choice. This choice is justified by the need to consider longer term scenario descriptors, rather than short-term fluctuations, and also due to insufficient empirical data to design the price volatility in future scenarios.

Combining the elements discussed above, we propose a household-level dynamic programming model, which can be represented as follows:

$$Z = F[z_1(x_t), z_2(x_t), \ldots z_q(x_t) \ldots, z_Q(x_t)] \tag{1}$$

s.t.

$$x_t \in X \tag{2}$$

$$x_t \geq 0 \tag{3}$$

where:

Z = objective function;

z_q = value of attribute/objective q, q=1, 2, …, Q;

X = feasible set;

x_t = vector of decision variables.

The objective function is a representation of household utility. The farm household is expected to take decisions based on an objective function defined as a combination of multiple criteria, each defined as a function of the set of decision variables. Decision variables change their value over time, so the utility function implicitly assumes some aggregation over time and related time preference. The maximisation is subject to constraints on decision variables, represented by the feasible set and by non-negativity constraints. As previously explained the empirical specification of the model follows the NPV maximising version used by Gallerani et al. (2008).

In this model, equation (1) is substituted by:

$$\text{Max } Z = \sum_t \delta F_t(x_t) \tag{4}$$

$$\text{s.t. } C_t \leq C^* \tag{5}$$

where δ is a discounting factor, $F_t(x_t)$ is the net cash flow expressed as a function of the activities carried out in time period t, C_t is the annual consumption and C^* is the minimum acceptable yearly consumption accepted by the household. Equation 4 is connected to (5) and both are connected to the investment behaviour by the fact that $x_t = f(I_{t'})$ and $I_{t'} = g(C_{t'})$, with f being an increasing function (i.e. net cash flows are increased by investment *I*) and g a decreasing function (due to the trade-off between investment and savings) and t' represents any period $t' < t$. More details are provided in Viaggi et al. 2010.

In this paper we focus on the constraint in equation (2). This constraint generates a vector λ of marginal values, one for each constraint (resource). Such values are affected by the changes in scenario values and are used here to evaluate the effects of scenarios on the shadow price of resources: land, labour and capital availability.

Compared to standard linear programming models, two complications apply in this case. First, being the model a dynamic model and constraints annual, the marginal value also includes the expected effects on the following year of the program. That is, the marginal value accounts for the change in the NPV due to an increased unit availability of the resource. Secondly, being the model an integer programming model, the marginal values are not necessarily continuous. This has been discussed in the literature, with solutions proposed to achieve a robust identification of shadow prices from integer programming (Crema, 1995; Williams 1989; Mukherjee and Chatterjee, 2006). In spite of such literature, in this paper we stick to the immediate shadow price generated by the model.

3. CASE STUDY

A representative model has been implemented for each of 18 different farming systems in 8 EU countries. Farming systems are differentiated with respect to region (Mediterranean, Eastern and Central regions), specialisation (arable, livestock and tree) and altitude (plain and mountain). The distribution of the models is presented in Table 1.

Table 1 – Number of models and distribution across case studies

Area	**Specialisation**	**DE**	**ES**	**FR**	**GR**	**IT**	**NE**	**PL**	**BG**	**Total**
Muntain	Arable	1				1			1	3
	Livestock	1				1		1	1	4
	Permanent									0
Plain	Arable	1		1	1	1		1	1	6
	Livestock	1				1	1	1		4
	Permanent		1							1
Total		4	1	1	1	4	1	3	3	18

The individual farms used for modelling within each system were selected through expert judgment, according to representativeness principles mainly based on household characteristics, farm size, type and combination of production processes.

The main characteristics of the modelled farm households, based on the information collected from the survey, are shown in Table 2. Generally speaking, a greater portion of the farm households modelled are individually or family-run; only a few farms in Bulgaria and Italy are limited liability companies.

The farmers tend to be younger of the averages in the case study areas. Legal owners older than 60 years of age have only been simulated in Italy and Spain.

Generally, the available household labour is sufficient to cover the labour required by the farm, since only 5 farm-households use external labour. Furthermore, more than half of the farm households simulated allocated at least one household member to off-farm work.

Twelve (12) farm-households use credit and the debt/asset ratio is higher than 50% for seven of them. In Italy and Poland the ratio is particularly low compared to the other countries.

All farm households are owners of some part of the land they cultivate; in addition, 15 out of 18 farms/households also rent-in land. The amount of Usable Agricultural Area (UAA) operated is heterogeneous among the farms/households modelled (from 15 ha to 295 ha per farm). In most cases, however, the UAA of modelled farms is higher than the average UAA for each case study area, yet there are relevant exceptions, such as the Italian mountain livestock farms and most of the German models.

The amount of the Single Farm Payment (SFP), and the share of this payment in farm income[1], is very high. The payment received by the farmers ranges from 1,000 € to 91,410 € per farm. Generally, for those farm households for which the data on farm income was available, the share of SFP is over 10% of total farm income. Only one farm household in Italy (IT80MCA) has a ratio of SFP/farm income lower than 10%, as a consequence of the high amount of land invested in forest and timber production.

The number of SFP entitlements varies from 0 to 164[2].

Table 2 – Main characteristics of the farm households modelled

Code	**Legal status**	**House hold components (#)**	**Age farmer**	**Use of external labour**	**Members working off farm**	**Household debt/assets ratio**	**Land owned (ha)**	**Land rent-in (ha)**	**Land rent-out (ha)**	**SFP (€) (average 2006-2009)**	**SFP/ income ratio**	**Rights (#) (average 2006-2009)**
BG 07 PCA	limited company	5	57	yes	no	0.5	15	280	-		-	
BG 09 MCL	individual/family run	4	59	yes	no	-	7	80	-		-	
BG 14 MCA	individual/family run	3	56	no	no	-	4	196	-		-	
DE 12 PCA	individual/family run	2	55	no	no	0.94	35	57	1	33500	0.36	89
DE 19 PCL	individual/family run	2	56	yes	no	1	36	-	-	12438	0.05	33
DE 28 MCA	individual/family run	2	28	no	yes	1	19	20	5	14000	1	61
DE 40 MCL	other	3	51	no	no	0.7	38	22	-	22000	0.13	60
ES 03 PCP	individual/family run	3	68	yes	no	-	150	-	-	40000	0	120
FR 06 PCA	individual/family run	3	40	no	yes	0.99	11	142	-	50000	0	140
GR 09 PCA	individual/family run	2	57	yes	no	0.41	2	26	-	14160	0	34
IT 21 MCL	individual/family run	7	37	no	yes	-	8	7	-	7500	0	14
IT 37 PCA	individual/family run	7	48	no	yes	0.06	105	5	-	34500	0.29	107
IT 75 PCL	limited company	3	58	no	yes	0.02	45	15	-	25657	0	34
IT 80 MCA	limited company	4	79	no	yes	-	34	32	-	1000	0.16	na
NL 08 PCL	individual/family run	4	52	no	yes	0.6	28	31	-	20757	0	na
PL 03 PCA	individual/family run	6	59	no	no	0.15	61	80	-	26915	0.24	164
PL 04 PCL	individual/family run	5	52	no	yes	0.13	34	20	-	9832	0.96	59
PL 18 MCL	individual/family run	3	60	no	no	-	25	-	-	3239	0.26	17

[1] Defined as total farm revenue (including CAP payments) minus variable costs, including the renting-in of land and external services costs.
[2] For Poland this number refers to the area generating payments, while proper entitlements in the EU15 are not in place.

Six different scenarios were developed: a baseline (2009 Health Check reform including already planned policy measures such as milk quota soft landing), and five alternative scenarios (Table 3).

The formulation of scenarios was carried out in coordination with The European Commissions Directorate-General for Agriculture and Rural Development. The scenarios are defined based on two main parameters: product prices and SFP payments. Note that against these parameters, all others (production costs, salaries, interest rates, etc.) are held constant across scenarios. Two of the scenarios (1.1 and 1.2) use as a basis the scenarios identified in the Scenar 2020 II study (Nowicki et al., 2009), in particular the reference scenario and the liberalisation scenario.

Table 3 – Scenarios

	Specification	**Correspondence with scenar2020 II**
1.1 (-30+RSP) **Reference**	Health Check CAP until 2013 + 30% decrease in (fully decoupled) payments after 2013 + lower prices	Same policy and prices as Reference scenario in Scenar 2020 II
1.2 (GR+LSP)	Health Check CAP until 2013 + gradual reduction of (fully decoupled) payments after 2013 (to zero in 2020) + lower prices	Same policy and prices as liberalisation scenario in Scenar 2020 II
2.1 (-30+LP)	Health Check CAP until 2013 + 30% decrease in (fully decoupled) payments after 2013 + lower prices	Same policy as reference scenario in Scenar 2020 II
2.2 (GR+LP)	Health Check CAP until 2013 + gradual reduction of (fully decoupled) payments after 2013 (to zero in 2020) + lower prices	Same policy as liberalisation scenario in Scenar 2020 II
3.1 (-100+CP)	Health Check CAP until 2013 + no payment after 2013 + current prices	
3.2 (-15+LP)	Health Check CAP until 2013 + 15% decrease in flat-rate payments at national level after 2013 + lower prices	Same policy as conservative CAP in Scenar 2020 II
4.1 (HC+LP)	Health Check CAP + lower prices (-20%)	
4.2 (HC+CP) **Validation**	Health Check CAP + current prices	

The specification "current prices" intends to refer to the prices (both for inputs and outputs) at the time of the start of the study (beginning 2009).

Scenarios 1.1 and 1.2 are the central scenarios of the study, in which the set of prices is the one generated by the ESIM model and used for the Scenar 2020 II study[3]. The conditions of

1. [3] This study, still unpublished, will replicate the homonymous study carried out in 2006 (European Commission, 2006).

the Scenar 2020 II reference scenario are used as the baseline conditions in our study (scenario 1.1, -30+LSP).

Scenario 2.1. assumes Health Check CAP until 2013 + 30% decrease in (fully decoupled) payments after 2013 + lower output prices while Scenario 2.2 assumes Health Check CAP until 2013 + gradual reduction of (fully decoupled) payments after 2013 (to zero in 2020) + lower output prices.

Scenarios in group 3 simulate additional combinations of payment reduction and prices. In particular, Scenario 3.1 provides for a radical change in payments (total abolition) after 2013, while maintaining current prices and Scenario 3.2 provides a (minor) change in payments.

The remaining two scenarios assume the 2009 policy conditions (Health Check), associated with opposite price hypotheses. Scenario 4.2 (Health Check+current prices) describes the policy as implemented in 2009 and projects it up until 2020. It is used as a reference for validation, as it was the closest to the expectation stated by the farmers. Scenario 4.1. (Health Check+lower prices) describes the same conditions as scenario 4.2 but assumes that output prices are lowered by 20% across the whole simulation period, in analogy with some of the previous scenarios.

4. RESULTS

In the following three tables are presented the marginal value for land max rented-in constrains; max labour used constrains and for the saving. These values represent the average of the yearly marginal value grouped in the two periods: 2009-2013 concerning the first period and 2014-2020 concerning the second period. The marginal value presented is compared to the baseline scenario. This has allowed to used in each new scenario generated the factors price and the factors availability constant and equal to the baseline hypothesis, Such specification determine to isolate the net effect of the scenario on the specific farm investments.

The marginal value of land rented-in in different scenarios is reported in Table 4.

Table 4 – Marginal value of land rented in (difference with baseline in euro/ha)

Code	12_GR+LSP		21_-30+LP		22_GR+LP		31_-100+CP		32_-15+LP		41_HC+LP		42_HC+CP	
	2009-2013	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*
BG 07 PCA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BG 09 MCL	- 0	-33	- 1	- 114	- 1	- 114	- 1	- 113	- 1	- 114	-1	- 114	-1	-67
BG 14 MCA	- 46	5	- 26	- 13	- 29	- 21	- 26	- 31	- 35	2	-35	6	-32	-0
DE 12 PCA	- 62	25	354	493	140	305	354	493	- 111	-	-111	-	-35	11
DE 19 PCL	-	-	- 209	234	-	-	-	-	- 209	234	-209	234	-	-
DE 28 MCA	- 1	-215	- 549	- 367	- 549	- 367	- 27	- 367	- 416	- 352	-534	- 323	-27	95
DE 40 MCL	20	-14	20	- 14	13	- 9	20	- 14	20	- 20	20	- 14	20	-35
ES 03 PCP	- 271	-60	- 31	- 290	- 31	- 290	- 90	- 184	- 31	- 362	-52	- 207	34	-32
FR 06 PCA	- 2	-134	- 151	- 74	- 151	- 173	257	- 28	- 151	- 14	-151	46	257	371
GR 09 PCA	- 6	-87	- 570	-1,054	- 570	-1,012	- 135	-1,054	- 570	- 807	-570	- 689	-135	-369
IT 21 MCL	1,417	-38	9	- 19	- 73	19	2,318	2,241	- 73	19	-73	19	2,318	2,241
IT 37 PCA	- 91	-109	- 379	- 339	- 420	- 339	- 30	- 296	- 300	- 274	-300	- 271	-30	28
IT 75 PCL	-	38	- 74	90	- 77	74	5	38	- 77	93	-	38	5	19
IT 80 MCA	- 9	-35	- 212	- 131	- 226	- 171	22	67	- 212	- 131	-212	- 131	22	67
NL 08 PCL	-	-	1	30	1	30	- 78	211	- 134	279	-134	- 3	-124	459
PL 03 PCA	-	0	-	-	-	-	-	0	-	0	-	-	-	-
PL 04 PCL	- 121	-	- 121	-	- 121	-	- 121	-	- 121	-	-121	-	-28	120
PL 18 MCL	- 37	20	- 113	29	- 70	- 21	- 3	22	- 70	- 21	-37	53	-3	73

In the large majority of cases the prevailing signs are negative, meaning that renting additional units of land is less profitable with respect to the baseline and this reduces the demand for land. Positive values are instead more frequent in scenario 4.2 (HC+CP), and scenario 3.1 (-100 + CP) due to the higher prices and payment conditions, which is also reflected in a willingness to pay for additional land. However in some farms even with high prices the abolishment of the SFP determine an higher reduction of marginal value. These farms are located in Greece and in the new member States (Poland and Bulgaria). The variety of differences across periods, scenarios and farms, however, shows that marginal results in these models are highly dependent on the specific combination of constraints related to the different assets of the farm, and rarely show smooth trends. This is particularly important for livestock farms in which the marginal value of land shows higher variability, depending on the extent to which the values generated by livestock production are actually transmitted to the marginal value of land.

The marginal value of the labour constraint is reported in Table 5.

Table 5 – Marginal value of labour constraints (difference with baseline in euro/hour)

Code	12_GR+LSP		21_-30+LP		22_GR+LP		31_-100+CP		32_-15+LP		41_HC+LP		42_HC+CP	
	2009-2013	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*
BG 07 PCA	- 0	- 1	- 3	- 4	- 3	- 4	- 0	- 4	- 3	- 3	-3	- 2	-0	1
BG 09 MCL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BG 14 MCA	-	- 0	- 0	- 0	- 0	- 1	-	- 1	- 0	- 0	-0	- 0	-	-
DE 12 PCA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DE 19 PCL	0	- 0	- 11	3	- 11	3	5	15	- 11	3	-11	3	5	15
DE 28 MCA	- 0	- 59	- 200	- 129	- 200	- 129	20	- 129	179	174	-60	- 85	20	66
DE 40 MCL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ES 03 PCP	-	- 1	- 2	- 2	- 2	- 2	-	- 1	- 2	- 2	-2	- 2	-	-
FR 06 PCA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GR 09 PCA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IT 21 MCL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IT 37 PCA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IT 75 PCL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IT 80 MCA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NL 08 PCL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PL 03 PCA	0	- 14	19	5	24	3	9	27	19	3	24	9	9	1
PL 04 PCL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PL 18 MCL	-	-	-	-	-	-	-	-	-	-	-	-	-	-

In almost all cases there is no difference across scenarios, meaning that the constraints related to external labour are not binding, and that the marginal value is simply related to the (linear) local salary. In the cases in which the scenarios make some difference, the difference is mostly negative compared to the baseline, with the exception of scenario 4.2 and scenario 3.1. Cases of very high marginal values, such as DE28MCA in scenario 3.2, reflect more a peculiarity of the specific farm, in which the strict labour constraints translates into high marginal values for labour, rather than leading to any general conclusions about the scenarios.

Such lower difference with respect the land factors allows to consider that the policy and prices scenario could less affected the demand of the labour and that such demand is more connected to the local labour market characteristics..

The difference in marginal value of (monetary) capital availability through the saving constraint is reported in Table 6.

Table 6 – Marginal value of saving constraints (difference with baseline in euro/euro)

Code	12_GR+LSP		21_-30+LP		22_GR+LP		31_-100+CP		32_-15+LP		41_HC+LP		42_HC+CP	
	2009-2013	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*	*2009-2013*	*2014-2020*
BG 07 PCA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BG 09 MCL	0	-	-0.82	-0.03	-0.82	-0.03	0.36	0.15	-0.82	-0.03	-0.82	-0.03	-0.28	0.05
BG 14 MCA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DE 12 PCA	-0.01	-	-0.01	-	-0.01	-	-0.01	-	-0.01	-	-0.01	-	-0.01	-
DE 19 PCL	-	-	-	-	-	-	-	-	-	-	-	-	-0.04	-0.03
DE 28 MCA	-	-	0.03	0.02	0.03	0.02	-	-	1.96	1.63	0.01	0.01	-	-
DE 40 MCL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ES 03 PCP	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FR 06 PCA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GR 09 PCA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IT 21 MCL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IT 37 PCA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IT 75 PCL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IT 80 MCA	-0.04	-0.03	-0.16	-0.14	-0.29	-0.25	0.1	0.09	-0.16	-0.14	-0.16	-0.14	0.1	0.09
NL 08 PCL	-	-	-0.01	-0.03	-0.01	-0.03	-0.04	-0.11	0.19	0.16	-0.04	-0.1	0.09	-0.03
PL 03 PCA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PL 04 PCL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PL 18 MCL	-	-	0.01	0.01	0.01	0.01	-	-	0.01	0.01	0.16	0.12	-	-

With respect to the saving constraint, in most cases (11 out of 18 farms) there is no change across scenarios, meaning that the marginal value of money available is in fact equal to the (linear) positive interest rate produced by savings. Higher marginal values reflect the existence of a liquidity constraint to investment and cause a differentiation across scenarios. In this case, the effect of scenarios is not straightforward, as the differences with respect to the baseline are always negative for two farms, always positive for another two farms, and mixed (positive and negative) signs for the further three farms showing some change across scenarios. Higher increases in marginal values are mostly associated with scenarios that include lower prices (e.g. scenario 3.2).

5. Discussion

Results have highlighted that both policy and market conditions can change strongly the demand of productive factors. This effect is however rather differentiated depending on the productive factor addressed and the particular farm-household conditions. In particular, the marginal value of land changes in almost all cases. Under baseline conditions, the marginal value of land above the local rent is generally positive, with a few exceptions for Bulgarian and Polish models. The highest marginal values are for France and Greece due to the large amount of value added crops cultivated in these case study areas. In the period 2014-2020, marginal values drop in most cases, as expected, with the general exception of livestock farms, in which the positive difference in prices overcompensates for the shortest time period for the exploitation of the dynamic effects. Under alternative policy and market scenarios, the value of marginal values of land in the large majority of cases is reducing; means that renting additional units of land is less profitable with respect to the baseline and this can be used to estimate the reducing in the demand for land.

On the contrary, alternative policy and market scenario have low effect on the change of the marginal value external labour. This is mostly due to the fact that labour is not constraining. The same applies to capital, for which, however, the number of changes in the marginal value is more frequent. In addition, for both labour and capital, when changes occur, their values appear more heterogeneous compared to land, reflecting a higher dependence on specific farm conditions.

The results should be taken carefully do the characteristics of the models used. In particular, being each model built on the particular configuration of individual farm constraints, such specificities may affect the results or even the occurrence of a positive marginal value. On the same grounds, the impact can also be affected by the individual prices attribute to land and labour (heterogeneous across farms).

In spite of these drawbacks, the paper however shows the relevance of policy scenarios for the marginal values of resources and related markets. For resources used in particular in agriculture, such as land, the heterogeneity of effects (including different direction of change in different farms in the same scenario) also hints at a potential impact of scenarios on the level of activity of the market in particular for land (as increased differentials in willingness to pay could reflect in higher propensity to transactions).

Putting together the potential interest and the limitation of the instrument used, the paper suggest that further research in this field would be highly relevant for a better understanding of the secondary effects of policy change. Two relevant strategies in this direction would be to reconsider the problem using more advanced techniques for addressing shadow price estimation in integer programming models, and consider the problem jointly with land re-allocation mechanism in multi-farm models, such as in agent based models (see for example Kellerman et al., 2008).

ACKNOWLEDGMENT

The content of this paper was developed within the project "Farm Investment Behaviour under the CAP reform process, funded by JRC-IPTS. The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

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