

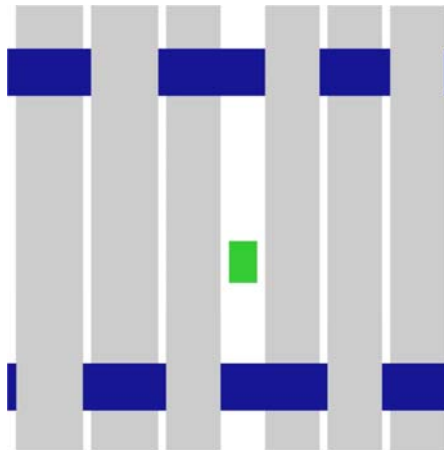
Deliverable n.4.2

TITLE

**ASSESSMENT OF PRESENT TRENDS, MECHANISMS
AND IMPACT OF THE CAP ON STRUCTURAL
CHANGE AND INNOVATION**

Authors

F. Bartolini, D. Viaggi, M Floridi



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SUMMARY

The main objective of WP4 is to assess the impact of the CAP on structural change and technological innovation. Structural change and innovation are two topics widely treated in the literature, using a variety of approaches.

The main research question of WP4 concerns the role of the CAP in structural adjustment and innovation. WP4 first identifies the main socio-economic trends in rural households that influence structural change and the adoption of innovation. Based on this, the impact of the CAP scenarios on structural change and innovation is analysed.

Structural adjustment can be viewed as the movement of productive factors among farm units and between the agricultural sector and other sectors of the economy. In turn, innovation is defined as new methods, customs, or devices used to perform new tasks.

In this report these two issues have been dealt with separately.

The assessment of the effects of the CAP on structural change is carried out through an econometric model enabling to explain the different impacts with respect to each productive factor and on the aggregate, considering all the main dimensions of farm structure (labour, capital, land). Both analyses are realised using the data derived from survey A of the project.

The assessment of innovation has been studied under three different perspectives:

1. Innovation and its adoption is firstly analysed through econometric modelling based on survey A information, in order to explain the variables affecting the adoption of the most relevant innovations in a wide set of EU areas;
2. An additional analysis of the sequence of the adoption of innovation is carried out in both Case Study Areas in France.
3. An In-depth analysis is further developed in order to study the effects of uncertainty in policy and market parameters on the diffusion of new technologies in a selection of Case Study Areas.

The CAP changes affect significantly the farm structure and the innovation processes. In particular medium-large farms that expect to have an “expanding” behaviour under the Baseline scenario will often reduce such expansion with the CAP abolishment. Such effect is particularly relevant for land use and capital use on farm. The CAP also abolishment effects the adoption of innovations. This is firstly the consequence of the exit behaviour. It is remarkable that the CAP abolishment would determine also the exit from the sector by farmers that would invest and innovate in the baseline scenario.

The results show the relevance of uncertainty about CAP first pillar payments (SFP/SAP) in determining the timing of adoption of a new technology. The

uncertainty in the policy context has a different impact in each European CSA due to the high heterogeneity of the innovations considered and of the farm and agricultural characteristics of the representative farm identified. Both SFP/SAP and RPD payments are relevant for the adoption of new technologies, but they are not substitutes, as they affect technology adoption in a different way. The results highlight the importance of “predictability” as a major policy feature and component of policy design facing a strongly uncertain context.

1 OBJECTIVES AND RESEARCH QUESTIONS

The general objective of the WP4 is to assess the impact of the CAP on the present trends in structural change and technological innovations in rural area. Furthermore WP4 has two specific objectives: the first specific objective is to identify trends of change on farm structures, technological adaptations and innovations; the second specific objective is to assess the impact of the CAP on such trends.

As stated in the Description of Work, WP4 is organised in three separate tasks:

Task 4.1 Background analysis and contribution to the methodology for the study of relationships between CAP, innovation and structural change

This task will provide a background to the study of CAP, innovation and structural change in rural areas. This will include an analysis of the literature and the definition of the methodology to study the interaction between CAP and such phenomena. The outcome will be a contribution to the structure of both household questionnaires. As structural change is connected to both household activities and agriculture activities, both household survey A and B will benefit of the contribution of this WP.

Task 4.2 Supporting WP2 and case study leaders on innovation and structural change

WP4 will support design of the survey and information collection through taking part to the definition of the questionnaire and of the target interviewees. It will interact with both household survey A and B.

Task 4.3 Elaboration and analysis of the results on innovation and structural change

The WP ends up analyzing the connection between CAP, household choices, innovation and structural change, building on the outcome of the surveys carried out in WP2. Both household surveys A and B will be used. Results of survey A will be used to assess contribution of household behaviour to structural change and innovation, and to extrapolate the outcome of survey B on a wider population; results of survey B will be used to assess specific impacts arising from changing farming choices and to validate interpretations of survey A.

2 Rationale of the Deliverable

The wide issues of the assessment of the CAP impacts on structural changes and on innovation, which are the concern of WP4 are addressed applying two main approaches: econometric analysis and mathematical programming models. The first approach (econometric analysis) has been used in order to explain the determinants of different behaviour facing a change of the CAP. Such approach has been applied to both structural changes and new technology diffusion. The second approach (mathematical modelling) has been applied to the analysis of the effects of uncertainty in the CAP and other relevant parameters on the adoption of innovations.

The heterogeneity of the issues covered by the WP4 and the approaches used to deal with such issues has required the use several sources of data:

- primary data collected survey A and B, data from expert interview, and additional questions targeted to the Survey A sample;
- secondary data, collected mainly from specialised journals.

Table 1 presents the connection between the issue developed within the WP4 and the data collected.

Table 1 – Rationale of the issues covered by WP4.

Issues developed by the WP4	Survey A	Survey B	Additional questions	LPN interview	Data from other WP	Expert interview	Secondary data
Identification of the <u>trends</u> in <u>structural changes</u>	X						
Assessment the <u>CAP impact</u> on the <u>structural changes</u>	X						
Identification of the <u>trends</u> in <u>technology adaptation</u>	X						

<u>and innovation</u>							
Assessment the <u>CAP impact</u> on the <u>innovation adoption (intensity of innovation)</u>	X						
Assessment the <u>CAP impact</u> on the <u>innovation adoption (sequence of innovation)</u>	X		X				
Assessment the <u>CAP uncertainty</u> on the <u>innovation adoption (mechanism of adoption)</u>	X	X		X		X	X
Assessment the <u>CAP Scenario impacts</u> on the <u>innovation adoption (mechanism of adoption)</u>	X	X		X	X	X	X

Survey A has been used to identify the trends in structural changes and in new technology adoptions, and in the assessment of the CAP impacts on such changes. Additional questions regard the sequence of innovation adopted at farm level and has been used to explain the impact of CAP scenarios on the adoption of innovation at

farm level. Such data has been collected in two CSA: CSA 8 “Centre” and CSA 9 “Midi Pyrenees” (France). Finally, the analysis of the innovation adoption mechanism is realised using several sources of data: survey A; survey B; LPN interviews; expert interviews and collection of secondary data.

3 Assessment the impact of policy change on Structural Changes

The assessment of the impact of policy changes on structural change has been analysed firstly observing the descriptive statistics about the questions concerning the changes in productive factors. This part has been split into two subchapters: the analysis of the trend in the use of productive factors, using the answers from the baseline conditions and the comparison of the stated intentions about use of productive factors under alternative CAP scenarios. The second part of the assessment of the impact of policy changes on structural change has been analysed using an econometric approach in order to explain the determinants of different negative or positive CAP impact on the use of productive factors. All the results provided in this document and generally within the WP4 activities, do not include the stated intention concerning the exit from agricultural sector. Such part has been developed separately into WP3 activity. Furthermore, in the following paragraph all results are provided without considering the farmers that stated the intention to exit from agricultural activity. In particular, in the section 3.1.1, all farmers that stated an intention to exit under baseline condition have been excluded from the results. In addition, in section 3.1.2, 3.2, 4.1 and 4.4 all farmers that stated an intention to exit under baseline condition and under the NO-PAC scenario have been excluded from the results. For an analysis of the exits and its dynamics see Raggi et al., 2010.

3.1 Descriptive Statistics

3.1.1 Analysis of the tendency in productive factors use

The identification of the trend in the use of productive factors has been firstly observed comparing the descriptive statistic concerning the stated intention about the productive factors. Questions considered are those relative to land change, labour change and capital invested on farm (See respectively Raggi et al., 2009; and the annex 1 for the list of questions asked in this WP).

The change in owned land, in land rented-in and in land rented-out in each CSA are shown respectively in Table 2, Table 3 and Table 4.

Table 2 – Stated intention concerning changes in owned land at 2020 (number and %).

CSA	Increase	No change	Decrease	Other	Do not know	Do not answer	Total
Emilia-Romagna (Italy)	28 (11.02)	203 (79.92)	5 (1.97)	2 (0.79)	14 (5.51)	2 (0.79)	254 (100)
Noord-Holland (Netherlands)	66 (34.2)	99 (51.3)	1 (0.52)	0 (0)	23 (11.92)	4 (2.07)	193 (100)
Macedonia and Thrace (Greece)	48 (17.58)	220 (80.59)	5 (1.83)	0 (0)	0 (0)	0 (0)	273 (100)
Podlaskie (Poland)	28 (11.67)	212 (88.33)	0 (0)	0 (0)	0 (0)	0 (0)	240 (100)
North East of Scotland (UK)	26 (16.56)	118 (75.16)	1 (0.64)	4 (2.55)	8 (5.1)	0 (0)	157 (100)
Andalusia (Spain)	33 (21.15)	111 (71.15)	2 (1.28)	0 (0)	10 (6.41)	0 (0)	156 (100)
South-East Planning Region (Bulgaria)	124 (52.54)	54 (22.88)	2 (0.85)	1 (0.42)	8 (3.39)	47 (19.92)	236 (100)
Centre (France)	43 (34.96)	55 (44.72)	0 (0)	0 (0)	23 (18.7)	2 (1.63)	123 (100)
Midi-Pyrénées (France)	35 (27.56)	73 (57.48)	2 (1.57)	0 (0)	15 (11.81)	2 (1.57)	127 (100)
Lahn-Dill-District (Germany)	28 (28)	57 (57)	1 (1)	0 (0)	5 (5)	9 (9)	100 (100)
Ostprignitz-Ruppin (Germany)	70 (49.65)	55 (39.01)	0 (0)	1 (0.71)	7 (4.96)	8 (5.67)	141 (100)
Total	529 (26.45)	1257 (62.85)	19 (0.95)	8 (0.4)	113 (5.65)	74 (3.7)	2000 (100)

The greater part of the sample states an intention to have no change in the amount of land owned (63.85%) while only 26.45% states an intention to increase the amount of land owned. Such figure is quite heterogeneous among the different CSA, with the main changes concerning the frequency of no-change or increasing. The CSAs

with higher share of intentions of increasing owned land are Noord-Holland; South-East Planning Region; Centre and Ostprignitz-Ruppin. Finally in the sample of the farms that do not exit from the sectors there is a low percentage of cases that state intention to reduce the amount of land owned.

Table 3 – Stated intention concerning the changes in land rented-in at 2020.

CSA	Increase	No change	Decrease	Other	Do not know	Do not answer	Total
Emilia-Romagna (Italy)	28 (11.02)	175 (68.9)	11 (4.33)	2 (0.79)	19 (7.48)	19 (7.48)	254 (100)
Noord-Holland (Netherlands)	57 (29.53)	92 (47.67)	13 (6.74)	0 (0)	27 (13.99)	4 (2.07)	193 (100)
Macedonia and Thrace (Greece)	35 (12.82)	230 (84.25)	8 (2.93)	0 (0)	0 (0)	0 (0)	273 (100)
Podlaskie (Poland)	101 (42.08)	138 (57.5)	0 (0)	0 (0)	0 (0)	1 (0.42)	240 (100)
North East of Scotland (UK)	29 (18.47)	111 (70.7)	6 (3.82)	2 (1.27)	8 (5.1)	1 (0.64)	157 (100)
Andalusia (Spain)	23 (14.74)	104 (66.67)	11 (7.05)	0 (0)	9 (5.77)	9 (5.77)	156 (100)
South-East Planning Region (Bulgaria)	144 (61.02)	43 (18.22)	9 (3.81)	0 (0)	3 (1.27)	37 (15.68)	236 (100)
Centre (France)	31 (25.2)	60 (48.78)	7 (5.69)	0 (0)	20 (16.26)	5 (4.07)	123 (100)
Midi-Pyrénées (France)	25 (19.69)	75 (59.06)	7 (5.51)	0 (0)	17 (13.39)	3 (2.36)	127 (100)
Lahn-Dill-District (Germany)	29 (29)	51 (51)	5 (5)	0 (0)	7 (7)	8 (8)	100 (100)
Ostprignitz-Ruppin (Germany)	54 (38.3)	50 (35.46)	14 (9.93)	8 (5.67)	6 (4.26)	9 (6.38)	141 (100)
Total	556 (27.8)	1129 (56.45)	91 (4.55)	12 (0.6)	116 (5.8)	96 (4.8)	2000 (100)

Trends in land rented-in follow those of land owned. In fact among the greater part of the farmers that maintains the farming activity, there is a high no change in the use of land rented-in (56.45%), and a quarter of farmers that state an intention to increase land rented-in (27.8%). Compared to land-owned, the stated intention concerning the rented-in land is more differentiated across CSA. CSA in Western Europe shown high demand for land rented-in, with high frequency of intention to increase the land rented-in. Whereas in the Mediterranean CSA (Emilia Romagna, Andalusia and Macedonia and Thrace) a lower share of farmers have intention to increase the land rented-in.

Table 4 – Stated intention concerning the changes in land rented-out at 2020.

CSA	Increase	No change	Decrease	Other	Do not know	Do not answer	Total
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Emilia-Romagna (Italy)	7 (2.76)	179 (70.47)	4 (1.57)	5 (1.97)	26 (10.24)	33 (12.99)	254 (100)
Noord-Holland (Netherlands)	11 (5.7)	127 (65.8)	17 (8.81)	0 (0)	33 (17.1)	5 (2.59)	193 (100)
Macedonia and Thrace (Greece)	16 (5.86)	252 (92.31)	2 (0.73)	0 (0)	3 (1.1)	0 (0)	273 (100)
Podlaskie (Poland)	3 (1.25)	235 (97.92)	2 (0.83)	0 (0)	0 (0)	0 (0)	240 (100)
North East of Scotland (UK)	7 (4.46)	119 (75.8)	5 (3.18)	18 (11.46)	5 (3.18)	3 (1.91)	157 (100)
Andalusia (Spain)	2 (1.28)	130 (83.33)	2 (1.28)	0 (0)	6 (3.85)	16 (10.26)	156 (100)
South-East Planning Region (Bulgaria)	14 (5.93)	97 (41.1)	9 (3.81)	0 (0)	22 (9.32)	94 (39.83)	236 (100)
Centre (France)	4 (3.25)	80 (65.04)	3 (2.44)	0 (0)	17 (13.82)	19 (15.45)	123 (100)
Midi-Pyrénées (France)	5 (3.94)	98 (77.17)	3 (2.36)	0 (0)	18 (14.17)	3 (2.36)	127 (100)
Lahn-Dill-District (Germany)	1 (1)	45 (45)	2 (2)	7 (7)	13 (13)	32 (32)	100 (100)
Ostprignitz-Ruppin (Germany)	4 (2.84)	57 (40.43)	7 (4.96)	38 (26.95)	3 (2.13)	32 (22.7)	141 (100)
Total	74 (3.7)	1419 (70.95)	56 (2.8)	68 (3.4)	146 (7.3)	237 (11.85)	2000 (100)

The figure about the intentions concerning the land rented-out is strongly affected by the high amount of no answers and “do not know”. The remaining parts of the answers show high no change in the amount of land rented-out. Looking this table and the previous one, it seems that the demand for land shown in the previous table will be mainly satisfied by the land of the farmers that exit from agricultural sector, rather than by transfers among those staying in farming.

Changes in the labour used, concerning the movement of household labour on-farm and off-farm are depicted in Table 5 and Table 6. Changes in the amount of external labour used on-farm are shown in Table 7.

Table 5 – Stated intention concerning the changes in household labour used on-farm at 2020.

CSA	Increase	No change	Decrease	Other	Do not know	Do not answer	Total
Emilia-Romagna (Italy)	18 (7.09)	170 (66.93)	33 (12.99)	1 (0.39)	30 (11.81)	2 (0.79)	254 (100)
Noord-Holland (Netherlands)	39 (20.21)	102 (52.85)	28 (14.51)	0 (0)	18 (9.33)	6 (3.11)	193 (100)
Macedonia and Thrace (Greece)	122 (44.69)	124 (45.42)	24 (8.79)	0 (0)	3 (1.1)	0 (0)	273 (100)
Podlaskie (Poland)	25 (10.42)	215 (89.58)	0 (0)	0 (0)	0 (0)	0 (0)	240 (100)
North East of Scotland	14	119	13	0	10	1	157

(UK)	(8.92)	(75.8)	(8.28)	(0)	(6.37)	(0.64)	(100)
Andalusia (Spain)	6	137	9	0	4	0	156
	(3.85)	(87.82)	(5.77)	(0)	(2.56)	(0)	(100)
South-East Planning Region (Bulgaria)	143	78	3	0	4	8	236
	(60.59)	(33.05)	(1.27)	(0)	(1.69)	(3.39)	(100)
Centre (France)	25	70	8	0	18	2	123
	(20.33)	(56.91)	(6.5)	(0)	(14.63)	(1.63)	(100)
Midi-Pyrénées (France)	19	85	8	0	11	4	127
	(14.96)	(66.93)	(6.3)	(0)	(8.66)	(3.15)	(100)
Lahn-Dill-District (Germany)	7	70	3	0	13	7	100
	(7)	(70)	(3)	(0)	(13)	(7)	(100)
Ostprignitz-Ruppin (Germany)	14	90	9	8	9	11	141
	(9.93)	(63.83)	(6.38)	(5.67)	(6.38)	(7.8)	(100)
Total	432	1260	138	9	120	41	2000
	(21.6)	(63)	(6.9)	(0.45)	(6)	(2.05)	(100)

The great part of the farmers interviewed that are keeping on farming state to expect no change on the amount of on-farm labour (63%). Among the others, the percentage of farmers that are increasing such amount is higher than the percentage of reduction (21.6% versus 6.9%). The diversification across CSA is very high, in fact there are two CSA (Macedonia and Thrace and South-East Planning Region) in which the increase in the use of household labour on-farm is respectively about 44.69 % and 60.59 % of the farmer households that maintains the farm activity. Such high value is due for the Greek CSA to the expected low opportunity cost of household labour off-farm associated to the surviving of the high labour consuming crops such as cotton and olive oil .Whereas, in south Bulgarian CSA the increasing of the household on-farm labour is due to the expected increase of the farm profitability due to the market opening followed by EU accession.

In the other CSAs such as Emilia-Romagna, Andalusia, North East of Scotland and both CSA in Germany there is a lower number farm households that are increasing the amount of on-farm labour. Furthermore, among these CSA, the two Mediterranean CSAs reveal a higher number of farmers that expect to reduce the amount of household labour used on-farm, compared to those stating an increase.

Table 6 – Stated intention concerning the changes in household labour used off-farm at 2020.

CSA	Increase	No change	Decrease	Other	Do not know	Do not answer	Total
Emilia-Romagna (Italy)	6	177	5	8	26	32	254
	(2.36)	(69.69)	(1.97)	(3.15)	(10.24)	(12.6)	(100)
Noord-Holland (Netherlands)	46	90	19	0	32	6	193
	(23.83)	(46.63)	(9.84)	(0)	(16.58)	(3.11)	(100)
Macedonia and Thrace (Greece)	41	224	2	0	6	0	273
	(15.02)	(82.05)	(0.73)	(0)	(2.2)	(0)	(100)
Podlaskie (Poland)	3	235	0	0	1	1	240
	(1.25)	(97.92)	(0)	(0)	(0.42)	(0.42)	(100)

North East of Scotland (UK)	11 (7.01)	122 (77.71)	9 (5.73)	6 (3.82)	7 (4.46)	2 (1.27)	157 (100)
Andalusia (Spain)	20 (12.82)	129 (82.69)	1 (0.64)	0 (0)	5 (3.21)	1 (0.64)	156 (100)
South-East Planning Region (Bulgaria)	36 (15.25)	93 (39.41)	66 (27.97)	0 (0)	10 (4.24)	31 (13.14)	236 (100)
Centre (France)	4 (3.25)	87 (70.73)	4 (3.25)	0 (0)	15 (12.2)	13 (10.57)	123 (100)
Midi-Pyrénées (France)	5 (3.94)	101 (79.53)	0 (0)	0 (0)	12 (9.45)	9 (7.09)	127 (100)
Lahn-Dill-District (Germany)	7 (7)	67 (67)	3 (3)	1 (1)	10 (10)	12 (12)	100 (100)
Ostprignitz-Ruppin (Germany)	8 (5.67)	92 (65.25)	7 (4.96)	12 (8.51)	7 (4.96)	15 (10.64)	141 (100)
Total	187 (9.35)	1417 (70.85)	116 (5.8)	27 (1.35)	131 (6.55)	122 (6.1)	2000 (100)

The stated intention concerning the use of household labour in off-farm activities appears more static than the change in on-farm labour (70% of no –change), with 9% of the farm-households that have intention to increase the amount of household labour allocated off-farm. The frequency of no changes in the allocation of household labour off-farm is low in the Noord-Holland (46.63%) and in the South-East Planning Region (39.41). In the former CSA the amount of household labour allocated to off-farm activity is increasing in about 23.83% of the farms, while in the latter CSA there is an opposite trend (reduction household labour allocated off-farm in 27.97% of the cases). In other CSAs there are a low percentage of farmers that state no changes in the allocation of household labour off-farm. Such CSA are Emilia-Romagna, Podlaskie, and the both CSA in France and Germany.

Table 7 – Stated intention concerning the changes in amount of external labour used on-farm at 2020.

CSA	Increase	No change	Decrease	Other	Do not know	Do not answer	Total
Emilia-Romagna (Italy)	26 (10.24)	189 (74.41)	7 (2.76)	6 (2.36)	20 (7.87)	6 (2.36)	254 (100)
Noord-Holland (Netherlands)	35 (18.13)	99 (51.3)	26 (13.47)	0 (0)	27 (13.99)	6 (3.11)	193 (100)
Macedonia and Thrace (Greece)	84 (30.77)	130 (47.62)	45 (16.48)	0 (0)	14 (5.13)	0 (0)	273 (100)
Podlaskie (Poland)	38 (15.83)	201 (83.75)	0 (0)	0 (0)	0 (0)	1 (0.42)	240 (100)
North East of Scotland (UK)	18 (11.46)	121 (77.07)	5 (3.18)	2 (1.27)	11 (7.01)	0 (0)	157 (100)
Andalusia (Spain)	10 (6.41)	125 (80.13)	11 (7.05)	0 (0)	7 (4.49)	3 (1.92)	156 (100)
South-East Planning	135	61	4	0	9	27	236

Region (Bulgaria)	(57.2)	(25.85)	(1.69)	(0)	(3.81)	(11.44)	(100)
	17	74	3	0	17	12	123
Centre (France)	(13.82)	(60.16)	(2.44)	(0)	(13.82)	(9.76)	(100)
	6	94	6	0	13	8	127
Midi-Pyrénées (France)	(4.72)	(74.02)	(4.72)	(0)	(10.24)	(6.3)	(100)
	10	58	1	5	8	18	100
Lahn-Dill-District (Germany)	(10)	(58)	(1)	(5)	(8)	(18)	(100)
	20	72	15	10	6	18	141
Ostprignitz-Ruppin (Germany)	(14.18)	(51.06)	(10.64)	(7.09)	(4.26)	(12.77)	(100)
	399	1224	123	23	132	99	2000
Total	(19.95)	(61.2)	(6.15)	(1.15)	(6.6)	(4.95)	(100)

The great part of the farmer (61.2%) stated an intention not to change the amount of the external labour used on-farm, while an increase of the amount of external labour used occurs in about 19.95%. Such values are strongly diversified across CSA. High shares of increasing in the use are stated in Macedonia and Thrace and South-East Planning Region (respectively with 30.77% and 57.2%). In the same CSA it was stated also a high intention to increase the amount of household labour on-farm, that suggests the growth of high labour using crops.

The changes in external labour used on farm do not show an effect of substitutions between household labour and external labour; this is confirmed by the low amount of external labour needed in the CSA with higher reduction in household labour on-farm (eg. Noord-Holland).

Changes in the capital use by the farm household revealed rather difficult questions to ask during an interview, and in order to identify a proxy of this element, the capital use has been interpreted as the changes in of livestock intensity, and in the building and machinery endowments. In Table 8, Table 9 and Table 10 the changes concerning respectively livestock intensity, building and machinery endowment in each CSA are presented.

Table 8 – Stated intention concerning the changes in amount of animal rearing at 2020.

CSA	Increase	No change	Decrease	Other	Do not know	Do not answer	Total
Emilia-Romagna (Italy)	7 (25)	15 (53.57)	3 (10.71)	1 (3.57)	2 (7.14)	0 (0)	28 (100)
Noord-Holland (Netherlands)	62 (46.97)	60 (45.45)	4 (3.03)	0 (0)	5 (3.79)	1 (0.76)	132 (100)
Macedonia and Thrace (Greece)	57 (37.75)	83 (54.97)	8 (5.3)	0 (0)	3 (1.99)	0 (0)	151 (100)
Podlaskie (Poland)	87 (46.28)	99 (52.66)	1 (0.53)	0 (0)	1 (0.53)	0 (0)	188 (100)
North East of Scotland (UK)	46 (33.33)	67 (48.55)	12 (8.7)	1 (0.72)	11 (7.97)	1 (0.72)	138 (100)
Andalusia (Spain)	6 (31.58)	10 (52.63)	2 (10.53)	0 (0)	1 (5.26)	0 (0)	19 (100)

South-East Planning Region (Bulgaria)	100 (75.76)	10 (7.58)	3 (2.27)	0 (0)	3 (2.27)	16 (12.12)	132 (100)
Centre (France)	22 (33.85)	35 (53.85)	2 (3.08)	0 (0)	5 (7.69)	1 (1.54)	65 (100)
Midi-Pyrénées (France)	32 (31.07)	53 (51.46)	7 (6.8)	0 (0)	10 (9.71)	1 (0.97)	103 (100)
Lahn-Dill-District (Germany)	18 (22.5)	42 (52.5)	8 (10)	2 (2.5)	5 (6.25)	5 (6.25)	80 (100)
Ostprignitz-Ruppin (Germany)	41 (43.62)	38 (40.43)	5 (5.32)	2 (2.13)	4 (4.26)	4 (4.26)	94 (100)
Total	478 (42.3)	512 (45.31)	55 (4.87)	6 (0.53)	50 (4.42)	29 (2.57)	1130 (100)

The stated intention to increase animal rearing in the farm household surveyed was rather frequent; in fact more than 40% of the farm household surveyed stated the intention to increase the livestock intensity. The highest most frequent increase is in the South-East Planning Region. The figures provided by this table are strongly affected by the weight of the livestock specialisation with respect the others specialisations in some CSAs, such as Emilia Romagna and Andalusia.

Table 9 – Stated intention concerning the changes in the endowment of building at 2020.

CSA	Increase	No change	Decrease	Other	Do not know	Do not answer	Total
Emilia-Romagna (Italy)	36 (14.17)	201 (79.13)	3 (1.18)	3 (1.18)	11 (4.33)	0 (0)	254 (100)
Noord-Holland (Netherlands)	79 (40.93)	89 (46.11)	8 (4.15)	0 (0)	13 (6.74)	4 (2.07)	193 (100)
Macedonia and Thrace (Greece)	9 (3.3)	256 (93.77)	8 (2.93)	0 (0)	0 (0)	0 (0)	273 (100)
Podlaskie (Poland)	117 (48.75)	122 (50.83)	0 (0)	0 (0)	1 (0.42)	0 (0)	240 (100)
North East of Scotland (UK)	29 (18.47)	122 (77.71)	2 (1.27)	0 (0)	4 (2.55)	0 (0)	157 (100)
Andalusia (Spain)	14 (8.97)	136 (87.18)	4 (2.56)	0 (0)	2 (1.28)	0 (0)	156 (100)
South-East Planning Region (Bulgaria)	103 (43.64)	97 (41.1)	0 (0)	0 (0)	3 (1.27)	33 (13.98)	236 (100)
Centre (France)	40 (32.52)	68 (55.28)	1 (0.81)	0 (0)	8 (6.5)	6 (4.88)	123 (100)
Midi-Pyrénées (France)	38 (29.92)	78 (61.42)	0 (0)	0 (0)	9 (7.09)	2 (1.57)	127 (100)
Lahn-Dill-District (Germany)	26 (26)	50 (50)	2 (2)	0 (0)	12 (12)	10 (10)	100 (100)
Ostprignitz-Ruppin (Germany)	43 (30.5)	74 (52.48)	5 (3.55)	3 (2.13)	6 (4.26)	10 (7.09)	141 (100)
Total	534 (26.7)	1293 (64.65)	33 (1.65)	6 (0.3)	69 (3.45)	65 (3.25)	2000 (100)

Table 10 – Stated intention concerning the changes in the endowment of machinery at 2020.

CSA	Increase	No change	Decrease	Other	Do not know	Do not answer	Total
Emilia-Romagna (Italy)	49 (19.29)	184 (72.44)	3 (1.18)	5 (1.97)	12 (4.72)	1 (0.39)	254 (100)
Noord-Holland (Netherlands)	53 (27.46)	114 (59.07)	16 (8.29)	0 (0)	6 (3.11)	4 (2.07)	193 (100)
Macedonia and Thrace (Greece)	7 (2.56)	263 (96.34)	3 (1.1)	0 (0)	0 (0)	0 (0)	273 (100)
Podlaskie (Poland)	149 (62.08)	90 (37.5)	1 (0.42)	0 (0)	0 (0)	0 (0)	240 (100)
North East of Scotland (UK)	23 (14.65)	127 (80.89)	5 (3.18)	0 (0)	2 (1.27)	0 (0)	157 (100)
Andalusia (Spain)	26 (16.67)	119 (76.28)	8 (5.13)	0 (0)	3 (1.92)	0 (0)	156 (100)
South-East Planning Region (Bulgaria)	164 (69.49)	43 (18.22)	2 (0.85)	0 (0)	7 (2.97)	20 (8.47)	236 (100)
Centre (France)	32 (26.02)	71 (57.72)	7 (5.69)	0 (0)	10 (8.13)	3 (2.44)	123 (100)
Midi-Pyrénées (France)	19 (14.96)	89 (70.08)	5 (3.94)	0 (0)	13 (10.24)	1 (0.79)	127 (100)
Lahn-Dill-District (Germany)	31 (31)	48 (48)	4 (4)	0 (0)	8 (8)	9 (9)	100 (100)
Ostprignitz-Ruppin (Germany)	50 (35.46)	66 (46.81)	7 (4.96)	1 (0.71)	5 (3.55)	12 (8.51)	141 (100)
Total	603 (30.15)	1214 (60.7)	61 (3.05)	6 (0.3)	66 (3.3)	50 (2.5)	2000 (100)

Investments in farm building and machinery have generally the same trends. In fact the great part of the farm households surveyed expects not to change the endowment of either buildings and machinery. However, the increase of the endowment of machinery is slightly more frequent than that of buildings. Across different CSAs, intentions to increase the endowment of both building and machinery are more frequently expressed by farmer belonging to Eastern Europe CSAs.

In Table 11 the stated intentions concerning the land use changes are presented for each farm specialisation.

Table 11 – Stated intention concerning the changes in the land possession per each farm specialisation.

Specialisation (2003/369 EC)	own land			land rented-in			land rented-out		
	Incr.	No change	Decr.	Incr.	No change	Decr.	Incr.	No change	Decr.
Field Crops	157 (33.48)	307 (65.46)	5 (1.07)	142 (30.87)	287 (62.39)	31 (6.74)	30 (7.65)	347 (88.52)	15 (3.83)

	13	24	0	15	21	1	0	27	2
Horticulture	(35.14)	(64.86)	(0)	(40.54)	(56.76)	(2.7)	(0)	(93.1)	(6.9)
	33	104	1	22	99	3	1	105	0
Permanent Crops	(23.91)	(75.36)	(0.72)	(17.74)	(79.84)	(2.42)	(0.94)	(99.06)	(0)
	144	304	1	209	214	25	19	358	19
Grazing Livestock	(32.07)	(67.71)	(0.22)	(46.65)	(47.77)	(5.58)	(4.8)	(90.4)	(4.8)
	6	14	0	3	15	1	0	17	2
Granivore	(30)	(70)	(0)	(15.79)	(78.95)	(5.26)	(0)	(89.47)	(10.53)
	15	110	1	13	103	6	4	115	4
Mixed Cropping	(11.9)	(87.3)	(0.79)	(10.66)	(84.43)	(4.92)	(3.25)	(93.5)	(3.25)
	26	86	1	35	71	5	5	94	1
Mixed Livestock	(23.01)	(76.11)	(0.88)	(31.53)	(63.96)	(4.5)	(5)	(94)	(1)
	127	290	9	108	302	19	13	339	13
Mixed Crops-livestock	(29.81)	(68.08)	(2.11)	(25.17)	(70.4)	(4.43)	(3.56)	(92.88)	(3.56)
	8	18	1	9	17	0	2	17	0
Not classifiable	(29.63)	(66.67)	(3.7)	(34.62)	(65.38)	(0)	(10.53)	(89.47)	(0)

Among the farm specialisations, those that have a higher frequency of increase of land (both owned and rented-in) are horticulture and grazing livestock specialisations. In addition the grazing livestock specialisation is the one with lower percentage of no changes, which reveal a high dynamism of this specialisation.

In Table 12 the stated intention concerning changes in labour use are presented for each farm specialisation.

Table 12 – Stated intention concerning the changes in the labour use per each farm specialisation.

Specialisation (2003/369 EC)	Household labour on-farm			Household labour off-farm			External labour on-farm		
	Incr.	No change	Decr.	Incr.	No change	Decr.	Incr.	No change	Decr.
	123	318	29	50	332	40	105	314	28
Field Crops	(26.17)	(67.66)	(6.17)	(11.85)	(78.67)	(9.48)	(23.49)	(70.25)	(6.26)
	12	18	7	5	22	8	17	17	3
Horticulture	(32.43)	(48.65)	(18.92)	(14.29)	(62.86)	(22.86)	(45.95)	(45.95)	(8.11)
	12	114	13	10	117	2	13	113	10
Permanent Crops	(8.63)	(82.01)	(9.35)	(7.75)	(90.7)	(1.55)	(9.56)	(83.09)	(7.35)
	121	322	31	52	368	30	124	305	23
Grazing Livestock	(25.53)	(67.93)	(6.54)	(11.56)	(81.78)	(6.67)	(27.43)	(67.48)	(5.09)
	7	14	0	0	17	3	3	18	0
Granivore	(33.33)	(66.67)	(0)	(0)	(85)	(15)	(14.29)	(85.71)	(0)
	20	96	9	12	107	3	10	91	14
Mixed Cropping	(16)	(76.8)	(7.2)	(9.84)	(87.7)	(2.46)	(8.7)	(79.13)	(12.17)
	30	78	8	11	87	5	19	81	6
Mixed Livestoc	(25.86)	(67.24)	(6.9)	(10.68)	(84.47)	(4.85)	(17.92)	(76.42)	(5.66)
	103	282	36	43	347	24	100	273	38
Mixed Crops-livestock	(24.47)	(66.98)	(8.55)	(10.39)	(83.82)	(5.8)	(24.33)	(66.42)	(9.25)

	4	18	5	4	20	1	8	12	1
Not classifiable	(14.81)	(66.67)	(18.52)	(16)	(80)	(4)	(38.1)	(57.14)	(4.76)

As in the previous table, the farm specialisation affects the stated intentions concerning the land use on farm and off-farm. In particular, compared to the other specialisations, the horticulture specialisation, determines a higher use of labour on-farm with higher frequency of increase in both household and external labour. In Table 13 the stated intention concerning the changes in capital use are presented for each farm specialisation.

Table 13 – Stated intention concerning the changes in the capital use per each farm specialisation.

Specialisation (2003/369 EC)	livestock			Building			machinery		
	Incr.	No change	Decr.	Incr.	No change	Decr.	Incr.	No change	Decr.
				93	374	8	143	320	19
Field Crops				(19.58)	(78.74)	(1.68)	(29.67)	(66.39)	(3.94)
horticulture				13	24	0	18	19	1
				(35.14)	(64.86)	(0)	(47.37)	(50)	(2.63)
Permanent Crops				16	124	2	28	111	3
				(11.27)	(87.32)	(1.41)	(19.72)	(78.17)	(2.11)
Grazing Livestock	262	205	16	233	235	7	225	241	17
	(54.24)	(42.44)	(3.31)	(49.05)	(49.47)	(1.47)	(46.58)	(49.9)	(3.52)
Granivore	6	15	0	11	10	0	11	9	0
	(28.57)	(71.43)	(0)	(52.38)	(47.62)	(0)	(55)	(45)	(0)
Mixed Cropping				16	102	7	20	102	4
				(12.8)	(81.6)	(5.6)	(15.87)	(80.95)	(3.17)
Mixed Livestock	49	60	5	34	77	2	45	70	1
	(42.98)	(52.63)	(4.39)	(30.09)	(68.14)	(1.77)	(38.79)	(60.34)	(0.86)
Mixed Crops-livestock	161	232	34	109	328	7	101	326	16
	(37.7)	(54.33)	(7.96)	(24.55)	(73.87)	(1.58)	(22.8)	(73.59)	(3.61)
Not classifiable				9	19	0	12	16	0
				(32.14)	(67.86)	(0)	(42.86)	(57.14)	(0)

Specialisation in livestock determines an increase of the intensity of the use of the capital in the endowment of building and machinery. Furthermore, stronger specialisation (Granivore and Grazing livestock) reveal a higher increase compared with mixed livestock and mixed crop-livestock. Only horticulture specialisation determines a high frequency in the endowment of buildings and machinery compared to the other crop specialisations.

In Table 14 the stated intention concerning changes in labour use are presented for different Usable Agricultural Area classifications.

Table 14 – Stated intention concerning the changes in the land possession per each Usable agricultural Area Category.

Usable agricultural Area	own land			land rented-in			land rented-out		
	Incr.	No change	Decr.	Incr.	No change	Decr.	Incr.	No change	Decr.
	50	154	0	46	146	3	9	159	3
UAA <5	(24.51)	(75.49)	(0)	(23.59)	(74.87)	(1.54)	(5.26)	(92.98)	(1.75)
	109	446	9	125	408	19	18	459	12
UAA 5- <20	(19.33)	(79.08)	(1.6)	(22.64)	(73.91)	(3.44)	(3.68)	(93.87)	(2.45)
	101	266	5	141	205	20	15	297	13
UAA 20- <50	(27.15)	(71.51)	(1.34)	(38.52)	(56.01)	(5.46)	(4.62)	(91.38)	(4)
	100	151	2	97	133	15	16	193	12
UAA 50- <100	(39.53)	(59.68)	(0.79)	(39.59)	(54.29)	(6.12)	(7.24)	(87.33)	(5.43)
	169	240	3	147	237	34	16	311	16
UAA > 100	(41.02)	(58.25)	(0.73)	(35.17)	(56.7)	(8.13)	(4.66)	(90.67)	(4.66)

Trends in land use are differentiated according to category of UAA in 2010. Increasing the UAA category there are more farmers that stated an intention to increase the size through both land-owned and land rented-in.

In Table 15 the frequencies of stated intention concerning the labour use changes are presented for different Usable Agricultural Area classifications.

Table 15 – Stated intention concerning the changes in the labour use per each Usable agricultural Area Category.

Usable agricultural Area	hh labour on			hh labour off			external labour		
	Incr.	No change	Decr.	Incr.	No change	Decr.	Incr.	No change	Decr.
	60	146	12	20	166	13	46	149	11
UAA <5	(27.52)	(66.97)	(5.5)	(10.05)	(83.42)	(6.53)	(22.33)	(72.33)	(5.34)
	141	378	44	58	449	26	122	370	43
UAA 5- <20	(25.04)	(67.14)	(7.82)	(10.88)	(84.24)	(4.88)	(22.8)	(69.16)	(8.04)
	79	267	28	38	292	27	68	268	23
UAA 20- <50	(21.12)	(71.39)	(7.49)	(10.64)	(81.79)	(7.56)	(18.94)	(74.65)	(6.41)
	57	184	18	34	191	16	62	160	16
UAA 50- <100	(22.01)	(71.04)	(6.95)	(14.11)	(79.25)	(6.64)	(26.05)	(67.23)	(6.72)
	95	285	36	37	319	34	101	277	30
UAA > 100	(22.84)	(68.51)	(8.65)	(9.49)	(81.79)	(8.72)	(24.75)	(67.89)	(7.35)

The stated intention in the use of household labour on-farm shows a progressive reduction of the percentage of farmers that stated intentions to allocate more household labour on-farm increasing the farm surface.

In Table 16 the stated intention concerning the changes in capital use are presented for different Usable Agricultural Area classification.

Table 16 – Stated intention concerning the changes in the capital use per each Usable agricultural Area Category.

Usable agricultural Area	livestock			building			machinery		
	Incr.	No change	Decr.	Incr.	No change	Decr.	Incr.	No change	Decr.
UAA <5	49 (52.69)	40 (43.01)	4 (4.3)	42 (19.53)	169 (78.6)	4 (1.86)	48 (21.82)	166 (75.45)	6 (2.73)
UAA 5- <20	111 (40.51)	148 (54.01)	15 (5.47)	94 (16.46)	463 (81.09)	14 (2.45)	145 (25.48)	416 (73.11)	8 (1.41)
UAA 20- <50	125 (54.11)	102 (44.16)	4 (1.73)	159 (41.51)	219 (57.18)	5 (1.31)	167 (43.26)	205 (53.11)	14 (3.63)
UAA 50- <100	78 (45.88)	83 (48.82)	9 (5.29)	101 (38.26)	160 (60.61)	3 (1.14)	97 (36.33)	160 (59.93)	10 (3.75)
UAA > 100	115 (41.52)	139 (50.18)	23 (8.3)	138 (32.32)	282 (66.04)	7 (1.64)	146 (33.49)	267 (61.24)	23 (5.28)

The UAA category determines a heterogeneous behaviour in the use of capital. Such heterogeneity is differentiated by typology of investment considered. In fact in the livestock specialisation, the UAA category does not seem to affect strongly the percentage of stated changes. In the use of this factors there is only a category of medium-large size farms (UAA 20- <50) for which the stated intention to increase such amount is very frequent. With higher UAA size, the intention to invest in buildings or machinery increases. This table shows that the more expected dynamic UAA category is the medium large size, in both stated increasing in the endowment of farm buildings and machinery. Below this class, the intention to increase such endowments is very low compared to the other: less than a half. Also, above the medium large category, there is a less frequent intention to increase the farm endowments.

3.1.2 Policy change impact on the use of productive factors

Agricultural economics literature has highlighted the role of agricultural policies among the drivers of the changes in the productive factors (See Bartolini et al., 2009)¹.

Table 17, Table 18 and Table 19 present the scenario effects on the stated intentions concerning the changes in the amount of owned land, in the amount of land rented-in and in the amount of land rented-out.

Table 17 – Changes in stated intentions about owned land (Baseline VS NO CAP scenario).

		NO CAP SCENARIO						
		increase	no change	decrease	other	do not know	do not answer	total
SLL N	Increase	217	109	13	2	36	4	381
	no change	38	726	39	0	44	7	854

¹ Note that in these table are excluded all farmers that state an intention to exit from agricultural sector. See Raggi et al 2010 for a description and the quantification of exits by farmers.

decrease	0	0	14	0	1	0	15
Other	0	0	0	2	1	1	4
do not know	2	14	1	0	70	0	87
do not answer	1	0	0	0	0	53	54
Total	258	849	67	4	152	65	1,395

This table provides a comparison of the state intentions previously explained in the baseline scenario, with the analogous intentions in the no-CAP scenario. The great part of the farmers does not change their behaviour about land-owned (more than 1000 farmers with a total of 1395). Such farmers are those that are placed across the diagonal: (217+726+14+2+70). A part of the sample stated a reduction of the owned land used, that are those that move from increase to no-change, or decrease (109+13) and move to no change to decrease in NO CAP scenario (39). Altogether reduction in the use of land owned is expected for more than the 10% of the farmers. 38 farmers stated an intention to have higher land owned with the abolishment of the CAP payments. Among these farmers, 50% are belonging to the higher UAA category (more than 100 ha), and the 31% are specialised in grazing livestock.

Table 18 – Changes in stated intentions about land rented-in (Baseline VS NO CAP scenario).

		NO CAP SCENARIO						
		increase	no change	decrease	other	do not know	do not answer	total
BASILINE	increase	198	154	31	1	33	4	421
	no change	45	615	48	0	37	6	751
	decrease	7	3	47	0	3	2	62
	other	0	0	0	6	0	0	6
	do not know	0	0	5	0	82	1	88
	do not answer	3	2	0	0	0	62	67
	total	253	774	131	7	155	75	1,395

The abolishment of CAP seems to determine a higher reduction in the use of land rented-in, with respect the land owned. In fact, if the great part of the farmers do not change their behaviour under NO-CAP scenario (those that are placed on the diagonal), more that the 15% of the farmers reduced the use on the land rented-in comparing the NO-CAP scenario with the baseline. The amount of farmers that stated a positive impact of policy abolishment is 4% (45+7+3). 55 farmers stated an intention to have higher land rented-in with the abolishment of the CAP payments. Among these farmers, 25% are belonging to the medium large UAA class (UAA 20- <50); 43% are belonging to the higher UAA category (more than 100 ha), and 40% are specialised in grazing livestock.

Table 19 – Changes in stated intentions about land rented-out (Baseline VS NO CAP scenario).

NO CAP SCENARIO

		increase	no change	decrease	other	do not know	do not answer	total
BASLINE	increase	35	10	2	0	6	2	55
	no change	36	901	10	1	35	8	991
	decrease	4	2	28	0	1	1	36
	other	1	1	0	33	0	2	37
	do not know	4	1	1	0	100	2	108
	do not answer	0	2	0	0	2	164	168
	total	80	917	41	34	144	179	1,395

Land rented out is the most static element analysed among the several land possession forms. Both positive and negative effects of the policy (all farmers that are not in the diagonal) are very low compared to the no effect of the policy abolishment (number of farmers that are on the diagonal). In fact, more than 90% of the farmers are not affected by policy changes about this specific issue.

Table 20, Table 21 and Table 22 present the scenario effects on the stated intentions concerning the changes in the amount of household labour used on farm, in the amount of household labour used off-farm and in the amount of external labour used on-farm.

Table 20 – Changes on stated intentions in the use of household labour on-farm (Baseline VS NO CAP scenario).

		NO CAP SCENARIO						
		increase	no change	decrease	other	do not know	do not answer	total
BASLINE	increase	189	46	22	0	26	1	284
	no change	43	712	74	0	54	12	895
	decrease	5	2	85	0	5	0	97
	other	0	1	0	4	0	1	6
	do not know	2	4	4	0	79	2	91
	do not answer	0	2	2	1	0	17	22
	Total	239	767	187	5	164	33	1,395

The NO-CAP scenario does not affect the change in the use of household labour off-farm. In fact 70 % of the farmers state that they have no intention to change their behaviour with the policy abolishment, and about 10% of the farmers reduce the use of this factor without CAP. 50 farmers stated an intention to have higher labour use on farm in with the abolishment of the CAP payments. Among these farmers, 78% are belonging to two larger UAA category (UAA 50- <100 and more than 100 ha); 38 % are specialised in grazing livestock and the 24% are specialised in mixed crop and livestock.

Table 21 – Change on stated intentions in the use of household labour off-farm (Baseline VS NO CAP scenario).

		NO CAP SCENARIO						
		increase	no change	decrease	other	do not	do not	total

						know	answer	
BASLINE	increase	93	8	1	0	8	1	111
	no change	104	819	23	0	39	11	996
	decrease	23	7	57	0	6	1	94
	other	0	0	0	17	0	1	18
	do not know	2	5	1	1	91	0	100
	do not answer	0	5	1	0	1	68	75
	total	222	844	83	18	145	82	1,394

The NO-CAP scenario does not affect the change in the use of household labour off-farm. In fact 70 % of the farmers state that they have no intention to change their behaviour with the policy abolishment, and about 10% of the farmers increase the allocation of the household labour off-farm to the scenario without CAP. There are few farmers (32) that are expected to react with higher use on-farm of the household labour.

Table 22 – Change in stated intentions in the use of external labour (Baseline VS NO CAP scenario).

		NO CAP SCENARIO						
		increase	no change	decrease	other	do not know	do not answer	total
BASLINE	increase	165	63	34	0	21	4	287
	no change	18	733	85	0	28	8	872
	decrease	5	3	58	0	1	0	67
	other	0	0	1	11	0	1	13
	do not know	2	6	1	0	86	2	97
	do not answer	0	3	2	0	1	53	59
	total	190	808	181	11	137	68	1,395

The NO-CAP scenario does not affect strongly the change in the use of external labour used on-farm. In fact, 65 % of the farmers state that they have no intention to change the use of external labour with the policy abolishment, and about 15% state an intention to reduce the use of this factor without CAP. There are few farmers (26) that are expected to react with higher use of external labour on-farm to the scenario without CAP.

Table 23, Table 24 and Table 25 present the scenario effects on the stated intentions concerning the changes in the livestock intensity, in building and machinery endowment.

Table 23 – Changes on stated intentions in the livestock intensity (Baseline VS NO CAP scenario).

		NO CAP SCENARIO						
		increase	no change	decrease	other	do not know	do not answer	total

BASLLINE	increase	180	102	25	2	35	3	347
	no change	42	224	44	2	29	6	347
	decrease	0	1	34	1	2	3	41
	other	0	0	0	2	0	1	3
	do not know	3	5	3	0	27	0	38
	do not answer	0	2	0	0	0	15	17
	total	225	334	106	7	93	28	793

The NO-CAP scenario determines a high reduction in the stated intentions about livestock intensity. In fact more than the 20% of the farmers stated a reduction in the intention to increase the amount of animal reared on the farm (102+25+44). Compared to the other productive factors, more farmers (43) are expected to react to the scenario without CAP with higher investment in the animal reared. 50% of these farmers are specialised in dairying production and are belonging to medium-high and high category of UAA.

Table 24 – Change on stated intentions in the buildings endowments (Baseline VS NO CAP scenario).

		NO CAP SCENARIO						
		increase	no change	decrease	other	do not know	do not answer	total
BASLLINE	increase	185	174	19	0	38	4	420
	no change	29	738	54	0	24	8	853
	decrease	1	1	16	0	1	1	20
	other	0	1	0	2	0	0	3
	do not know	2	3	1	0	45	2	53
	do not answer	3	4	0	0	0	39	46
	total	220	921	90	2	108	54	1,395

Table 25 – Change in stated intentions in the machinery endowments (Baseline VS NO CAP scenario).

		NO CAP SCENARIO						
		increase	no change	decrease	other	do not know	do not answer	total
BASLLINE	increase	170	220	36	0	28	8	462
	no change	19	638	107	0	35	7	806
	decrease	2	1	34	0	1	2	40
	other	0	1	0	4	0	0	5
	do not know	0	3	1	0	45	2	51
	do not answer	1	0	1	0	0	29	31
	total	192	863	179	4	109	48	1,395

Stated intention concerning the endowment of building and machinery are strongly affected by the abolishment of CAP. In particular for both buildings and

machinery, more than 50% of the farmers that under baseline condition stated an intention to increase their endowments, with the CAP abolishment will move to no-change.

3.2 Analysis of the determinants of the policy impact on the changes of the productive factors use

3.2.1 Methodology

The literature highlights the effect of policy changes on the re-allocation of productive factors over time. In particular, on the one hand several authors have found a positive effect on the land market of decoupling policy, generated by an increasing of formalised relationships between actors concerning land possession. On the other hand the income support payments have reduced land re-allocation towards more efficient farms, with the effect of preventing farmers exit and maintaining active also less efficient farms.

The impact of policy scenarios on structural change are quantified comparing the stated intention under baseline and NO-CAP scenario concerning the changes in land, labour and capital. Each of the three productive factors has been represented through a single variable:

- Land used (stated intentions about land owned and rented-in land) using questions Q4.09A+Q4.10 A concerning the Baseline condition and questions Q4.09B+ Q4.10B concerning the NO CAP Scenario (the overview of these two variables are depicted in Table 17 and in Table 18).
- Labour used on farm (stated intentions about changes in household labour) using questions Q4.06A; Q4.08A concerning the Baseline condition and questions Q4.06B; Q4.08B concerning the NO CAP Scenario (the overview of these two variables are depicted in Table 20 and in Table 22)
- Capital used on farm (stated intention concerning buildings, and the machinery endowments) using questions Q4.16A; Q4.17A concerning the baseline and Q4.16 B; Q4.17B concerning the NO CAP scenario (the overview of these two variables are depicted in Table 23, Table 24 and in Table 25).
- Capital used on farm as in the previous point plus the change in livestock intensity using questions Q4.12A; Q4.16A; Q4.17A concerning the baseline and Q4.12B; Q4.16 B; Q4.17B concerning the NO CAP scenario (the overview of these two variables are depicted in Table 24 and in Table 25).

The observations used for the simulation are those that allow for a clear identification of the intentions revealing a negative or positive effect of the hypothesis of CAP removal on the factor use. On the contrary, the observations for which there is a substitution across different typology of the same factors has been excluded (e.g. stated intention to decrease the land owned increasing with simultaneous intention to reduce land rented-in).

In Table 26 the stated intentions concerning the land use are shown.

Table 26 – Policy effect on the stated intention about the land used (owned +rented-in) (Baseline VS NO CAP scenario).

		NO PAC			Total
		Reduction	no change	increasing	
BASELINE	Reduction	30	0	4	34
	No change	48	479	37	564
	Increasing	31	153	237	421
	Total	109	632	278	1019

The great part of the farmers (45%) state an intention not to change the use of land in both scenarios. Farmers state a big reduction in the increase of the land use (19%), due to the abolishment of the CAP. Such policy effect is mainly observed in those farmers that have an expectation to increase the amount of land under baseline and with the CAP abolishment prefer to state “no change” in the land use.

In Table 27 the stated intentions concerning the labour use are shown.

Table 27 – Policy effect on the stated intention about the labour used on-farm (household labour+ external labour used on-farm) (Baseline VS NO CAP scenario).

		NO CAP			Total
		Reduction	no change	increasing	
BASELINE	Reduction	77	1	5	83
	No change	83	500	30	613
	Increasing	40	53	210	303
	Total	200	554	245	999

The effect of CAP abolishment on the amount of labour used on farm is lower compared to land use. In fact the farmers that maintain the same behaviour under the two scenarios are 80% of the surveyed sample. Farmers that state an intention in the reductions of labour used on-farm are about 17% (176 farmers) which are equally distributed between those that state a change from “No-change” answer under Baseline to “reduction” answer under NO-CAP scenario (83 farmers) and a change from “increasing” intentions under baseline to “no-change”, or “reduction” under NO-PAC scenario (93 farmers).

In Table 28 the stated intentions concerning the capital used are shown (without livestock).

Table 28 – Policy effect on the stated intention about the capital used on-farm (machinery+ buildings) (Baseline VS NO CAP scenario).

		NO CAP			Total
		Reduction	no change	increasing	
BASELINE	Reduction	30	1	1	32
	No change	83	504	31	618
	Increasing	46	210	223	479
	Total	159	715	255	1129

Changes in the use of capital (identified as proxy of the buildings and machinery endowments), as a consequence the hypothesis of the CAP abolishment shows high reduction (about the 30% of the farmers), compared to the previous factors. However, farmers that maintain the same behaviour are about the 67%. Only few farmers react to policy abolishment with higher use of capital (3%).

In Table 29 the stated intentions concerning the capital uses are shown (without livestock).

Table 29 – Policy effect on the stated intention about the capital used on-farm (livestock+ machinery+ buildings) (Baseline VS NO CAP scenario).

		NO CAP			Total
		Reduction	no change	increasing	
BASELINE	Reduction	35	0	2	37
	No change	37	104	24	165
	Increasing	37	126	189	352
	Total	109	230	215	554

Adding the changes in the number of animal reared, the effect of the CAP abolishment is higher in the direction of the capital use reduction. In fact the farmers that stated an intention to reduce the use of the capital with such abolishment are 36%.

The determinants of the different effects of policy changes are analysed using two different approaches: four different multinomial logit, one for each productive factor plus two for capital (with and without livestock); and a multivariate model (trivariate probit), with the intention to analyse the joint decision in all three factors as a reaction to the abolishment of the CAP.

In the first approach a different model has been run for each factor, treating each of them as an independent change and using the following variable codes for the dependent variables considered (Table 30):

- “0” baseline VS NO CAP = **negative effects** of the CAP abolishment on the factor use. Such value means that comparing the NO CAP versus Baseline the farmer states the intention to reduce the factor use. Reducing the factors use has been interpreted as: a) change the stated intention from “increase” (in Baseline) to “no change” or “reduction” (in NO CAP scenario); b) change the stated intention from “no change”(in Baseline) to “reduction” (in NO CAP scenario) using data from Table 26, Table 27, Table 28 and Table 29.
- “1” baseline VS NO CAP = **no effects** of the CAP abolishment on the factor uses. Such value means that the abolishment of the CAP does not affect the use of the productive factor: farmers in both scenarios maintain the same intention (e.g. “no change” in Baseline and “no change” in NO CAP scenario).

- “2” baseline VS NO CAP = **positive effects** of the CAP abolishment on the factor use. Such value means that comparing the NO CAP versus Baseline the farmer states the intention to increase the factor use. Increasing the factors use has been interpreted as: a) change the stated intention from “reduction” (in Baseline) to “no change” or “increasing” (in NO CAP scenario); b) change the stated intention from “no change”(in Baseline) to “increasing” (in NO CAP scenario) using data from Table 26; Table 27; Table 28 and Table 29.

Table 30 – Policy effect on the use of productive factors (dependent variables for the four multinomial logit models)

Productive Factor	Baseline VS NO PAC scenario			Sum
	negative effects(-) (0)	no effects(=) (1)	positive effects (-) (2)	
land	232 (23)	746 (73)	41 (4)	1019 (100)
labour	176 (18)	787 (79)	36 (4)	999 (100)
capital (without livestock)	339 (30)	757 (67)	33 (3)	1129 (100)
capital (with livestock)	200 (36)	328 (59)	26 (5)	554 (100)

Secondly a multivariate model (trivariate probit) using multiple equations for all factors in order to explain the effect of CAP abolishment of the different factors as a joint decision. For this purposes, the variable representing the CAP abolishment effects on the use of land, labour and capital has been presented as a binary variable, analysing the two modalities with higher frequency: no –effect and negative effect of policy abolishment on the use of the factors (Table 31).

Table 31 – Policy effect on the use of productive factors (dependent variables for triprobit model)

Productive Factor	Baseline VS NO CAP scenario		Sum
	no effects (=) (0)	Negative effects (-) (1)	
land	746 (73)	232 (23)	1019 (100)
labour	787 (82)	176 (18)	963 (100)
capital (without livestock)	757 (69)	339 (31)	1096 (100)
capital (with livestock)	328 (62)	200 (38)	528 (100)

3.2.2 Analysis of the effect of CAP changes in the use of each single productive factor

First Simulation (four independent Multinomial Logit)

The determinants of CAP abolishment effect on the use of land/labour/capital factors were estimated using four independent multinomial logit models. Such models allow expressing and explaining the probability that a stated farm household strategy about the factor use was been affected by CAP abolishment.

As mentioned before, four separate models were implemented, each model containing, as a dependent variable, the changes in state intentions on the use of a productive factor when policy are completely removed (both first and second pillar CAP measures) with respect to the use of the same factor under baseline condition. In both models the stated choice has been interpreted as a multiple choice among: 0) negative effect of the on the factor use, 1) no change in the factor use and 2) positive effects on the factor use. The dependent variables were already presented in Table 30.

Let U_{ij} denote a non observed utility that farm household i derives in the change (j) of productive factor use; it is possible to write $U_{ij} = \mu_{ij} + \varepsilon_{ij}$ where μ_{ij} is an observable portion of the utility function which is a linear combination of the covariates (set of observed variables) and ε_{ij} is an unobservable term (Werbeek, 2004).

Assuming that ε_{ij} are independent and with Gumble distribution (extreme value distribution Type 1), the probability that the i -th farm have a change (j) in use

of a productive factor is: $P_{ij} = \frac{\exp\{\mu_{ij}\}}{\sum_j^M \exp\{\mu_{ij}\}}$ with $j = 1, 2, \dots, M$ alternatives.

Under this notion, it is automatically assumed that $0 \leq P_{ij} \leq 1$ and $\sum_j^M P_{ij} = 1$.

Assuming that μ_{ij} is a linear function, which means that it is possible to write $x'_{ij}\beta = \mu_{ij}$, where the matrix x'_{ij} contains the set of the explanatory variables. Under the assumptions of linearity and error distribution it is possible to rewrite a normalised form of probability calculation:

$P_{ij} = \frac{\exp\{x'_{ij}\beta\}}{\sum_j^M \exp\{x'_{ij}\beta\}}$ for each $j = 1, \dots, M$ alternatives.

Under this notion, the probability for the i -th farmer choice to have a behaviour (j) in front of policy changes, between a set of M alternatives is a function of the explicative variables x_{ij}' and the β coefficients (Green, 2000). The positive/negative sign of β coefficient, when significant, can be interpreted as the increment/decrement of the probability that a farmer with a certain characteristic being affected positively or negatively or not affected by policy abolishment. Note that a non-significant coefficient implies that the regressor do not affect the utility or the probability of being in a certain group. In

Table 32 the statistical descriptive are presented for all independent variables considered.

Table 32 – Statistical Descriptive of the independent variables

Category	Variable (Description)	Variable (Code)	Obs	Mean	Std. Dev	Min	Max
CSA	Centre CSA (dummy)	centre	2363	0.30	0.46	0	1
	Eastern CSA (dummy)	eastern	2363	0.22	0.41	0	1
	Mediterranean CSA (dummy)	med	2363	0.40	0.49	0	1
	North CSA (dummy)	north	2363	0.07	0.26	0	1
Geographical	Plain (dummy)	plain_d	2358	0.57	0.50	0	1
	Hill (dummy)	hill_d	2358	0.34	0.47	0	1
	Mountain (dummy)	mountain_d	2358	0.09	0.28	0	1
Household characteristics	Household members younger than 18 years old (dummy)	house18_d	2363	0.41	0.49	0	1
	Land-in relative (dummy)	land_in_relatives	2363	0.16	0.37	0	1
	Unemployed (# in the Household)	unemp_c	2336	0.21	0.58	0	3
	Farm income from agricultural activity > 50% of total household (dummy)	f_inco_more50	2363	0.65	0.48	0	1
	farmer younger than 40 years old (dummy)	age_min_40	2363	0.23	0.42	0	1
Farmer characteristics	farmer older than 60 years old (dummy)	age_more_60	2363	0.20	0.40	0	1
	Age of respondent (Ln of age_y)	lnage_y	2334	3.85	0.29	2.89	4.44
	Educational level lower than secondary school (dummy)	edu_level_low	2363	0.14	0.34	0	1
	Educational level higher than degree (dummy)	edu_level_high	2363	0.51	0.50	0	1
	Current SFP received (1000€)	pay_sfp_1000e	2363	18.32	52.54	0	1200
Policy	Payment per ha (€)	SFP_ha	2363	395.27	1124.61	0	17675
Commercial/Relational characteristics	Regular activity of advisory (dummy)	advisory_d	2363	0.56	0.50	0	1
	sell to contract (dummy)	sell_contrac_d	2363	0.25	0.43	0	1
	sell to cooperative (dummy)	sell_coop_d	2363	0.40	0.49	0	1
	sell to private (dummy)	sell_private_d	2363	0.44	0.50	0	1
Farm Structure	external labour used on farm (# of Full time equivalents)	fulltime_equ	2363	1.48	4.93	0	104
	household labour used on farm (# of Full time equivalents)	hh_fulltime_equ	2363	1.56	0.86	0	12
	household members working on farm > 2 (dummy).	hh_fulltime_more2	2363	0.39	0.49	0	1
	land rented-in (dummy)	land_in	2363	0.67	0.47	0	1
	land rented-out (dummy)	land_out	2363	0.12	0.32	0	1

UAA (ha)	UAA_ha	2363	95.71	281.24	0	7500
UAA less than 10 ha (dummy)	UAA_less10	2363	0.27	0.44	0	1
UAA greater than 50 ha (dummy)	UAA_more50	2363	0.09	0.28	0	1
UAA greater than 100 ha (dummy)	UAA_more100	2363	0.22	0.42	0	1
More than 50 dairy cows reared (dummy)	liv_dairy_more50	2363	0.09	0.28	0	1
Farm type field crop (dummy)	field_crops	2363	0.27	0.44	0	1
Farm type permanent crop (dummy)	permanent_crop	2363	0.07	0.26	0	1
Farm type grazing livestock (dummy)	grazing_livestock	2363	0.27	0.44	0	1
Farm type mixed crop livestock (dummy)	mixed_crop_livestock	2363	0.21	0.41	0	1

The dependent variables differ among the models, though the set of independent variables is mostly the same. Independent² variables can be classified as belonging to the following categories: CSA geographical, farm-household, farmer, farm, commercial and relational and policy variables.

In all models the CSA has been grouped in different areas, which is presented as four dummies (North CSA; Mediterranean CSA; Eastern CSA and Centre CSA)

In all models, geographical variables are represented by altitude, which is presented as three dummy variables (plain, hill and mountain).

Household variables are mainly related to the household long term unemployed (unemp_c) and the weight of farm income with respect to the total household income (f_inco_more50). Finally the presence/absence of land rented-in among relatives has been considered (land_in_relatives_d) and the presence/absence of household members young than 18 years old (house18_d).

Farm characteristics included are the age of the farm owner (lnage_y; age_more_60; age_less_40), which, however, is expressed in differ ways among the models considered. In addition, while in the first model two variables (edu_level_low; edu_level_high) were included representing the educational level (respectively upper than the university degree and lower than secondary school)

Commercialisation and relational characteristics are referred to presence/absence of the technical advice received by the farmer (advice_d) and the typology of collocation on the market of the farm productions: presence or absence of contracts for selling the production (sell_contrac_d); presence or absence of the vertical relationship with cooperative (sell_coop_d) or private (sell_private_d)

In all models the farm characteristic variables are related to farming specialisation and the current farm size, regarding operated land area, the land rent-in and the number of dairy cows reared, and the amount of labour needed. Finally the

² The independent variables used in both models were selected coherently with the literature on determinants of farm expansion and the final model was, for each scenario, the one with lower BIC value (Bayesian Information Criterion).

amount of SFP received and the SFP per ha received has been included into the policy category.

In Table 33 the results of the four multinomial logit are presented.

Table 33 – Results of the four multinomial logit (not significant variables omitted).

Variable (Code)	Land		Labour		Capital (without livestock)		Capital (with livestock)	
	Negative effects	Positive effects	Negative effects	Positive effects	Negative effects	Positive effects	Negative effects	Positive effects
plain	-							
hh_fulltime_eq				-				
hh_fulltime_eq_more2		+						
full_time_eq		-	+				+	
UAA_less10	-	-		-	-	-		
UAA_more50	+							
UAA_more100					+			
UAA_ha							+	
live_dairy_more_50			-					
land_in	+		+					
field_crops	+		+					
permanent_crop	+	+	+					
grazing_livestock	+		+			-		
mixed_crop_livestock	+		+	+				
age_more_60							-	
ln_age								-
unemp_c							-	
pay_sfp_1000e		+					-	
SFP_ha				+				
Med			-					
North				-				
Centre					+		-	
Eastern	+				+			
edu_level_low			-	-				
land_in_relative			+					
f_inco_more50				+				
advisory_d					+			
sell_private					+			
Sell_coop					+			
Sell_contract								+
house_18					+		+	
Observation	999		979		1129		547	
R2	0.16		0.18		0.18		0.21	

(for all dependent variable value=1 (no change) is the base outcome)

In the first model (effect of CAP abolishment in the land use) the probability to have negative effect is increased for those farmer with large farm size (more than 50 ha), that are current rented-in land and that are located eastern CSA. In addition such probability increased for those farmers specialised in field crops; permanent crop; grazing livestock and mixed crop and livestock. The probability to have negative effect is low for the farmers with low UAA (less than 10 ha) and finally for those farmers located on plain. The probability to have positive effect of CAP abolishment is increasing for those farmers that are using high amount of household labour on farm, those farmer specialised in permanent crops and for those farmer that in the past have received high amount of SFP. Differently the probability to have the same effect of policy abolishment is reducing for those farmer that are using a very low amount of land (less than 10 ha) and increasing the external labour used on farm.

Altogether the model results provides a picture of impact of effect of policy removing on the use of land that suggest a substantially indifference for the farm with small size farms but a strong impact in those farm with generally large size farms or large intensity. In this last farms the effect are of policy abolishment is expected in both directions: from one the reduction of the land use is more likely for the farms with a very large size and from the other hand farmer that are received higher amount of SFP and with high use of household labour on farm is such for example livestock farm or for specialised those farmer with high value of entitlements have higher probability to react to policy abolishment with an increasing of the use of the land factor.

The probability to have changes (reduction of the factor use) in the stated intention about the on-farm labour use after policy abolishment is consequence of farm, farmer and household characteristics. The probability to have negative effect on the on-farm labour use, decrease with a higher amount of animal reared; with lower level of the education of the farmer owner and in the farmer placed on the Mediterranean area. Differently the probability to have the same effect of policy abolishment increasing with higher amount of external worker used, if the farmer rented-in some land and if a portion of this land is rented-in from the relatives. Finally specialised in fields crops, in permanent crops, in grazing and livestock and in mixed crop-livestock have higher probability to reduce the amount labour used on-farm

These variables allows to consider more resilient to the reduction in the use of labour the large livestock farmer that could be expected a benefit from the quota abolishment mechanism and farmer located Mediterranean area as consequences of a lower expectation to allocate household labour in off-farm activity or due to the lower opportunity cost of the labour allocated to such activities.

The probability to have positive effect on the stated intentions concerning the on-farm labour use after policy abolishment, decrease for those farmer with lower level of education and for those farmer that currently use high amount of household

labour and lower amount of land currently used. Finally the location in the north of Europe (farmers from CSA 5) induce a lower probability to increase the labour on-farm as consequence of CAP abolishment mainly due to the lower needed of labour for alternative crops. The probability to have positive effect on the stated intentions concerning the on-farm labour use after policy abolishment, increase in those farmers which the main part of the household income coming from farming activity and for those farmer that have received a higher SFP per ha.

Altogether farmer with low level of education are more resilient to change in labour use on-farm in fact if from one hand such modality of the education variable reduce the off-farm alternative job opportunity and from other hand the literature emphasise the reduction in the change attitude about for example innovation or new technology adoption, able to survive when adverse condition happened.

The probability to have negative impact (reduction of the factor use) in the stated intention about the capital use on-farm after policy abolishment (without changes in livestock), decrease only for those farmer that are operated with UAA lower than 10 ha. Otherwise the probability to have a reduction in state intention about the capital use after a CAP removing, increase for those farmer that are regularly advised, with sell the main production directly to cooperative or to private, those farmer with young household components and farmers that have a large farm. Results shown that the probability of a negative impact is increased also for farmer placed in the CSA belonging to the Centre area.

The probability to have an increasing of the capital use on-farm consequently o the CAP abolishment increasing for specialised in livestock and grazing farmers and reducing for farmers with lower amount of UAA.

Reduction of capital use on-farm is differentiated between farm sizes. In fact such reduction is more probability for large farm size and for those farmers with characteristics that in the literature has been associated to the market oriented form and has low probability for small farms size. As well as changes in land factor, the farms with low size are more resilient to the changes in capital due to the CAP abolishment.

The probability to have a reduction in the capital use on-farm (with changes in the amount of animals reared) consequently o the CAP abolishment increasing for farmers with young household components; increasing the amount of external labour used on-farm and the land size and for the farmers located in the eastern CSAs. Differently the probability to have a reduction in the capital use on-farm is reducing for older farmer owners; with higher amount of household un-employees for higher amount of the SFP received and for the farmers placed on the centre CSAs.

The probability to have an increasing in the capital use on-farm (with changes in the amount of animals reared) consequently o the CAP abolishment increasing for those farmers that sell the mayor part of the production by contracts. Differently with increasing the age of farmers' owner there is a lower probability to have a positive effect due to CAP abolishment.

Results shown a lower significance of the different amount of received SFP and the amount of SFP per ha on the determination of a different changes on the use of factors. The expectation comparing two situations differentiate only for the abolishment of the CAP was for a strong effect of the amount of payments and for the effect of different entitlements in the determination of factors use changes.

3.2.3 Analysis of the effect of CAP changes in the simultaneous use of all productive factors

Second Simulation (Multivariate probit)

Considering again Table 31, the main reactions to the removal of the CAP concern the no change and the reduction in the use of land; labour and in the capital use. The data allow considering the policy impact on joint decisions concerning the productive factors use, through a better understanding of how decisions are correlated. The objective of this analysis is to derive the correlation between the policy abolishment effect among the different factors. With this aim, it has been developed a model aimed at representing the simultaneous effects of the CAP abolishment on the different factors. This means that a joint probability in the changes behaviour as a consequences of policy changes do exists. The decision problem could be expressed as:

$$y_{ij}^* = x'_{ij} \beta_j + \varepsilon_{ij} \quad (\text{Green, 2000})$$

$$\text{With } y_{ij} = \begin{cases} 1 & \text{if } y_{ij}^* > 0, \text{ and} \\ 0 & \text{otherwise} \end{cases}$$

Where y_{ij} represent the stated intention of the farmer i in front of policy change concerning the productive factors j ($J = 1, \dots, M$), in our case $M=3$; ε_{ij} have a multivariate normal distribution with mean vector 0 and covariance matrix R with

diagonals elements equal to 1, formally: $\begin{pmatrix} \varepsilon_{i1} \\ \varepsilon_{i2} \\ \varepsilon_{i3} \end{pmatrix} \rightarrow N(0, \Sigma)$.

The probabilities to solve the models are determinate using the Geweke-Hajivassiliou-Keane simulator, which produces approximation to the M-fold multivariate normal integral:

$$\int_{-\infty}^{x_M} \dots \int_{-\infty}^{x_1} f(\mathbf{x}_1, \dots, \mathbf{x}_m) d\mathbf{x}_1 \dots d\mathbf{x}_m$$

Where $f(\mathbf{x}_1, \dots, \mathbf{x}_m)$ is the M-variate normal density \mathbf{x} with means vector 0 and $M \times M$ positive definite covariance W. The log likelihood for the model is then

calculated as the sum of the log probabilities of the observed outcomes:
 $\text{Prob}(y_1, \dots, y_m | \mathbf{x}_1, \dots, \mathbf{x}_m) = \text{MVN}(\mathbf{Tz}, \mathbf{TRT}')$

Where \mathbf{z} is the vector of utilities, defined from $\mathbf{z}_m = \beta'_m \mathbf{x}_m$, \mathbf{R} is the correlation matrix; \mathbf{T} is a diagonal matrix with $t_{mm} = 2y_m - 1$ and MVN specifies a multivariate normal. In this part of the deliverable a pairwise correlation of the error terms associated with a different factor use impacts is estimated and is tested.

In Table 34 and in Table 35 the pairwise correlation coefficient across the three reduction of the use of each of the three factors are presented respectively when for all dataset and without the change in livestock intensity (Table 34) and for the livestock specialised farms with the inclusion of the livestock intensity change (Table 35). These coefficients are the pairwise correlation between the error terms in the systems of equations (Velandia et al., 2009).

Table 34 – Correlation between the probability (without livestock).

Effect to CAP abolishment	Correlation Coefficient	Standard Deviation
Reduction in land use and reduction in on-farm labour use	0.4702***	0.0706
Reduction in land use and reduction in capital use	0.5864***	0.0591
Reduction in on-farm labour use and reduction in capital use	0.4556***	0.0741

*** indicates significant at 1% level

All correlation coefficient are positive and significant, and this support the fact that the error terms to react to policy abolishment with a reduction of the factors are correlated the multivariate approach instead to several multinomial logit is more appropriated to describe the CAP impacts on the factors use.

Table 35 – Correlation between the probability (with livestock).

Effect to CAP abolishment	Correlation Coefficient	Standard Deviation
Reduction in land use and reduction in on-farm labour use	0.3505***	0.1046
Reduction in land use and reduction in capital use	0.6228***	0.0737
Reduction in on-farm labour use and reduction in capital use	0.4512***	0.1013

Also in this case all correlation coefficient are positive and significant. As previously the higher correlation is between the choice to reduce both land and the capital.

4 Assessment of the impact of policy change on innovation

New technology adoption and innovation diffusion represent two central elements for the enterprise and industry development process in all sectors of the economy. Innovation is one of the main drivers of economic growth and an important instrument for achieving sustainability and cohesion. Innovation adoption and the re-organization of agri-food chains are two of the Common Agricultural Policy (CAP) Health Check priorities. Such priorities aim to improve the competitiveness of agri-food sectors in the European Union (EU). Competitiveness is one of the axes of the EU Rural Development Programs (RDP) instrument. RDP as a whole and the first axis in particular, are expected to be strengthened in the next years.

However, the effectiveness of an even stronger investment support policy is not ensured, as farmers are operating in an increasingly uncertain environment and such uncertainty is a cause of delay in the process of farm innovations. Uncertainties can derive primarily from the markets, but are also emphasized by the upcoming CAP reform process. Rodrik (1991) has for example shown that only little uncertainty regarding a policy reform may withhold farmers from investing.

4.1 Assessment the impact of policy change on Innovation adoptions (innovation intensity)

The assessment of the impact of policy changes on innovation intensity has been carried out firstly observing the descriptive statistics about the questions concerning the expected adoption of a selection of 5 relevant innovations across all CSA. This part has been split into two subchapters: the analysis of the tendency in the intention about innovation adoption, using the answers from the baseline conditions and the comparison of the stated intentions about use of productive factors under alternative CAP scenarios. The second part of the assessment of the impact of policy changes on innovation adoption has been carried out using an econometric approach in order to explain the determinants of negative or positive CAP impact on the innovation intentions.

4.2 Descriptive Statistics

4.2.1 Analysis of the trend in innovation adoptions

This chapter addresses the analysis of the trends in innovation adoption for the next 10 years. In order to assess the impact of the policy changes and of the trends across the EU, the common list of innovations considered relevant for all CSA has been selected:

- Robotisation/precision farming, in order to consider innovation strongly connected with high investment costs and mainly connected to the reduction of the labour needed to farming activity.
- New irrigation systems.
- E-commerce/direct selling or other innovation in commercialisation of the farmer's production.
- Energy crops or production of energy by the farm through solar panel, wind or biogas etc.
- Other innovation, a category let "blank" for adding other innovations that each farmers could intend to adopt in the next years.

In Table 36 the number of the adopters for each innovation type and the related percentages are presented for all CSA. The results do not included those farmers that state they would exit from agriculture, and the percentages are calculated including only the farmers that state an intention to be enrolled in agricultural activity until 2020, under baseline conditions.

Table 36 – Stated intention concerning the adoption of innovation in each CSA (number and % of adoption with respect the active farmers).

CSA	No innovation adoption	Robotisation/precision farming	New irrigation systems	e-commerce	Energy crops/energy prod.	Other innovation
Emilia-Romagna (Italy)	156 (61.42)	42 (16.54)	47 (18.5)	28 (11.02)	62 (24.41)	0 (0)
Noord-Holland (Netherlands)	132 (68.39)	13 (6.74)	2 (1.04)	20 (10.36)	30 (15.54)	4 (2.07)
Macedonia and Thrace (Greece)	226 (82.78)	0 (0)	15 (5.49)	0 (0)	21 (7.69)	22 (8.06)
Podlaskie (Poland)	226 (92.92)	7 (2.92)	9 (3.75)	0 (0)	6 (2.5)	2 (0.83)
North East of Scotland (UK)	89 (56.69)	27 (17.2)	4 (2.55)	16 (10.19)	56 (35.67)	3 (1.91)
Andalusia (Spain)	81 (51.92)	29 (18.59)	46 (29.49)	13 (8.33)	33 (21.15)	1 (0.64)

South-East Planning Region (Bulgaria)	122 (51.69)	8 (3.39)	26 (11.02)	29 (12.29)	75 (31.78)	1 (0.42)
Centre (France)	41 (33.33)	60 (48.78)	14 (11.38)	26 (21.14)	51 (41.46)	14 (11.38)
Midi-Pyrénées (France)	37 (29.13)	34 (26.77)	14 (11.02)	26 (20.47)	45 (35.43)	20 (15.75)
Lahn-Dill-District (Germany)	68 (68)	12 (12)	8 (8)	1 (1)	19 (19)	1 (1)
Ostprignitz-Ruppin (Germany)	68 (48.23)	32 (22.7)	10 (7.09)	7 (4.96)	44 (31.21)	16 (11.35)
Total	1243 (62.15)	264 (13.2)	195 (9.75)	166 (8.3)	442 (22.1)	84 (4.2)

The 62.15 % of the active farmers state an intention to not adopt any of selected innovation. Such percentages are however quite differentiated across CSA. In fact there are several CSA (Macedonia and Thrace and Podlaskie) with an extremely high percentage of non-adopters (more than 80%). Otherwise in both France CSA and in Ostprignitz-Ruppin CSA, such percentage is lower than the 50%.

Adoption of energy crops/ energy production has the higher percentage among the considered innovation. In fact 22 % of the farmers state the intention to adopt such innovation. Among the other innovation options, a high stated adoption is expressed by the robotisation/precision farming with the 13 % of the farmers; followed by new irrigation systems with the 10% and by e-commerce with 8%. About 4% of the farmers state an intention to adopt other innovations. The full list of other innovation and the number of farmers that state an intention to adopt it is presented in the Annex2. The percentages of the farmers that state an intention to adopt the selected innovation types are lower than the average in Macedonia and Thrace, Podlaskie and Lahn-Dill-District CSAs for all innovations. CSAs with higher stated intention to adopt the robotisation/precision farming technology compared with the average CSAs Emilia Romagna; North East of Scotland; both France CSA and Ostprignitz-Ruppin. CSAs with higher intention to adopt the new irrigation technology compared with the average CSAs are all Mediterranean CSA with addition to Centre CSA and South-East Planning Region. CSAs with higher stated intention to adopt the e-commerce compared with the average are the Noord-Holland, North East of Scotland both French CSA and South-East Planning Region.

CSAs with higher stated intention to adopt energy production or energy crops compared with the average are the North East of Scotland, both French CSA, South-East Planning Region and Ostprignitz-Ruppin. In Macedonia and Thrace and Podlaskie CSA the adoption of such new technology are very low compared with the averages.

In Table 37 the number of adopters for each innovation type and the related percentages organised by specialisation are presented.

Table 37 – Stated intention concerning the adoption of innovation per each specialisation (number and % of adoption with respect the active farmers).

Specialisation (2003/369 EC)	No innovation adoption	Innovation typology				
		Robotisation/ precision farming	New irrigation systems	e-commerce	Energy crops/energy production.	Other innovation
Field Crops	270 (51.53)	81 (15.46)	73 (13.93)	59 (11.26)	170 (32.44)	13 (2.48)
Horticulture	16 (40.00)	7 (17.5)	15 (37.5)	3 (7.5)	9 (22.5)	0 (0)
Permanent Crops	73 (50.34)	32 (22.07)	39 (26.9)	16 (11.03)	26 (17.93)	6 (4.14)
Grazing Livestock	381 (73.27)	43 (8.27)	21 (4.04)	37 (7.12)	71 (13.65)	21 (4.04)
Granivore	17 (80.95)	2 (9.52)	3 (14.29)	1 (4.76)	4 (19.05)	1 (4.76)
Mixed Cropping	100 (76.34)	7 (5.34)	10 (7.63)	3 (2.29)	18 (13.74)	10 (7.63)
Mixed Livestock	101 (82.11)	4 (3.25)	3 (2.44)	5 (4.07)	15 (12.2)	1 (0.81)
Mixed Crops- livestock	267 (57.54)	83 (17.89)	28 (6.03)	34 (7.33)	123 (26.51)	32 (6.9)
Not classifiable	18 (56.58)	5 (15.63)	3 (9.38)	8 (25)	6 (18.75)	0 (0)

Intention about the innovation adoption of the different innovation types is heterogeneous across farm specialisations. In fact farms specialised in field crops, mixed crops livestock, horticulture and permanent crops state higher intention to adopt robotisation or precision farming with respect the other specialisations. Such new technologies are referred to precision farming in the field crops, mixed crops, livestock and permanent crops, while the robotisation of the process is mainly relevant for horticulture (especially in the greenhouse). The adoption of new irrigation systems is higher for farms specialised in horticulture and permanent crops. The adoption of e-commerce is quite homogeneously distributed across the different farm specialisations and the percentage of adopters is generally low for all specialisations. The percentage of farmers that state an intention to adopt energy production/energy crops innovation is higher compared to other innovation types. In particular the stated adoptions are very high (more than 20% of the farmers) for specialisations in field crops, horticulture and mixed crop livestock specialisation. In addition high value of intention to adopt such innovation is stated also for farmers specialised in permanent crops, and granivore. Altogether specialised farms in mixed cropping and mixed livestock have very low percentage of adoptions for all innovation types considered. This means that otherwise the farm with strong specialisation have higher percentage of adoption across the innovations.

In Table 38 the number of the adopters for each innovation type and the related percentages are presented for different classes of UAA.

Table 38 – Stated intention concerning the adoption of innovation per each UAA class (number and % of adoption with respect the active farmers).

Usable agricultural Area	No innovation adoption	Innovation typology				
		Robotisation/ precision farming	New irrigation systems	Robotisation/ precision farming	Energy crops/energy production.	Robotisation/ precision farming
UAA <5	189 (79.41)	14 (5.88)	23 (9.66)	7 (2.94)	15 (6.3)	5 (2.1)
UAA 5- <20	452 (74.83)	32 (5.3)	53 (8.77)	23 (3.81)	82 (13.58)	20 (3.31)
UAA 20- <50	280 (68.97)	33 (8.13)	40 (9.85)	26 (6.4)	67 (16.5)	14 (3.45)
UAA 50- <100	161 (57.09)	39 (13.83)	23 (8.16)	34 (12.06)	66 (23.4)	15 (5.32)
UAA > 100	161 (34.24)	146 (31.06)	56 (11.91)	76 (16.17)	212 (45.11)	30 (6.38)

Percentages of farmers that state an intention to adopt the new types of innovation are strongly differentiated across UAA category. In particular the two larger category of UAA (UAA 50-<100 and UAA>100) have very high percentage of adoption of innovation in particular concerning the robotisation/precision farming, e-commerce and energy crops/energy production. The other three innovation types considered have roughly the same percentage for all classes of farm size considered. This reveals a better attitude to innovate for the largest farms, with respect to innovation that requires high investment costs (e.g. robotisation/precision farming) or more managerial/commercial skills (e.g. e-commerce).

In Table 39 the number of the adopters for each innovation type and the related percentage are presented for different classes of on-farm household labour.

Table 39 – Stated intention concerning the adoption of innovation per each category of Full Time Employes of on-farm household labour used (number and % of adoption with respect the active farmers).

Household labour (fte)	No innovation adoption	Innovation typology				
		Robotisation/ precision farming	New irrigation systems	e-commerce	Energy crops/energy production.	Ot innoy
HH lab <5	33 (55.00)	15 (25)	5 (8.33)	2 (3.33)	14 (23.33)	(3.
HH lab= .5	114 (69.00)	13 (7.88)	23 (13.94)	8 (4.85)	25 (15.15)	(2.

HH lab t = 1	305 (51.00)	107 (17.89)	72 (12.04)	75 (12.54)	179 (29.93)	25 (4.18)
HH lab = 1.5	232 (66.67)	43 (12.36)	20 (5.75)	30 (8.62)	66 (18.97)	15 (4.31)
HH lab = 2	285 (64.92)	43 (9.79)	45 (10.25)	30 (6.83)	98 (22.32)	14 (3.19)
HH lab >= 2.5	274 (70.26)	43 (11.03)	30 (7.69)	21 (5.38)	60 (15.38)	24 (6.15)

Intention to adopt the selected types of innovation change weakly with different category of on-farm household labour. In fact there are no strong difference among the different classes of labour considered. Only farms that allocated on-farm less than units 0,5 of household labour on farm (that means that the owner have only direction and management function) have higher percentage of adoption in robotisation /precision farming (25%) and energy crops/energy production (23.33%).

In Table 40 the number of the adopters for each innovation type and the related percentage are presented for each legal status considered.

Table 40 – Stated intention concerning the adoption of innovation per each legal status considered (number and % of adoption with respect the active farmers).

legal status considered	No innovation adoption	Innovation typology				
		Robotisation/ precision farming	New irrigation systems	e-commerce	Energy crops/energy production.	Other innovation
Sole proprietorship	988 (68.85)	132 (9.2)	134 (9.34)	83 (5.78)	245 (17.07)	55 (3.83)
Partnership	229 (50.00)	97 (21.18)	43 (9.39)	65 (14.19)	143 (31.22)	22 (4.8)
Limited liability companies	15 (20.55)	27 (36.99)	14 (19.18)	13 (17.81)	38 (52.05)	6 (8.22)
Others	4 (17.39)	7 (30.43)	4 (17.39)	4 (17.39)	14 (60.87)	1 (4.35)

Innovation adoptions are affected by several legal statuses. In fact with partnership or limited liability companies the percentage of stated adoption increase for all types. Such percentage is higher for limited liability companies with percentage of adoption about 37% for robotisation/precision farming and 52% for energy crops/energy productions

4.2.2 Policy change impact on the adoption of innovation

Table 41, Table 42, Table 43, Table 44 and Table 45 present the effects of the two policy scenarios (BASELINE and NO-CAP) on the stated intentions concerning the

intention to adopt the selected innovations. In this section a table for each one of the 5 selected innovations is shown.

Table 41 – Stated intention concerning the adoption of robotisation/precision farming under different policy scenarios (number and % of adoption with respect the active farmers).

		NO CAP				
		No adoption	Adoption	do not know/no answer	exit	total
BASELINE	No adoption	1,125	10	68	533	1,736
	Adoption	63	121	9	71	264
	Total	1,188	131	77	604	2,000

CAP abolishment has the effect to reduce by more than the 50% the intention concerning the adoption of robotisation/precision farming innovations. In fact only 121 of the 264 farmers initially willing to innovate maintain such intention also without the CAP. Among the others, 71 farmers, states an intention to exit from agricultural activity and so will not adopt any innovations and 63 farmers change intention with respect to such innovations. The adoption of this innovation is hence very affected by the hypothesis of CAP abolishment after 2013.

A few farmers (10) state the intention to react to the CAP abolishment with an increase of adoption with respect to the baseline conditions.

Table 42 – Stated intention concerning the adoption of new irrigation systems under different policy scenarios (number and % of adoption with respect the active farmers).

		NO CAP				
		No adoption	Adoption	do not know/no answer	exit	total
BASELINE	No adoption	1,179	7	88	531	1,805
	Adoption	39	79	4	73	195
	Total	1,218	86	92	604	2,000

CAP abolishment has the effect to reduce by more than 60% intentions to adopt new irrigation systems. In fact there are only 79 famers out of 195 that do not change stated intention concerning the adoption of such innovation. As shown in the case of robotisation/precision farming the reduction is mainly connected with the exit, but a relevant part of farmers state an intention to reduce the innovation

consequently to the hypothesised removal of the CAP. The table shows a few farmers (7) that states to react to CAP abolishment with an increasing of adoptions with respect the baseline condition.

Table 43 – Stated intention concerning the adoption of e-commerce under different policy scenarios (number and % of adoption with respect the active farmers).

		NO CAP				
		No adoption	Adoption	do not know/no answer	exit	total
BASELINE	No adoption	1,170	34	62	568	1,834
	Adoption	15	111	4	36	166
	Total	1,185	145	66	604	2,000

Stated intentions concerning e-commerce are less affected by CAP abolishment with respect the other innovation types. Stated intentions concerning the adoption of this innovation type are maintained for 70% of the adopters in baseline conditions (111). The table shows that a relevant share of farmers (34) states to react to CAP abolishment with an increasing of adoptions in e-commerce with respect the baseline condition.

Table 44 – Stated intention concerning the adoption of energy crops/energy production on farm under different policy scenarios (number and % of adoption with respect the active farmers).

		NO CAP				
		No adoption	Adoption	do not know/no answer	exit	total
BASELINE	No adoption	984	34	70	470	1,558
	Adoption	54	240	14	134	442
	Total	1,038	274	84	604	2,000

CAP abolishment has the effect to reduce about 45% of the intention to adopt new irrigation systems. In fact there are 240 famers over 442 that do not change their intention concerning the adoption of such innovation. As shown in the previous tables the reduction is mainly connected with the exit, but a relevant part of farmers states an intention to reduce the innovation consequently to CAP removing (13%). The table shows that various farmers (34) states to react to CAP abolishment with an increasing of adoptions of this innovation type with respect the baseline condition. However, taking into account the number of adoption in the baseline scenario, this reaction is less relevant compared to the case of e-commerce.

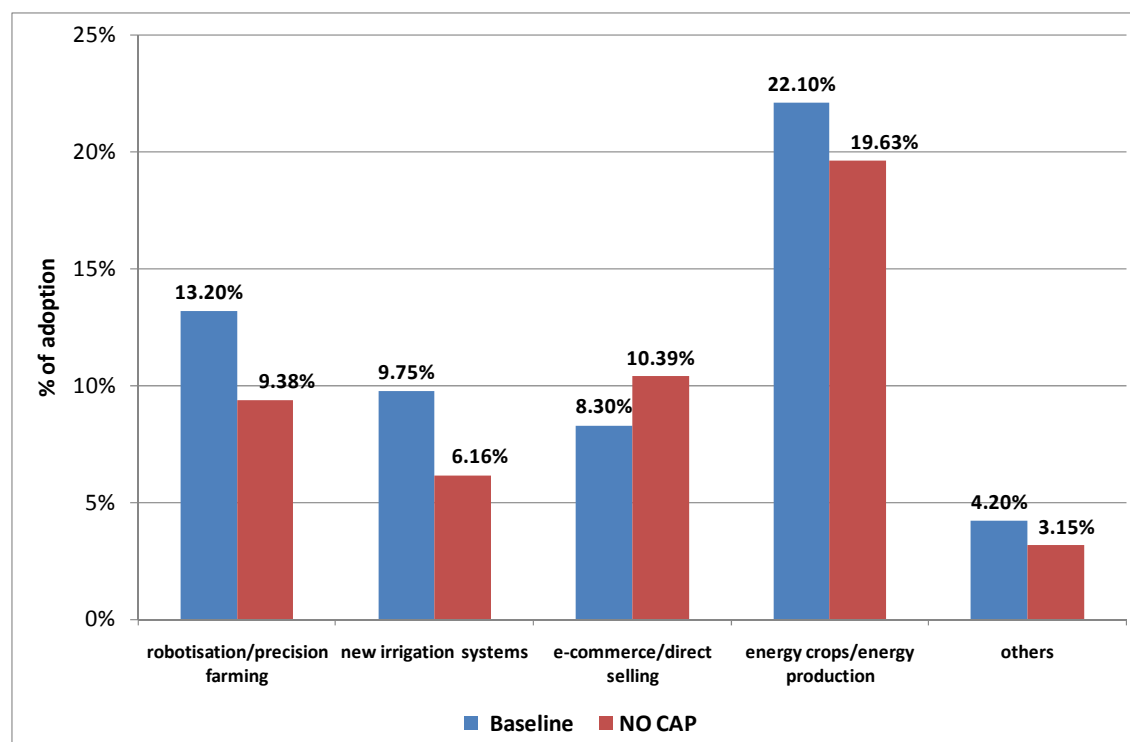
Table 45 – Stated intention concerning the adoption of other innovations under different policy scenarios (number and % of adoption with respect the active farmers).

		NO CAP				
		No adoption	Adoption	do not know/no answer	exit	total
BASELINE	No adoption	1,205	16	132	563	1,916
	Adoption	8	28	7	41	84
	Total	1,213	44	139	604	2,000

CAP abolishment has the effect to reduce by about 67% the number of positive intentions concerning the adoption of new irrigation systems. In fact there are only 28 farmers over 84 that do not change stated intentions concerning the adoption of other innovations. As shown in previous tables the reductions are mainly connected with the exit.

Altogether CAP abolishment affect significant the intention to adoption of new technology. In Figure 1 the effect of policy scenario on innovation adoption is presented.

Figure 1 CAP effects on the stated intention concerning the adoption of new technology (% of adoptions^A).



A: Percentages are calculated over the total of farmers that remain active (excluding exit).

The figure shows that only innovation in commercialisation innovation (e-commerce, direct selling etc) farmers state an increasing of the intention to adopt without CAP. As shown previously such percentages are consequence of low number of exit for those farmers that stated an intention to adopt such innovation with CAP abolishment. Differently for all other selected innovations CAP abolishment has the effect to reduce the stated adoptions. Such reduction is about the -29% for the robotisation/precision farming (-3.82%/13.20%); - 37% for new irrigation systems; - 11% for energy crops/energy productions and finally -25% for other innovations.

4.3 Analysis of the determinant of different innovation intensity under CAP changes scenarios

In literature several models were implemented in order to explain the innovation adoptions determinants. Some models represented innovation adoption as a binary choice (yes/no) or as a multiple choice when innovations adoptions are alternatives. An option to analysed innovation adoption when are characterised by multiple choice of innovation is adopt two or more stage process. These models are more coherent with the literature that indentify in some factors connected to the farm structure, social capital, age and access to credit the decision to be eligible for an innovation. On the contrary, the determinants of adoption of a specific innovation or the intensity of different innovation could be different from the previous ones and more connected with the farming systems, the payments received, the farm strategy and the innovations already implemented on the farm. The literature on the mechanism of innovation adoption has emphasised the positive effect of SFP and Rural Development Payments in the adoption of new technologies. The expected process of CAP reform after 2013, indeed, will affect the adoption of the new technology and the process of modernisation of the farms.

The CAP abolishment effects on the innovation intensity were identified comparing two separated models, in each of which the determinants of innovation intensity are estimated. Two separate Count Models are developed in order to explain the stated intention concerning different intensity of innovation adoption under two different policy scenarios. The two models considered are realised in the case of baseline condition (first model) and under NO CAP (second model). Such two policy scenario are referred to current (year 2009) CAP framework, that includes the actual level of payments plus the already planned measures such as milk quota abolition at year 2015, and the scenario assuming a complete abolition of all CAP instruments.

In either model the intensity of innovation is obtained summing for each farm the number of stated intentions about the adoptions of all innovation typologies. These innovations are: 1) mechanical innovation (milking robotisation or no-tillage practices), 2) new-irrigation technology, 3) production of energy on farm (by solar, methane digester or with new crops), 4) e-commerce and commercialisation/direct sell and 5) other that means an additional open category with other innovation types.

Under such framework the dependent variable (innovation intensity) is expressed as count data with a value between 0 (no intention to adopt any of the suggested innovations) to 5 (stated intention concerning the adoption of all suggested innovations). In Table 46 the value for all modalities of the innovation intensity is presented for either Baseline or NO-CAP scenario.

Table 46 – Innovation intensity (number and % of adoption with respect the active farmers).

Number of innovation adopted	BASELINE	NO –CAP scenario
0	1243 (62.15)	972 (68.84)
1	497 (24.85)	274 (19.40)
2	155 (7.75)	106 (7.51)
3	78 (3.9)	45 (3.19)
4	25 (1.25)	12 (0.85)
5	2 (0.1)	3 (0.21)

The model considered has been used to combined a categorical data (adoption or not of any innovation) with the count data (number of innovations adopted) that allows to consider the number of innovation as a proxy of innovation adoption intensity. The zero inflated negative binomial model developed by Lambert (1992), merges an estimation of the probability to have zero innovation (using logit model) with the probability to have increasing the innovation intensity (negative binomial model).

Two separate negative binomial models³(model 1 for baseline; model 2 for NO-CAP scenario) are developed. The dependent variables are shown in the In Table 46 and the explanatory variables considered for both models are presented in Table 47.

Table 47 – Innovation intensity explanatory variables.

Category	Variable (Description)	Variable (Code)	Obs	Mean	Std. Dev	Min	Max
CSA	Centre CSA (dummy)	centre	2363	0.30	0.46	0	1
	Eastern CSA (dummy)	eastern	2363	0.22	0.41	0	1
	Mediterranean CSA (dummy)	med	2363	0.40	0.49	0	1
	North CSA (dummy)	north	2363	0.07	0.26	0	1
Geographical	Plain (dummy)	plain_d	2358	0.57	0.50	0	1
	Hill (dummy)	hill_d	2358	0.34	0.47	0	1

³ Negative binomial model adopted (with respect the Poisson model NBM takes into account a high heterogeneity among the observations). The heterogeneity has been tested with LR test of $\alpha=0$ that has results the significantly of the α different from zero and has reinforced the validity of NBM against Poisson model. As well a Young Test has been performed in order to compare zero-inflated negative binomial model versus negative binomial model, and results have not rejected a better performing of the of the zero-inflated model against NBM.

	Mountain (dummy)	mountain_d	2358	0.09	0.28	0	1
Household characteristics	Household members younger than 18 years old (dummy)	house18_d	2363	0.41	0.49	0	1
	Unemployed (# in the Household)	unemp_c	2336	0.21	0.58	0	3
	Farm income from agricultural activity > 50% of total household (dummy)	f_inco_more50	2363	0.65	0.48	0	1
Farmer characteristics	Age of respondent (Ln of age_y)	lnage_y	2334	3.85	0.29	2.89	4.44
	Educational level lower than secondary school (dummy)	edu_level_low	2363	0.14	0.34	0	1
	Educational level higher than degree (dummy)	edu_level_high	2363	0.51	0.50	0	1
Policy	Current SFP received (1000€)	pay_sfp_1000e	2363	18.32	52.54	0	1200
Commercial/Relational characteristics	Regular activity of advisory (dummy)	advisory_d	2363	0.56	0.50	0	1
	Other activity on farm different from crop cultivation and animal rearing	ah_activty_other	2363	0.19	0.39	0	1
	sell to contract (dummy)	sell_contrac_d	2363	0.25	0.43	0	1
	sell to cooperative (dummy)	sell_coop_d	2363	0.40	0.49	0	1
	sell to processor (dummy)	sell_process_d	2363	0.23	0.43	0	1
Farm Structure	external labour used on farm (# of Full time equivalents)	fulltime_equ	2363	1.48	4.93	0	104
	Part-time farming (hh labour less than .5) (dummy).	hh_partime	2363	0.13	0.33	0	1
	Land-in relative (dummy)	land_in_relatives	2363	0.16	0.37	0	
	land rented-out (dummy)	land_out	2363	0.12	0.32	0	1
	UAA (ha)	UAA_ha	2363	95.71	281.24	0	7500
	UAA less than 10 ha (dummy)	UAA_less10	2363	0.27	0.44	0	1
	UAA greater than 50 ha (dummy)	UAA_more50	2363	0.09	0.28	0	1
	Livestock intensity cows (number)	cows	2363	25.89	79.63	0	1600
	Farm type field crop (dummy)	field_crops	2363	0.27	0.44	0	1
	Farm type horticultural (dummy)	horticulture					
	Farm type grazing livestock (dummy)	grazing_livestock	2363	0.27	0.44	0	1
	Farm type mixed crop livestock (dummy)	mixed_crop_livestock	2363	0.21	0.41	0	1
Farm type mixed livestock (dummy)	mixed_livestock	2363	0.06	0.23	0	1	

The dependent variables differ among the models, though the set of independent variables is mostly the same. Independent⁴ variables can be classified as belonging to the following categories: CSA, geographical area, household characteristics, farmer characteristics, policy, commercial and relational and farm structure.

In all models the CSAs have been grouped in different areas, which are presented as four dummies (North CSA; Mediterranean CSA; Eastern CSA and Centre CSA).

⁴ The independent variables used in both models were selected coherently with the literature on determinants of farm expansion and the final model was, for each scenario, the one with lower BIC value (Bayesian Information Criterion).

In all models, geographical variables are represented by altitude, which is presented as three dummy variables (plain, hill and mountain).

Household variables are mainly related to the household long term unemployed (`unemp_c`) and the weight of farm income with respect to the total household income (`f_inco_more50`) and the presence/absence of household members younger than 18 (`house18_d`).

Farmer characteristics included are the age of the farm owner (`lnage_y`;) and two variables that describe the education level (`edu_level_low`; `edu_level_high`) were included representing the educational level (respectively upper than the university degree and lower than secondary school).

Commercialisation and relational characteristics are referred to presence/absence of the technical advice received by the farmer (`advisory_d`), the typology of collocation on the market of the farm productions: presence or absence of contracts for selling the production (`sell_contrac_d`); presence or absence of vertical relationship with cooperatives (`sell_coop_d`) or processors (`sell_process_d`). Finally in this category a dummy variable with the identification of other on-farm activity different to crops growing and animal reared is considered (`ah_activty_other`).

In both models the farm characteristic variables are related to farming specialisation and the current farm size, regarding operated land area, the land rent-in and the number of dairy cows reared, and the amount of labour needed. Finally the amount of SFP received were included into the policy category.

Table 48 – Results of the zero inflated negative binomial models (not significant variables omitted).

Variable (Code)	Parameter estimated under	Parameter estimated under NO
	Baseline (Model 1)	CAP scenario (Model 2)
Plain	0.5779	
Hill	0.3886	
full_time_equ	0.0155	0.0123
UAA_less10	-0.5189	-0.3623
UAA_more50	0.6068	
UAA_ha		0.0005
cows	-0.0011	
grazing_livestock	-0.3594	-0.7054
mixed_crop_livestock		-0.2644
mixed_livestock		-0.6086
ln_age	-0.2910	-0.3525
unemp_c	0.1659	
pay_sfp_1000e	0.0019	
Med	0.3475	
North		0.3475
Eastern	-0.3292	-0.3932
edu_level_high	0.1472	
edu_level_low		
land_in_relative	0.2220	
f_inco_more50	-0.1776	-0.1970
hh_activity_d		0.2598
advisory_d		0.4335
Sell_contract		0.2894
Sell_coop		0.3355
ZERO INFLATED OUTCOME (factor change in Odds of always 0)		
hh_partitme	1.1417	1.2819
ln_age	6.0950	5.0125
edu_level_low		1.1857
ln_alpha	-2.5426	-1.3426
Observation	1944	1480
Non-zero observation	731	430

The coefficients are interpreted relative to observing a zero count (logit inflation model), thus the positive coefficient of the significant variables means that respondents are more likely to expect value of zero count (that means no innovation

adoption). Otherwise negative sign have opposite probability. This implies that for the first model (BASELINE condition) the part-time farming and the higher age of the owner have the effect to increase the probability to be excluded by the innovation process. In addition to these two variables, in the second model (NO-CAP scenario) the education level becomes significant. In fact the negative sign of high education level means that the farmers with high education level have low probability to not innovate on the future. The low education level (positive sign), have the opposite effect.

The coefficients of the count model (upper part of the table) represent the change in the expected count for those observations presented in the second regimes. This regime contains those farmers with intention to invest.

Concerning the first model (Baseline), variables with positive effect on the innovation intensity are connected with the structure and with the education. In fact the farm that have higher intention to innovation are those with higher use of land and labour factors. This is particularly relevant for those farms with an amount of UAA higher than 50 ha. Location and altitude are also relevant in the decisions: in fact farmers located in plain and in the hill have higher expected innovation intensity with respect to the farms located in the mountain. Farmers in the Mediterranean CSA have higher innovation intensity, due to the typology of innovation considered (eg. New irrigation technology adoption is higher in Mediterranean CSA). Variables that affect negatively the innovation intensity are the age, the higher weight of farm income in the household income and the specialisation in grazing-livestock. In particular the variable that have higher negative effect on the count of innovation intensity is the small land size (less than 10 ha). This means that the land size in both directions is one of main factors that explain a different behaviour connected with innovation intensity. Finally the amounts of CAP payments received have a positive effect on the innovation adoption. The amount of money received increases the count of innovation intensity about 0.0019 for each 1000 €.

Concerning the second model the variables that have positive effect on the count of innovation intensity are those connected with the farm structure highlighted in the previous model (both labour and land). In addition, removing the CAP, there are other variables that affect positively the innovation intensity. Such variables are connected with the factor to receive advice by the farmers, and the selling through contracts that ensure certainty stability of the income or through cooperative and finally the existence of differentiated sources of farm income coming from other on-farm activities different from crop growing and animal rearing. Differently to the first model, without the CAP some specialisations have a very strong negative effect on the innovation intensity. In particular such negative effects on innovation intensity are for mixed grazing-livestock, mixed crop livestock and finally for mixed livestock. In addition, variables that affect negatively the count value of innovation intensity are the same highlighted in the first model (baseline), such as increasing age and small farm size.

4.4 Assessment the impact of policy change on Innovation adoptions (sequence of innovations)

The objective of this chapter is to highlight the effect of adoption of past innovation to the future behaviours. Such analysis has been carried out with additional questions to the survey A. such additional questions has been asked only in the two French CSA due to the option to conduct a face-to-face interviews. Additional questions are shown in Annex 3.

In are presented the past innovation adopted respectively for the two different CSA; for the different class of UAA; for different farm specialisation and for different class of on-farm household labour.

Table 49 – Descriptive of the past innovation adopted in the last 10 years in both French CSA (number and % of adoption with respect the active farmers).

CSA	Farm systems	Mechanical	Biological	Agronomic	Chemical	Biotechnological	Marketing	Processing
Centre (France)	6 (4.29)	59 (42.14)	23 (16.43)	32 (22.86)	22 (15.71)	2 (1.43)	25 (17.86)	1 (0.71)
Midi-Pyrénées (France)	17 (10.97)	73 (47.10)	7 (4.52)	40 (25.81)	17 (10.97)	3 (1.94)	28 (18.06)	1 (0.63)
Total	23 (7.8)	132 (44.75)	30 (10.17)	72 (24.41)	39 (13.22)	5 (1.69)	53 (17.97)	1 (0.33)

Categories of innovation with higher percentage of adoption in both CSA are mechanical, agronomical and marketing; otherwise the categories of innovation with lower percentage of adopters are biotechnological and processing.

No one CSA has higher percentage of adoption among all categories, and with the exception of farm systems innovations, biological and chemical the two CSA have the same percentage of past adoptions.

Table 50 – Descriptive of the past innovation adopted in the last 10 years with respect several UAA categories (number and % of adoption with respect the active farmers).

Usable Agricultural Area Category	Farm systems	Mechanical	Biological	Agronomic	Chemical	Biotechnological	Marketing	Processing
UAA <5	0 (0)	2 (50.00)	0 (0)	1 (25)	0 (0)	0 (0)	1 (25)	0 (0)
UAA 5- <20	2 (33.33)	3 (50.00)	0 (0)	2 (33.33)	0 (0)	0 (0)	2 (33.33)	0 (0)
UAA 20- <50	1	8	0	2	0	1	4	0

	(5)	(40.00)	(0)	(10)	(0)	(5)	(20)	(0)
UAA 50- <100	3	31	7	13	6	0	12	1
	(3.9)	(40.26)	(9.09)	(16.88)	(7.79)	(0)	(15.58)	(1.3)
UAA > 100	17	88	23	54	33	4	34	2
	(9.04)	(46.81)	(12.23)	(28.72)	(17.55)	(2.13)	(18.09)	(1.06)

With exception of the first three UAA class that are composed only by few farmers (4 farmers in the lower UAA; 6 in the second and 20 in the third), innovation adopted increase significantly. The two biggest categories have higher percentage of adoptions with difference between plus 1% until plus 10% for the larger category of UAA size.

Table 51 – Descriptive of the past innovation adopted in the last 10 years with respect farm specialisations (number and % of adoption with respect the active farmers).

UAA class	Farm systems	Mechanica I	Biological	Agronomic	Chemical	Biotechnol ogical	Marketing	Processing
Field Crops	5 (5.81)	33 (38.37)	15 (17.44)	24 (27.91)	12 (13.95)	1 (1.16)	14 (16.28)	1 (1.16)
horticulture	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Permanent Crops	2 (20)	3 (30.00)	1 (10)	8 (80)	2 (20)	2 (20)	4 (40)	0 (0)
Grazing Livestock	7 (8.86)	41 (48.10)	5 (6.33)	16 (20.25)	9 (11.39)	0 (0)	12 (15.19)	1 (1.27)
Granivore	1 (16.67)	3 (50.00)	0 (0)	2 (33.33)	1 (16.67)	0 (0)	1 (16.67)	0 (0)
Mixed Cropping	1 (16.67)	4 (66.67)	1 (16.67)	2 (33.33)	0 (0)	0 (0)	1 (16.67)	1 (16.67)
Mixed Livestock	0 (0)	46 (48.94)	0 (0)	0 (0)	0 (0)	0 (0)	1 (7.14)	0 (0)
Mixed Crops-livestock	7 (7.45)	132 (44.75)	8 (8.51)	20 (21.28)	15 (15.96)	2 (2.13)	20 (21.28)	1 (1.06)

Innovations adopted in the last 10 years are quite homogenous across farm specialisations. These results are also due to the lower frequencies of some specialisation on the sample (e.g. permanent crops, granivore, mixed cropping and mixed livestock.) For the other farm Specialisation there is an high frequency of mechanical and agronomic innovation that are mainly due to the development of the mechanics industries, with for example no tillage techniques or a mechanisation of some livestock process for the first category and for the second, the change in crop rotation, new crops and new seeds. Only for mixed-crop livestock there are higher percentage for marketing innovation that are represented mainly by direct sale or sale on-farm.

Table 52 – Descriptive of the past innovation adopted in the last 10 years with respect land use category(number and % of adoption with respect the active farmers).

Household labour (fte)	Farm systems	Mechanical	Biological	Agronomic	Chemical	Biotechnological	Marketing	Processing
	0	1	0	1	1	0	1	0
HH lab <5	(0)	(100)	(0)	(100)	(100)	(0)	(100)	(0)
HH lab= .5	0	4	1	1	0	0	0	0
	(0)	(33.33)	(8.33)	(8.33)	(0)	(0)	(0)	(0)
HH lab t = 1	9	74	17	39	23	2	29	2
	(5.33)	(43.79)	(10.06)	(23.08)	(13.61)	(1.18)	(17.16)	(1.18)
HH lab = 1.5	4	19	4	11	7	1	2	0
	(11.43)	(54.29)	(11.43)	(31.43)	(20)	(2.86)	(5.71)	(0)
HH lab = 2	9	21	5	15	6	1	16	2
	(17.65)	(41.18)	(9.8)	(29.41)	(11.76)	(1.96)	(31.37)	(3.92)
HH lab => 2.5	1	13	3	5	2	1	5	0
	(3.7)	(48.15)	(11.11)	(18.52)	(7.41)	(3.7)	(18.52)	(0)

Percentage of past adoptions is affected by the amount of on-farm household labour used. In fact higher percentage of past adoption has been observed for the farms that use on-farm more than 1.5 full time equivalents of household labour. For these farms there is higher percentage of mechanical, agronomical and chemical innovations. Increasing the amount of on-farm household labour used is possible to observe that are more likely to observe marketing innovation adopted. In fact with household on-farm labour higher than 2 FTE such innovation has higher percentage than agronomical and chemical.

After shown the statistical descriptive of the additional question has been grouped the farmers based on past innovation attitude (number of innovation adopted and timing of adoption) and the age of the owner (young or old). Such operation has been realised through k-means cluster analysis.

In Table 53 is presented the frequencies and the main descriptive of the clusters.

Table 53 – Descriptive of the cluster identified (number and % of adoption with respect the active farmers).

Cluster	Cluster description	Farmers (#)	Age(average)	Innovation adopted (#)	Innovation adopted last 5 years (#)	Innovation adopted last 3 years (#)
CL1	Laggards and young	77	26.55	0.86	0.84	0.81
CL2	Innovators and young	31	27.55	2.16	1.96	0.71
CL3	Innovators	39	49.12	2.33	0.71	0.38

	and old					
CL4	Laggards and old	64	55.54	0.67	0.54	0.34
CL5	Late majority	82	41.39	1.06	0.78	0.59

Five clusters have been identified. Such clusters represent different attitude with respect the innovation timing. First cluster “CL1” is composed by homogenous farmers that have an attitude to adopt with some lag the innovations or even no adopt. In fact the number of innovation adopted in past is low: 0.86 per farm. In addition such cluster is characterised by a young farmers (average of 26.55). Cluster 2 “CL2” is composed by low frequency with respect the previous cluster and is composed by young farmers (average of 27.55) but differently than the previously by innovators. In fact the amount of innovation adopted is higher than the previous cluster: 2.16 innovations per farm.

The cluster 3 and cluster 4 are composed by mostly less young farmers: in fact the age average is respectively about 49.12 for the cluster 3 and 55.54 for the cluster 4. The main difference about the two clusters is the number of the past innovation adopted: where the cluster 3 is mostly composed by innovators (average innovation per farm equal to 2.33) and differently the cluster 4 is composed by laggards or no innovators (0.67 innovation adopted in the years).

Finally cluster 5 contains a group of farmer with an age between young and old (average of 41.39) and a late majority attitude with respect the adoption of innovations.

In Table 54 the stated intention about continuing farm activity or exit is presented.

Table 54 –Stated intentions in continue farm activity (number and % of adoption with respect the active farmers).

Cluster	Continuing farm activity (Baseline)	Exit from farm activity (Baseline)	Continuing farm activity (No CAP)	Exit from farm activity (No CAP)
CL1	60 (77.92)	7 (9.09)	37 (48.05)	21 (27.27)
CL2	25 (80.65)	1 (3.23)	17 (54.84)	8 (25.81)
CL3	25 (64.10)	6 (15.38)	16 (41.03)	12 (30.77)
CL4	35 (54.92)	20 (31.25)	17 (26.56)	30 (46.88)
CL5	61 (75.61)	11 (15.36)	35 (42.68)	29 (35.37)

Grouping based on innovation adoption attitude affects the stated intention concerning the exits and the continuing the farm activity. In fact investment attitude implies different stated behaviours connected with the continuing farm activity strategy. In fact comparing cluster 1 against cluster 2 and cluster 3 against cluster 4 (which are homogenous concerning the age category) the exit are higher in those laggards clusters (cluster 1 and cluster 4). The behaviour is more differentiated between innovators and laggards under NO-CAP scenario. In fact, with the CAP abolishment the difference of the percentages of continuing between laggards and innovators is bigger than with current CAP. In fact for the young farmers (CL1 and CL2) the intention to continue comparing baseline versus NO-CAP scenario is reduced about the 30 % for laggards farm (from 77 % to 48%) and about the 25% for innovators (from 80% to 55%). The differences behaviours with respect the intention to continuing the farm activity are bigger for old farms (CL3 and CL4). In fact the innovators have a reduction of 23 % (from 64% to 41%) and the laggard a reduction of 29% (from 55 to 26%).

In Table 55 the expected adoptions of new technology under baseline are shown.

Table 55 –Stated intentions concerning the future innovation adoption under baseline (number and % of adoption with respect the active farmers).

Cluster	No adoption	Robotisation/precision farming	New irrigation systems	e-commerce	Energy crops/energy production	Other innovation
	21	34	9	20	27	8
CL1	(30.00)	(48.57)	(12.86)	(28.57)	(38.57)	(11.43)
CL2	6	17	0	6	14	4
	(20.00)	(56.67)	(0)	(20.00)	(46.67)	(13.33)
CL3	12	10	4	6	11	4
	(36.36)	(30.30)	(12.12)	(18.18)	(33.33)	(12.12)
CL4	20	10	4	5	14	3
	(45.45)	(22.45)	(9.09)	(11.36)	(31.82)	(6.82)
CL5	19	22	9	14	29	15
	(26.76)	(30.99)	(12.68)	(19.72)	(40.85)	(21.13)

Future new technology adoptions are connected with the innovation attitude obtained by the past behaviours. This sentence could be observed comparing the percentage of no adoption among the different cluster. In fact, innovators farmer have lower percentage of no adoption: respectively about 10 % less for young farmers (difference between CL2 and CL3) and 8% less for old farmers (difference between CL3 and CL4).

The future adoption of the different innovation typology is quite heterogeneous across the five clusters. Among the future adoption the

robotisation/precision farming technology and the e-commerce and direct selling have percentages of stated intentions about the adoption differentiated between innovators and laggards (about 8-9% in favour to innovator farms for both innovations). These innovations, in fact, require a sequence of innovation before and high know how. Other innovations, which do not require a specific know how, or a sequences of innovation do not shows significant difference in percentage between innovators and laggards.

In Table 56 the expected adoptions of new technology with CAP abolishment are shown.

Table 56 –Stated intentions concerning the future innovation adoption under NO-CAP scenario (number and % of adoption with respect the active farmers).

Cluster	No adoption	Robotisation/precision farming	New irrigation systems	e-commerce	Energy crops/energy production	Other innovation
CL1	21 (37.50)	16 (28.57)	7 (15.50)	18 (32.14)	19 (33.93)	4 (7.14)
CL2	9 (39.13)	8 (34.78)	0 (0)	6 (26.09)	8 (34.78)	2 (8.70)
CL3	10 (37.04)	7 (25.93)	2 (7.41)	6 (22.22)	7 (25.93)	6 (22.22)
CL4	18 (52.94)	5 (14.17)	0 (0)	6 (17.65)	9 (26.47)	3 (8.82)
CL5	17 (32.08)	11 (20.75)	6 (11.32)	13 (25.39)	22 (41.51)	10 (18.87)

CAP abolishment reduces the technology adoption in all clusters. Such reductions are however quite differentiated across the 5 clusters. In particular the CAP abolishment reduces the adoption for the laggards farmers characterised in addition by an old age. Innovators have different behaviour as consequences of different age of the farmers. In fact, old farmers and laggards have higher percentage of no adoptions (+15% of no adoption for laggards), while young farmers reduce more the percentage of adoption for the innovators farmers.

4.5 Assessment of the impact of policy change on the innovation adoption mechanism

The objective of the section is to provide an ex-ante analysis of the effectiveness of alternative policy design options concerning the RDP measures intended to provide incentives for investment/innovation adoption in five case study areas across Europe under uncertainty in the future of the current CAP main subsidy, the Single Farm Payment (SFP) in the EU old member states and the Single Area Payment (SAP) in the EU new member states, after 2013.

The case study areas considered are Emilia Romagna Region (Italy), Noord-Holland (the Netherlands); Podlaskie (Poland); South-East Planning (Bulgaria); Midi-Pyrénées (France).

The section is structured as follows. In the next section we describe the theoretical model; in the following section we describe the methodology used and then the case studies to which the empirical methodology is applied. This is followed by a result and a discussion sections.

We address the decision to adopt an innovation using the Real Options (RO) approach. Such a model typology is able to describe in a better way than capital budgeting tools the investment choice when the decision to adopt an innovation is affected by irreversibility and uncertainty (Dixit and Pindyck, 1994; Schwartz and Trigeorgis, 2004). In fact, with the RO approach it is possible to consider in the investment choice the increase of its value as a result of the greater information obtained by the decision maker over time, concerning future decision variables (McDonald and Siegel, 1986). Such an increase is the result of the option to delay investment decisions until further information about the state of nature (as well as market and other prices) has been collected (Trigeorgis, 1988).

Several authors have developed methodologies based on the RO approach in order to simulate the decision to invest in specific new technologies. Some examples in agriculture are Stokes et al. (2008) and Bartolini et al. (2010) for an application to methane digester systems adoption, Engel and Hyde (2003) and Sauer and Zilberman (2010) for an application to the adoption of automatic milking system (AMS), Tozer and Stokes (2009) for an application to a new livestock management system and Kurkalova et al. (2006) for the adoption of different tillage systems.

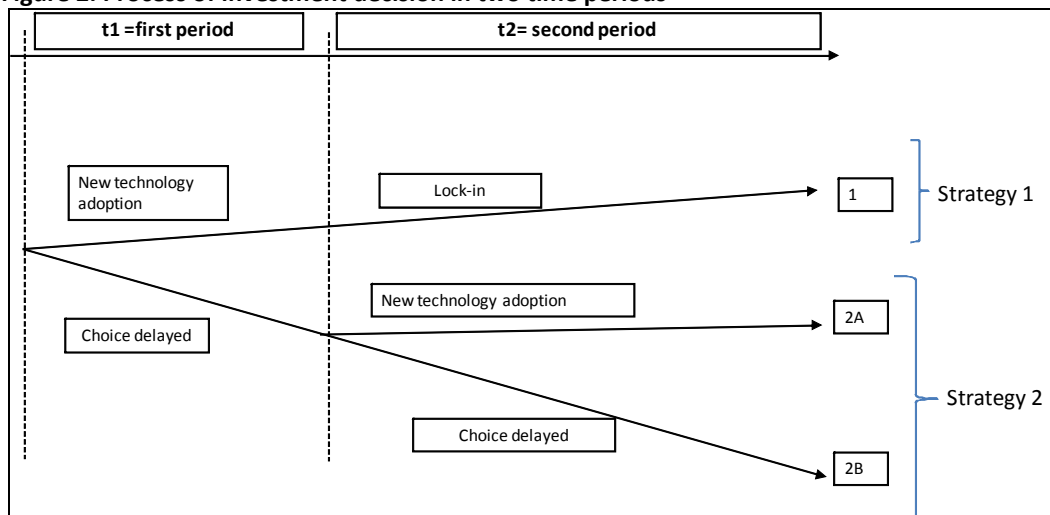
Under conditions of uncertainty and investment irreversibility, the RO approach enables the quantification of the Net Present Value (NPV) increment due to the option to delay the investment until a following period, when the farmer will have access to more information about the exogenous uncertain variables determining investment profitability (Sauer and Zilberman, 2010).

New investment can imply high costs, changes in related farming activities and more complex production management compared to previous farm conditions. In fact, adoption of a new technology implies a reorganisation of the entire farm production

system. Therefore, in order to study the investment it is necessary to take into account not only the production operation of a farm, but also the household decisions, given that both play a key role in investment decisions. The decision to invest is also strongly influenced by the uncertainty about many of the decision variables, given the uncertain outcomes. Such variables can be classified with those connected to the farm structure such as household labour availability on-farm, and those connected to market conditions such as shadow prices of household labour allocated off-farm, the prices of the agricultural outputs, and the cost of the hired labour. Furthermore, they can be associated with variables related to the investment financial management rate of the loan, loan accessibility, and the amount and certainty of obtaining SFP/SAP and RDP payments.

This approach is presented in figure 1, with an example in which the choice to invest can be undertaken during two distinct periods.

Figure 2. Process of investment decision in two time periods



For example, assuming that a decision to adopt an innovation can be undertaken in two separate periods (t_1 and t_2), the decision process can be interpreted as a discrete choice, which the farmer can carry out in either the first (strategy 1) or the second period (strategy 2). The decision to invest during the first period locks-in the farm with the investment during the second period (strategy 1). Lock-in is determined by high investment and sunk costs and by the irreversibility of the investment (Carruth et al., 2000). However, the farmer can also delay the investment until he/she obtains more information about the uncertain decision variables, and will then choose to invest or not during the second period. The delay allows the farmer to observe the value of such variables (which were assumed to be stochastic in the first period) and, if such variables are favourable to the adoption of the considered innovation, then the farmer will undertake the investment in period t_2 .

(strategy 2A). Otherwise, if the value of the uncertain variables is not favourable to the profitability of the innovation investment, then the farmer will neither choose to invest in the second period (strategy 2B).

The optimal strategy will be the one that determines a higher net present value (NPV) of the cash flow over both periods: $NPV = \max(NPV_1, NPV_2)$; where NPV_1 , referring to figure 1, is the net present value of the cash flow in strategy1 and NPV_2 is the net present value of the cash flow in strategy2. Expressions of NPV_1 and NPV_2 are given in equations 1 and 2.

$$NPV_1 = -k + \sum_0^{t1} \frac{cf_{inn}^{t1}}{(1+i)^t} + \sum_{t1+1}^{t2} \frac{\gamma \overline{cf_{inn}^{t2}} + (1-\gamma) \underline{cf_{inn}^{t2}}}{(1+i)^{t1+t}} \quad (1)$$

$$NPV_2 = \sum_0^{t1} \frac{cf^{t1}}{(1+i)^t} + \left(\gamma \left(\frac{-k}{(1+i)^{t1+t}} + \sum_{t1+1}^{t2} \frac{\overline{cf_{inn}^{t2}}}{(1+i)^{t1+t}} \right) + (1-\gamma) \sum_{t1+1}^{t2} \frac{\underline{cf_{inn}^{t2}}}{(1+i)^{t1+t}} \right) \quad (2)$$

Where:

cf^t = cash flows of a generic year t , with $t = t1$ if years belong to the first period and $t = t2$ if years belong to the second period;

k = cost of investments;

i = discount rate;

γ = probability of having a state of the nature favourable to innovation adoption;

$\overline{cf_{inn}^{t2}}, \underline{cf_{inn}^{t2}}$ = cash flow of a generic year t when $t = t2$ and stochastic variable values are favourable to innovation adoption;

$\overline{cf_{inn}^{t2}}, \underline{cf_{inn}^{t2}}$ = cash flow of a generic year t when $t = t2$ and stochastic variable values are unfavourable to innovation adoption;

inn = subscript, means new technology adoption.

The innovation adoption is subject to uncertainty in the second period. This assumption implies stochastic cash flow values during this period. Following Dixit and Pindyck (1994) we assumed that the annual cash flows follow a Brownian Motion with drift, so that $dcf^t = \mu c f^t dt + \sigma c f^t dz$, where dcf^t is the instantaneous value of the cash flow; $\mu^t c f^t dt$ is the expected cash flow value; μ is drift (percentage); σ is the volatility (percentage); and dz is a Wiener process with a mean of zero and independent increments.

Under such an approach, it is possible to differentiate two values of cash flows: one favourable to the new technology investment ($\overline{cf^t}$), and the other unfavourable ($\underline{cf^t}$). These two values are generated assuming that the random variable generated

from the Wiener process can have positive or negative values in order to allow for adding or removing the same amount from the expected value at any time in the period t_2 . This approach enables to maintain a constant expected value, and to change only the amount of uncertainty in the second period.

4.5.1 Empirical analysis

The empirical analysis has followed three steps:

- 1) Identification of relevant innovation and the representative farm;
- 2) Building of the household model;
- 3) Modelling uncertainty in exogenous variables.

4.5.1.1 Identification of relevant innovation and the representative farm

The simulation of the innovation adoption model has been tested to different representative farm households in each of the five case study areas (CSAs) for a relevant innovation in each CSA.

A different innovation adoption in each CSA has been identified. The innovations⁵ considered have been identified as the most relevant in each CSA by the consultation of local networks of stakeholders. Such innovations are:

- a. adoption of methane digester systems in dairy farming in Emilia Romagna (Italy);
- b. adoption of AMS in dairy farming in Noord-Holland (The Netherlands);
- c. concentration in livestock and the modernisation of dairy farms in Podlaskie (Poland) consequently to changes in milk quota traded;
- d. adoption of EU hygienic and veterinary standards for livestock breeding in South-East Planning (Bulgaria);
- e. adoption of no-tillage techniques in Midi-Pyrénées (France).

The technical and economic coefficients for the respective innovations have been collected through secondary data mainly coming from technical papers and through expert interviews.

The representative farm households have been obtained using cluster analysis starting from the CAP-IRE⁶ database. For each CSA a farm households subsample was

⁵ To run a comparable identification of the innovations, the definition of innovation provided by Sounding and Zilberman (2001) has been used, according to whom an innovation (at farm level) is defined by “the new methods, customs or devices used to perform new tasks”.

selected in order to identify the specific farm typology addressed by the innovations. In table 1 the composition of the subsamples is presented.

Table 57. Subsamples' size and coverage

CSA	Farm specialisation	N° of observations considered	% of observations with respect to the CSA full sample
Emilia Romagna (IT)	Livestock (dairy and beef)	31	10
Noord-Holland (NL)	Dairy livestock	151	50
Podlaskie (PL)	Dairy livestock	98	39
South-East Planning (BG)	Dairy livestock	71	26
Midi Pyrénézs (FR)	Arable crops	22	14

Applying a Cluster Analysis⁷ in each CSA using its subsample, representative farm typologies were identified for each CSA. The variables used for cluster analysis are different in each CSA, however generally the herd number for dairy livestock and the total labour used on farm, expressed in full time equivalents (both household and hired labour), have been used.

The characteristics of the farm household simulated are presented in table 60.

Table 58. Characteristics of the representative farm-household simulated

Cluster	Cow	hh labour (full time equivalent)	no-hh labour (full time equivalent)	Land owned (ha)	Land rented-in (ha)	Weight within the subsample (%)
IT1	12	1.96	0.25	12.46	10.13	77
IT2	130	3.5	1	192.5	10	6
IT3	128	2.30	1.50	45.20	36.00	16
NL1	27	1.47	0.33	18.4	9.94	23
NL2	213	1.79	2.71	94.14	42.43	5
NL3	106	1.84	0.43	50.13	19.75	26
NL4	62	1.76	0.33	24.84	12.10	46
PL1	15	2.18	0.02	16.77	3.43	6
PL2	24	2.08	0.05	24.22	10.88	42
PL3	69	2.95	0.37	59.73	30.77	12
PL4	19	1.81	0.13	25.20	4.8	26
PL5	27	2.64	0.43	25.41	10.89	12
BG1	18	1.66	1.5	1.59	10.79	76
BG2	95	1.65	7.5	10.51	63.24	24
FR1	-	2,00	1,33	259,00	53,33	14
FR2	-	2,60	2,00	84,46	40,31	23
FR3	-	1,25	-	32,63	25,86	36

⁶ The FP7 CAP-IRE project database contains a survey of 150 to 300 representative farm-households in each CSA. Further information is available on the following web-site: <http://www.cap-ire.eu/default.aspx>.

⁷ A non-hierarchical k-means cluster analysis was applied. The best clustering considered was the one with the highest Calinski/Harabasz pseudo-F value.

Cluster	Cow	hh labour (full time equivalent)	no-hh labour (full time equivalent)	Land owned (ha)	Land rented- in (ha)	Weight within the subsample (%)
FR4	-	2,17	4,17	142,00	71,17	27

Note: 'hh' means 'household'.

The Italian clusters generated represent three different livestock systems. Cluster IT1 represent a small farm, characterised by a low number of animal reared, having, in addition, an equal weight of beef and dairy cows rearing. Household members involved in farming activity are less than two and less than one part-time employee is involved as non-household farm worker. Land cultivated is small compared to the other two clusters with a surface of 22.59 Hectares. IT2 and IT3 are intensive livestock farms, with a similar number of cows reared but strongly specialised in beef and in dairy production respectively. Total labour used on-farm is quite similar among the two clusters, but the distribution between household and external labour is rather different. In fact, cluster IT2 has a strong use of household labour (3.5 full time equivalents) and cluster IT3 has less use of household labour but higher value of external labour (1.50 full time equivalents). Finally, the amount of land possessed is strongly diversified, with a higher amount of land owned for the second cluster and homogenous division between land owned and land rented-in for the third cluster.

The Dutch clusters are representative of four dairy livestock systems. Cluster NL1 is strongly differentiated with respect to the other three. The characteristic of this farm typology is a smaller dairy livestock intensity, with only 26 dairy cows and a low UAA, respectively composed of 18.40 ha of land owned and 9.35 ha of land rented-in. The average age of the farm owner is higher than for the other clusters (54 years of age). The other three clusters (NL2, NL3 and NL4) are composed of younger farmers with respect to the first cluster, and could also be differentiated by the livestock intensity and the farm size. NL 2 has higher livestock intensity, with a 213 dairy cows and a very high use of labour, mainly provided by hired labour. Clusters NL3 and NL4 are characterised respectively by medium livestock intensity (106 dairy cows) and small livestock intensity (62 dairy cows). These two clusters are quite homogenous with respect to the age of the farm owner and the amount of labour required. NL3 has a higher use of land with respect to NL4.

The first Polish cluster is composed by small farms with a small number of cows, the lowest number of household members working on farm full time and the biggest number of part time family workers. Cluster PL2 is the most numerous group, with relatively young farmers but with many older persons in the household. The number of cows in this cluster is 24 and the land cultivated in 35 ha (24 owned and 11 ha rented-in). Cluster PL3 is composed by big farms with the highest value of cows (69) and surface cultivated (60 ha owned and 31 ha rented-in). The fourth cluster in terms of the herd size is similar to the first one, although much larger in terms of area (25 ha owned and 5 rented-in). The labour available on-farm is the lowest of the CSA (1.81 full

time equivalent). Cluster PL5 has the oldest farmers and an average of 27 cows and 36 ha of agricultural area.

Within the dairy livestock farm in South-East Planning Region, we generated two clusters. The two clusters have different size in all the main characteristics considered: number of cows (18 in BG1 and 95 in BG2), external labour used (1.5 full time equivalent in BG1 and 7.5 in BG2), land owned (2 ha in BG1 and 11 in BG2) and land rented-in (11 ha in BG1 and 63 in BG2). They are similar only in the household labour available.

In France, we identified 4 clusters. FR1 is composed by farms with an large agricultural area: 259 ha owned and 53 ha rented in. The labour available is 2 full time equivalent units in the household and 1.33 units outside. FR2 has a surface lower then the 40% of the previous cluster (125 ha) but an higher availability of labour (4.60 full time equivalent unit in total). FR3 is composed by the smallest farm (less than 60 ha) that use a very little amount of labour (1.25 full time equivalent unit) only from the household. FR4 has a 213 ha of agricultural area, that is a middle value between FR1 and FR2, but has a very high amount of labour available: 6.34 full time equivalent units (2.17 from the household).

4.5.1.2 Building of the household model

The empirical analysis was conducted using a Dynamic Farm Household Model with the objective to maximise the NPV of the cash flow over the next 20 years. The model was hypothesised to be structured in two time periods; the first period (t^1) includes the years 2010-2013, and the second (t^2) includes the years 2014-2030, coherently with the actual policy framework. Farm household models enable the maximisation of the utility function generated by the household income, the household leisure time and the household consumption (Taylor and Adelman, 2003). The investment has been simulated considering the connections between the various activities of the farm: energy productions, livestock activity, crop cultivation and labour allocations among such activities. The household has been assumed to maximise the whole household NPV, subject to consumption and leisure constraints. In fact, with reference to equations 1 and 2, the cash flow in a generic year t (cf_t) is equal to the algebraic sum of on-farm income (Π_{onfarm}^t), off-farm income ($\Pi_{offfarm}^t$) minus the eventual loan repayment (C_r^t). Formally: $cf_t = \Pi_{onfarm}^t + \Pi_{offfarm}^t - C_r^t$

On-farm income is obtained by summing the crop production incomes (π_c^t), the milk production income (if present) (π_m^t), and energy production income (if present) (π_e^t), the eventual RDP received for the investment realised (RDP^t), and the SFP/SAP

received (SFP^t), minus the cost of external labour purchased (C_l^t). Formally, the on-farm income is $\Pi_{onfarm}^t = \pi_c^t + \pi_m^t + \pi_e^t + RDP^t + \theta SFP^t - C_l^t$.

Where the notation \mathcal{G} means that the considered parameter is stochastic.

Off-farm income is obtained by summing the financial income (Fin^t), pensions received by household members ($Pens^t$) and the income obtained by allocating household labour to off-farm activity (Oin^t). Formally, the off-farm income is $\Pi_{offfarm}^t = Fin^t + Pens^t + Oin^t$

With reference to equation 1, the cash flows of a generic year in the first period (t1) and in the second period (t2) are respectively: $cf_{inn}^{t1} = \Pi_{onfarm}^{t1-i} + \Pi_{offfarm}^{t1} - C_r^{t1}$ and $cf_{inn}^{t2} = \Pi_{onfarm}^{t2-i} + \Pi_{offfarm}^{t2} - C_r^{t2}$

Where:

$$\Pi_{onfarm}^{t1-i} = \left(\sum_c x_c^{t1} i_c p_c^{t1} - C_c - C_h^{t1} \right) + \left(i_m^{t1} p_m - C_m - C_q^{t1} \right) + \left(i_e^{t1} p_e^{t1} - C_e - C_{sb} \right) + RDP^{t1} + SFP^{t1} - C_l^{t1}$$

$$\begin{aligned} \Pi_{onfarm}^{t2-i} = & \left(\sum_i x_c^{t2} i_c p_c^{t2} - C_c - C_h^{t2} \right) + \left(i_m^{t2} p_m^{t2} - C_m - C_q^{t2} \right) + \left(i_e^{t2} p_e^{t2} - C_e - C_{sb} \right) + \\ & + \left(\overline{\gamma SFP}^{t2} + \left((1-\gamma) SFP^{t2} \right) \right) - C_l^{t2} \end{aligned}$$

With reference to equation 2, the cash flows of a generic year in the first period (t1) and in the second period (t2) are respectively: $cf_{inn}^{t1} = \Pi_{onfarm}^{t1} + \Pi_{offfarm}^{t1} - C_r^{t1}$ and $cf_{inn}^{t2} = \left(\gamma \Pi_{onfarm}^{t2-i} + \left((1-\gamma) \Pi_{onfarm}^{t2} \right) \right) + \Pi_{offfarm}^{t2} - C_r^{t2}$.

Where:

$$\Pi_{onfarm}^{t1} = \left(\sum_c x_c^{t1} i_c p_c - C_c - C_h^{t1} \right) + \left(i_m^{t1} p_m^{t2} - C_m - C_q^{t1} \right) + \left(i_e^{t1} p_e^{t1} - C_e - C_{sb} \right) + SFP^{t1} - C_l^{t1} \quad (3)$$

$$\begin{aligned} \Pi_{onfarm}^{t2-i} = & \left(\sum_c x_c^{t2} i_c p_c^{t2} - C_c - C_h^{t2} \right) + \left(i_m^{t2} p_m^{t2} - C_m - C_q^{t2} \right) + \\ & + \left(i_e^{t2} p_e^{t2} - C_e - C_{sb} \right) + RDP^{t2} + \left(\overline{SFP}^{t2} \right) - C_l^{t2} \end{aligned} \quad (4)$$

$$\begin{aligned} \Pi_{onfarm}^{t2} = & \left(\sum_c x_c^{t2} i_c p_c^{t2} - C_c - C_h^{t2} \right) + \left(i_m^{t2} p_m^{t2} - C_m - C_q^{t2} \right) + \\ & + \left(i_e^{t2} p_e^{t2} - C_e - C_{sb} \right) + \left(\overline{SFP}^{t2} \right) - C_l^{t2} \end{aligned} \quad (5)$$

With:

x_c^t = surface of crop c on the year t;

i_c = yield of the crop c ;

i_m^t = amount of milk sales in the year t ;

i_e^t = Watt of energy sales in the year t ;

C_c = production cost of crop c ;

C_m = milk production cost;

C_h^t = cost of land rented-in;

C_q^t = milk quota rent cost;

C_e = energy production cost;

C_{sb} = cost of purchase of by-products for energy production;

P_c^t = crop prices for the year t ;

P_m^t = milk price for the year t ;

P_e^t = energy price for the year t ;

γ = probability to have favourable context conditions for new technology adoption;

CP_m^t = milk prices for the year t ;

C_l^{t2} ;= labour cost for the year t during the second period;

\overline{SFP}^{t2} ; \underline{SFP}^{t2} = SFP/SAP favourable and not favourable for the year t during the second period.

Constraints applied to the model are: rotation constraints, cow-shed dimension; manure and slurry spreading constraints. Finally, a liquidity constraint has been applied in order to force the farm to obtain a loan and to pay an interest on the loan, when cash is insufficient to make the investment.

4.5.1.3 Modelling uncertainty in exogenous variables

The model has one stochastic parameter: the amount of SFP/SAP received by the farm. We assumed, coherently with the current policy framework that during time $t1$ (first period) the farmer knows the average amount of SFP/SAP received by the farm, the average level of agricultural prices, the average cost of labour and the oscillation for each of the stochastic parameters. Formally, uncertainty can be expressed by: $S^{t2} = S^e dt \pm \sigma dz$, where S^{t2} is the expected value for a generic year belonging to the second period ($t2$) of each stochastic parameter; S^e is the average or known value during the first period; σ is the oscillation (known during the first period)

and dz is a random variable uniformly distributed with a minimum value of 0 and a maximum value of 1. Through a Monte Carlo Approach, dz has been simulated as an $N \times M$ matrix of random values, where M represents the times at which each stochastic parameter changes during the second period, and N represents the number of samples generated by the Monte Carlo simulation.

The parameter S^e (expected value of the SFP/SAP after 2014) and parameter σ (the oscillation of SFP/SAP), were assumed with different values coherently with the different policy expectations in the old member states and in the new member states. In fact in Emilia Romagna, Noord-Holland and Midi Pyrénées the SFP expected value and the SFP oscillation are equal to half of the current SFP. Under this assumption, the amount of SFP can take values between the current level and zero in each year of the second period. By contrast, for CSA belonging to the new member states (Podlaskie and South-East Planning), the SAP expected value and the SAP oscillation are equal to the current value of SAP. Under this assumption, the amount of SAP can take values between two times of the current level and zero in each year of the second period.

Such way to treat SFP/SAP enables to include into the model the random value of SFP/SAP in each year of the second period. Following this, and referring to equations 3-5, the variable used in the simulation can be summarised⁸ for SFP/SAP as follows: $\overline{SFP}^{t2} = S^e dt + \sigma dz$; $\underline{SFP}^{t2} = S^e dt - \sigma dz$;

4.5.2 Results

The results of the models are presented in table 61, with each result having been parameterised on different levels of RDP support (expressed as a percentage of investment costs covered).

For each representative farm household, the average value of the NPV and the average Value of Option due to the choice to delay the decision in the second period are presented. The NPV is that of the cash flows when the adoption is undertaken in t1. In this situation, the farmer adopted methane digester systems (Italy), AMS (The Netherlands), hygienic and veterinary standards (Bulgaria), no-tillage techniques (France) and modernizes the dairy farm (Poland) during period 1 without possibility of delay. The value of the option is the increment of NPV obtained by delaying the decision to adopt innovation after 2014. In this case, the decision concerns the adoption of innovation if the state of nature becomes favourable, or the use of existing technology if the state of nature becomes unfavourable. The average value obtained by all interactions (N) using the Monte Carlo approach is presented in table 3. In addition, the percentages of adoptions in each period over the total of number of interactions for each cluster are presented. For t1, we indicated the percentage of

⁸ Note that the macron indicates an innovation adoption favourable situation, and *vice versa* the underscore indicates an innovation adoption unfavourable situation.

situations in which an immediate adoption is more profitable than a delay, for t2 we indicated the share of interactions in which the adoption is postponed to the second period when the investment will be made under favourable conditions.

Table 59. Results

Cluster	Variable	RDP cost coverage (%)				
		0	25	50	75	
IT1	NPV	-15,745,209	-15,321,015	-14,896,822	-14,472,691	
	Value of Option	16,723,464	16,299,270	15,875,077	15,450,946	
	Adoption	t1 (% of N)	-	-	-	-
		t2 (% of N)	-	-	-	-
IT2	NPV	7,074,556	7,606,560	8,014,817	8,746,608	
	Value of Option	1,522,177	990,277	581,958	-	
	Adoption	t1 (% of N)	-	-	-	100
		t2 (% of N)	-	-	-	-
IT3	NPV	6,737,091	7,285,961	7,828,476	8,371,169	
	Value of Option	965,594	417,426	-	-	
	Adoption	t1 (% of N)	-	-	100	100
		t2 (% of N)	-	-	-	-
NL1	NPV	461,554	499,900	512,276	570,471	
	Value of Option	198,463	166,436	157,272	109,779	
	Adoption	t1 (% of N)	-	-	-	-
		t2 (% of N)	47	59	63	100
NL2	NPV	11,761,560	12,121,053	12,480,546	12,840,038	
	Value of Option	1,066,155	592,426	276,638	63,861	
	Adoption	t1 (% of N)	-	-	-	-
		t2 (% of N)	-	100	100	100
NL3	NPV	4,432,716	4,774,603	5,130,805	5,473,879	
	Value of Option	907,457	565,878	95,242	-	
	Adoption	t1 (% of N)	-	-	1	100
		t2 (% of N)	-	-	99	-
NL4	NPV	3,793,083	4,057,488	4,302,949	4,550,040	
	Value of Option	628,103	363,699	118,237	-	
	Adoption	t1 (% of N)	-	-	-	100
		t2 (% of N)	-	-	-	-
PL1	NPV	55,487	79,640	103,794	127,947	
	Value of Option	106,836	82,683	58,530	34,377	
	Adoption	t1 (% of N)	-	-	-	-
		t2 (% of N)	-	-	-	-
PL2	NPV	313,296	337,450	361,603	385,756	
	Value of Option	95,644	71,491	47,338	23,160	
	Adoption	t1 (% of N)	-	-	-	-
		t2 (% of N)	-	-	-	2
PL3	NPV	978,126	1,002,568	1,026,322	1,075,085	
	Value of Option	127,315	102,871	78,068	54,134	
	Adoption	t1 (% of N)	-	-	-	-
		t2 (% of N)	-	-	21	100

Cluster	Variable	RDP cost coverage (%)			
		0	25	50	75
PL4	NPV	248,160	272,313	296,466	320,619
	Value of Option	101,371	77,218	53,065	28,911
	Adoption t1 (% of N)	-	-	-	-
	Adoption t2 (% of N)	-	-	-	-
PL5	NPV	395,233	419,387	443,540	467,693
	Value of Option	90,104	65,951	41,798	17,644
	Adoption t1 (% of N)	-	-	-	-
	Adoption t2 (% of N)	-	-	-	-
BG1	NPV	394,204	426,474	458,744	491,014
	Value of Option	-	-	-	-
	Adoption t1 (% of N)	100	100	100	100
	Adoption t2 (% of N)	-	-	-	-
BG2	NPV	2,785,946	2,818,216	2,850,486	2,882,757
	Value of Option	-	-	-	-
	Adoption t1 (% of N)	100	100	100	100
	Adoption t2 (% of N)	-	-	-	-
FR1	NPV	4,852,659	4,860,106	4,867,553	4,875,001
	Value of Option	29,198	21,751	14,304	6,857
	Adoption t1 (% of N)	-	-	-	-
	Adoption t2 (% of N)	-	-	-	-
FR2	NPV	2,785,946	2,818,216	2,850,486	2,882,757
	Value of Option	-	-	-	-
	Adoption t1 (% of N)	100	100	100	100
	Adoption t2 (% of N)	-	-	-	-
FR3	NPV	1,587,467	1,594,915	1,602,362	1,609,809
	Value of Option	31,923	24,476	17,029	9,582
	Adoption t1 (% of N)	-	-	-	-
	Adoption t2 (% of N)	-	-	-	-
FR4	NPV	3,751,483	3,758,930	3,767,116	3,786,908
	Value of Option	-	-	-	-
	Adoption t1 (% of N)	100	100	100	100
	Adoption t2 (% of N)	-	-	-	-

Note: N stands for number of interaction of the Montecarlo approach.

Under uncertainty in SFP/SAP, the NPV is rather homogeneous for the given percentage of cost coverage by RDP, but it is strongly differentiated across the case studies and the clusters due to the different innovations considered and the characteristics of the farm households. The option value is not present in every cluster, so in some cases it is convenient to invest in the first period, for example in the Bulgarian clusters. When the sum of adoption in t1 and t2 is lower than 100%, for some stochastic variation of SFP it is never convenient to adopt the innovation, as in the first and third French clusters.

In Emilia Romagna it is always profitable to delay the decision until the second period. In the first cluster, composed by very small farms, the investment in a methane

digester is highly unprofitable, so the NPV for the adoption in the first period is strongly negative and the option value very high because the delay in the decision allow to avoid the investment and the great economic loss which it cause. In the second and in the third Italian cluster, there is a positive NPV for the adoption in t1, but only with an high RDP coverage of investment cost (at least 75% for IT2 and 50% for IT3) it is convenient to adopt immediately the methane digester system; under different RDP support conditions, the investment is not profitable also in t2.

The possibility to postpone the decision is the best choice in the first and second cluster of Noord-Holland for every value of RDP coverage, and no AMS investments are made during the first period. In NL1, the percentage of interaction where is convenient to adopt AMS in t2 under favourable conditions increases with higher RDP cost coverage, from 47% without support to 100% with the coverage of the 75% of investment costs. In NL2 AMS will be adopted in the second period if the RDP covers at least 25% of their cost. Following our model, this implies that without RDP in this cluster, the AMS will never be adopted, even with more information about SFP/SAP. In the third cluster, AMS are convenient with at least the 50% of investment cost coverage by RDP; in this case the adoption is more convenient in t2 if in 99% of interactions meanwhile in 1% of them is more profitable to invest immediately. With an higher cost coverage (75%) is always convenient to invest in t1. In the fourth Dutch cluster the investment is convenient only with a RDP cost coverage of 75%; with this support, the farmer adopt in the first period.

The optimal strategy in Podlaskie always implies delaying the decision until the second period, and having more information about the amount of SFP/SAP to be received after 2014 before making a decision regarding concentration in livestock and the modernisation of the dairy farm. The adoption is convenient in the third cluster, that is composed by largest farm household, with a RDP support of 50% (21% of interactions) and 75% (all the interactions). The investment is also convenient in 2% of interactions in the second Polish cluster with the maximum RDP support. increases with higher RDP support.

In South-East Planning the Option Value is always 0, so the investment in hygienic and veterinary standards for livestock breeding is always undertaken in the first period, for all levels of RDP support in both the clusters. Here the investment allows the Bulgarian farmers to selling their milk produced in the domestic market.

In Midi Pyrénées the adoption of no-tillage techniques increases only a little the current crop yields and is a labour intensive technology. For this reason, the investment is profitable only in cluster FR2 and FR 4, where the amount of labour (internal and external at the household) is higher. In these clusters, the adoption is convenient in t1 meanwhile in the first and in the third French clusters the investment in never profitable.

4.6 Assessment the CAP Scenario impacts on the innovation adoption (mechanism of adoption)

In this section the effect of policy scenarios on innovation adoptions. The methodology is based on with two main implications about the policy and about the uncertainty:

1. Certainty in the policy after 2013 is assumed and otherwise has been assumed uncertainty in prices of output (crops, milk or energy) and in the labour costs.
2. Analysis of CAP scenarios has been carried out. CAP scenario used are those identified in the scenarios exercises realised within CAP-IRE project by WP8 (See for more details about the identification of the scenario Cristoiu et al. 2009).

4.6.1 Operative identification of the policy scenarios and uncertainty

Four scenarios were identified. For the purposes to modelling the effect of scenario on adoption of new technology, an operational definition and specification of these scenarios in element usable within the model was needed. In fact the different scenarios represent a combination between the following policy parameters:

- SFP or SAPS amount (calculate as a % of current payment)
- probability to receive payments by the RDP and percentage of innovation co-funding (calculated as % of current co-funding measure)
- abolishment or the persistence of milk quota
- Application of conditionality. The persistence or abolishment of a ratio between number of cows and hectares of land owned or rented-in was applied.

The combination of these policy parameters has allows to identify for policy scenarios:

- Baseline 2020
- Environmental 2020
- Liberalisation 2020
- Subsidiary 2020

In the Table 62 the policy parameters is presented for each scenario

Table 60. Policy parameters for each scenario.

Scenario	Baseline 2020	Environmental 2020	Liberalisation 2020	Subsidiary 2020
Amount of SFP received (money received during 2009)	100%	25%	0%	50%
Amount of SAPS received (money received during 2009)	150%	50%	0%	100%
RDP payments as amount of innovation co-founding (calculated as % of current co-founding measure)	100%	133%	0%	50%
Milk quota	Abolishment during year 2015	Abolishment during year 2015	Abolishment during year 2013	Continuation
Cross-compliance	Existing	Existing	Abolishment	Existing

Concerning the second specification the uncertainty in the second period were assumed differently according to CSA specificity. In fact in Table 61 is specified the source of uncertainty in each CSA.

Table 61. Uncertainty parameters assumed in each CSA.

CSA	Uncertainty in crop prices	Uncertainty in milk price	Uncertainty in energy prices	Uncertainty in labour cost
Emilia Romagna (IT)	X		X	X
Noord-Holland (NL)	X	X		X
Podlaskie (PL)	X	X		X
South-East Planning (BG)	X	X		X
Midi Pyrenees (FR)	X			X

Two sources of uncertainty have been simulated in all CSA and are those related to the crop selling prices and external labour costs. In addition in three CSA Noord-Holland (NL) Podlaskie (PL) and South-East Planning (BG) uncertainty in milk

prices were assumed. Only in Emilia Romagna CSA was assumed the uncertainty on energy prices because innovation chosen was concern to the biogas productions.

The model has four stochastic parameters: the level of agricultural prices; the energy sale prices;

This implies that the farmer at time t_1 (first period) knows the average of amount of energy price; level of crop prices and milk prices and labour costs and the oscillation for each of the stochastic parameters. Formally uncertainty can be expressed by: $S^{t_2} = S^e dt \pm \sigma dz$. Where S^{t_2} is the expected value for a generic year belonging to the second period (t_2) of each stochastic parameters; S^e is the average or known value during the first period; σ is the oscillation (known during the first period) and dz is a random variable uniformly distributed with minimum value 0 and maximum value 1. Through a Monte Carlo Approach, dz has been simulated as an $N \times M$ matrix of random values, where M represents the times on which each stochastic parameters changes over time and N represents the number of interactions generated by the Monte Carlo simulation⁹.

The general approach has further specifications depending by the stochastic parameter considered:

- With regard the energy price variable we have the following specification: S^e is the current price of energy; σ is the standard deviation obtained by placing as the maximum value the current energy price and as the minimum value the minimum guaranteed prices by Italian Legislation. Such specification allows to determine a random energy price variable (ep^{t_2}) with a uniform distribution with the maximum and minimum values equal respectively to the current energy prices (0.28 per kW) and 0.22 (€ per kW) that correspond to the minimum guaranteed prices. Energy prices have been assumed to change during the second period six times, coherently with schemes of guaranteed prices, that are redefined each three years by the public administration ($M_{j_1}^{ep}, \dots, M_{j_6}^{ep}$): $M_{j_1}^{ep}$ is the sub-set that includes the years 2014 -2016 by steps of three years; the last sub-set is $M_{j_6}^{ep}$, that includes years 2029-2030.
- With regard the crop prices variable we have the following specification: $S_c^e = S_c^{2009} \mu_c$, where S_c^{2009} is a vector of dimension $c \times 1$ with the price level placed at year 2009 and c is the set of crops considered in the simulation; μ_c is the annual drift¹⁰; σ_c is a vector of dimension $c \times 1$ of the standard

⁹ Monte Carlo Model Simulation has been carried out using MATLAB software

¹⁰ Drift has been calculated as percentage of annual change to obtain the foresee price levels that are presented in the OECD-FAO Agricultural Outlook 2009 report.

deviations¹¹. Such specification allows to determine a random crop prices variable (cp_c^{t2}) with a uniform distribution with a maximum value $cp_c^{t2} = S_c^{2009} \mu_c + \sigma_c$ and a minimum value $cp_c^{t2} = S_c^{2009} \mu_c - \sigma_c$. Crop prices have been assumed changing during the second period each year until 2030, so we will have thirty sub-set $s(M_{j1}^{cp}, \dots, M_{j30}^{cp})$.

- With regard the milk price we have the following specification: S^e is the current 2009 milk price and; σ is the standard deviation. The standard deviation was calculated using the foreseen prices from year 2009-2018 in the OECD-FAO Agricultural Outlook 2009 report. In addition, we have added an annual drift (μ) which was calculated as a percentage of the annual change to obtain the foreseen price level from the OECD-FAO Agricultural Outlook 2009 report.
- With regard the labour cost we have the following specification: S^e is the current 2009 labour price and; σ is the standard deviation. The standard deviation was calculated using the foreseen cost from the Scenar 2020 report. In addition, we have added an annual drift (μ) which was calculated as percentage of the annual change to obtain the foreseen price level from the Scenar 2020 report.

Such a specification allows for the determination of a random value of the price/cost variables with a uniform distribution and a maximum value $S^e \mu + \sigma$ and a minimum value $S^e \mu - \sigma$. Following this notion the variable used in the simulation can be summarised¹² for energy price: $\overline{ep}^{t2} = S^e dt + \sigma dz$; $\underline{ep}^{t2} = S^e dt - \sigma dz$ for milk price: $\overline{p}_m^{t2} = S^e dt \mu + \sigma dz$; $\underline{p}_m^{t2} = S^e dt \mu - \sigma dz$ for labour cost: $\overline{C}_l^{t2} = S^e dt \mu + \sigma dz$; $\underline{C}_l^{t2} = S^e dt \mu - \sigma dz$ and for crop prices $\overline{cp}_c^t = S_c^{2009} \mu_c + \sigma_c$ $\underline{cp}_c^t = S_c^{2009} \mu_c - \sigma_c$.

4.6.1 Results

The results for each CSA are presented in Table 62; Table 63; Table 64; Table 65 and Table 66. In each table it is presented the probability of adoption, calculated as % of Montecarlo interaction on which the strategy among no adoption, adoption during t1 or adoption during t2 determines a higher NPV.

¹¹ Standard deviation has been calculation using the foresee prices from year 2009-2018 present in the OECD-FAO Agricultural Outlook 2009 report.

¹² Note that the macron indicates an AMS adoption favourable situation, and *vice versa* the underscore indicates an AMS adoption unfavourable situation

Table 62. Results for Emilia Romagna Region (% of adoption)

Cluster	Strategy	baseline	environmental	liberalisation	subsidiarity
CL1	No adoption	100%	100%	100%	100%
	Adoption t1 (2010-2013)	-	-	-	-
	Adoption t2 (2014-2020)	-	-	-	-
CL2	No adoption	95%	76%	100%	100%
	Adoption t1 (2010-2013)	-	-	-	-
	Adoption t2 (2014-2020)	5%	24%	-	-
CL3	No adoption	99%	90%	100%	100%
	Adoption t1 (2010-2013)	-	-	-	-
	Adoption t2 (2014-2020)	1%	10%	-	-

The adoption of methane digester system for the production of biogas in Emilia Romagna is affected by policy scenarios. In particular, in all scenarios the highest probability is for non-adoption, but for the two biggest clusters, the environmental scenario determines an increasing of the probability of adoption during the second period. This is mainly a consequence of the highest opportunity of investment co-funding in the second period for this scenario.

Table 63. Results for Noord Holland (% of adoption)

Cluster	Strategy	baseline	environmental	liberalisation	subsidiary
CL1	No adoption	-	-	-	-
	Adoption t1 (2010-2013)	-	-	-	-
	Adoption t2 (2014-2020)	100%	100%	100%	100%
CL2	No adoption	100%	38%	100%	100%
	Adoption t1 (2010-2013)	-	-	-	-
	Adoption t2 (2014-2020)	-	62%	-	-
CL3	No adoption	-	-	-	-
	Adoption t1 (2010-2013)	100%	89%	100%	87%

	Adoption t2 (2014-2020)	-	11%	-	13%
	No adoption	-	-	-	-
CL4	Adoption t1 (2010-2013)	46%	20%	100%	0%
	Adoption t2 (2014-2020)	54%	80%	0%	100%

Scenarios have a low effect on the decision to adopt AMS in the Noord Holland Region. In fact the adoption is more effected by the cluster than by scenario characteristics. In fact for the smallest clusters there is a general profitability in adoption of innovation mainly in the second period (CL1 and CL4). Differently the decision to adopt a new technology in the bigger cluster is more affected by policy scenarios; in particular there is higher profitability in the adoption of innovation under the environmental scenario.

Table 64. Results for Podlaskie (% of adoption)

Cluster	Strategy	baseline	environmental	liberalisation	subsidiarity
	No adoption	100%	100%	100%	100%
CL1	Adoption t1 (2010-2013)	-	-	-	-
	Adoption t2 (2014-2020)	-	-	-	-
	No adoption	100%	73%	100%	100%
CL2	Adoption t1 (2010-2013)	-	-	-	-
	Adoption t2 (2014-2020)	-	27%	-	-
	No adoption	100%	100%	100%	100%
CL3	Adoption t1 (2010-2013)	-	-	-	-
	Adoption t2 (2014-2020)	-	-	-	-
	No adoption	100%	100%	100%	100%
CL4	Adoption t1 (2010-2013)	-	-	-	-
	Adoption t2 (2014-2020)	-	-	-	-
	No adoption	98%	99%	100%	93%
CL5	Adoption t1 (2010-2013)	-	-	-	-

Adoption t2 (2014-2020)	2%	1%	-	7%
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Adoption of the new technology in Podlaskie Region is strongly connected to different policy scenarios, and the innovation considered is profitable only for two clusters: CL2 and CL5, though with different percentage. For cluster 2 there is a rather high probability to adopt the innovation, but only under the environmental scenario. On the contrary, for cluster 5, such probability is very low (from 1 to 7%), with higher value for the subsidiary scenarios.

Table 65. Results for South East Planning Region (% of adoption)

Cluster	Strategy	baseline	environmental	liberalisation	subsidiary
	No adoption	-	-	-	-
CL1	Adoption t1 (2010-2013)	100%	100%	100%	100%
	Adoption t2 (2014-2020)	-	-	-	-
	No adoption	-	-	-	-
CL2	Adoption t1 (2010-2013)	100%	100%	100%	100%
	Adoption t2 (2014-2020)	-	-	-	-
	No adoption	-	-	-	-

The effect of policy scenarios in the adoption of veterinary and sanitary requirement in South East Planning Regions is very low. In fact for all scenarios there is a probability of 100% of adoption of the innovation during t1.

Table 66. Results for Midi Pyrenees (% of adoption)

Cluster	Strategy	baseline	environmental	liberalisation	subsidiary
	No adoption	-	100%	100%	100%
CL1	Adoption t1 (2010-2013)	-	-	-	-
	Adoption t2 (2014-2020)	100%	-	-	-
	No adoption	-	-	-	-
CL2	Adoption t1 (2010-2013)	100%	100%	100%	100%
	Adoption t2 (2014-2020)	-	-	-	-
	No adoption	100%	100%	100%	100%
CL3	Adoption t1	-	-	-	-
	No adoption	100%	100%	100%	100%

	(2010-2013)				
	Adoption t2 (2014-2020)	-	-	-	-
	No adoption	-	-	-	-
CL4	Adoption t1 (2010-2013)	100%	100%	100%	100%
	Adoption t2 (2014-2020)	-	-	-	-

Scenarios have a low effect on the decision to adopt no tillage techniques in midi Pyrenees. The adoptions are more effected by the cluster the farm belongs to, than by the characteristics of the scenario considered. In fact for the largest cluster there is a general profitability in the adoption innovation mainly in the first period (CL2 and CL4). On the contrary, the decision to adopt a new technology in the smallest cluster is affected by policy scenarios; in particular only under baseline there is a high profitability in the adoption of innovation.

5 Main findings and policy implication

5.1.1 Survey A

CAP changes affect significantly the farm structure and the innovation processes. In particular medium-large farms that expect to have an “expanding” behaviour under the Baseline scenario will reduce such expansion with the CAP abolishment. Such effect is particularly relevant for land use and capital use on farm. In addition the decisions about land and capital use under different policy scenarios are correlated to each other more than with labour use on farm, the latest being more dependent on other factors, external to the farming activity. These factors are particularly connected with off-farm job expectations.

As well as for the farm structure, the CAP abolishment effects the adoption of innovations. This is firstly the consequence of the exit behaviour. It is remarkable that the CAP abolishment would determine also the exit from the sector by farmers that would invest and innovate in the baseline scenario. Secondly the CAP abolishment affects intention about innovations adoption more strongly when innovations are not connected with an overall farm development strategy, and the innovation adoption are realised individually, and without any advices.

5.1.2 In-depth analysis

The results show the relevance of uncertainty about CAP first pillar payments (SFP/SAP) in determining the timing of adoption of a new technology. The uncertainty in the policy context has a different impact in each European CSA due to the high heterogeneity of the innovations considered and of the farm and agricultural characteristics of the representative farm identified. Both SFP/SAP and RPD payments are relevant for the adoption of new technologies, respectively ensuring liquidity and income support (though decoupled), and reducing the risk exposure, through the co-funding of investment. The results highlight that uncertainty about the future of the CAP after 2013 has a significant impact on decisions to delay the adoption of innovation, with some consequence of such delay on farm profitability.

Innovation adoption and timing of adoption is strongly affected by policy (innovation type-dependent). In particular the NO-CAP scenario has the lower number of innovations adopted, while the Single Farm Payments and innovation co-funding measures have different effects on innovation adoption and on the timing of adoption. This implies that Single Farm Payments and innovation co-funding measures are not perceived as substitute, and the impact of such two different policy instruments are differentiate, and both may be needed for promoting the diffusion of innovations.

The results emphasize that decisions to adopt the new technology, and the timing of such decisions, depend on the quality of the information available, as well

as the length of the policy reform process. In particular, they highlight the importance of “predictability” as a major policy feature and component of policy design facing a strongly uncertain context. These findings confirm the existing literature on the negative influence of policy uncertainty on private farm and firm investment (e.g. Rodrik 1991, Feng 2001), but bring a novel light on the consequences of the numerous CAP reforms. The results also underscore the need, in some CSAs, to reinforce (or build) links between investment support measures and uncertainty reducing measures (such as insurance). Such measures are suitable to prevent excessive exposition for those farmers with the strongest intention to invest and encourage a more timely reaction by farmers facing funding opportunities.

ANNEX 1 – LIST OF QUESTIONS ASKED CONCERNING THE FARM STRUCTURE AND THE INNOVATIONS

What is the main farm specialisation¹³?

- a) Specialist cereals, oilseed and protein crops
- b) General field cropping
- c) Specialist horticulture
- d) Specialist vineyards
- e) Specialist fruit and citrus fruit
- f) Specialist olives
- g) Various permanent crops combined
- h) Specialist dairying
- i) Specialist cattle-rearing and fattening
- j) Cattle-dairying, rearing and fattening combined
- k) Sheep, goats and other grazing livestock
- l) Specialist granivores (e.g. poultry)
- m) Mixed cropping
- n) Mixed livestock, mainly grazing livestock
- o) Mixed livestock, mainly granivores
- p) Field crops-grazing livestock combined
- q) Various crops and livestock combined
- r) Non classifiable

If specialisation includes livestock, please specify how many animals are kept on your farm¹⁴

- a) Dairy cows _____
- b) Beef cows _____
- c) Fattening cattle (including veals) _____
- d) Sows and hogs _____
- e) Fattening pigs _____
- f) Adult sheep or goats _____
- g) Poultry (n. adults depending on species) _____

Please indicate how many hectares the farm owns or operates (including non-UAA)¹⁵

Category	ha
a) Land owned by the farm	
b) Land rented out	
b1) Of which any rented to relatives (Yes/No)? _____	
c) Land rented in	
c1) Of which any rented from relatives (Yes/No)? _____	

¹³ This list and most of the others should not be read by the interviewer; he/she would classify the answer given by the interviewee.

¹⁴ Yearly average.

¹⁵ This should be read in a “hierarchical” way: 1) owned vs. rent; 2) if owned, how much rent out; if yes, to whom; 3) if rent in, from whom.

How many employees¹⁶ does the agricultural holding have (excluding household members)?

- a) Full time male employees_____
- b) Part time and other¹⁷ male employees_____
- c) Full time female employees_____
- d) Part time and other female employees_____

Question	Baseline	No CAP
Would there be increase, decrease or no change in the following...		
HOUSEHOLD AND FARM LABOUR ALLOCATION		
...household labour used on the farm	Increase No change Decrease Do not know Comments_____	Increase No change Decrease Do not know Comments_____
... household labour used in off-farm activities ¹⁸	Increase No change Decrease Do not know Comments_____	Increase No change Decrease Do not know Comments_____
... non-household labour used on the farm	Increase No change Decrease Do not know Comments_____	Increase No change Decrease Do not know Comments_____
FARM SIZE		
...owned land ¹⁹	Increase No change Decrease Do not know Comments_____	Increase No change Decrease Do not know Comments_____
... land rented in	Increase No change Decrease Do not know Comments_____	Increase No change Decrease Do not know Comments_____
... land rented out	Increase No change Decrease Do not know Comments_____	Increase No change Decrease Do not know Comments_____
CAPITAL		
... size of the farm in terms of the number of animals	Increase No change Decrease Do not know Comments_____	Increase No change Decrease Do not know Comments_____
...farm endowment of buildings	Increase No change Decrease Do not know Comments_____	Increase No change Decrease Do not know Comments_____

¹⁶ We ask for physical persons, not person year equivalents

¹⁷ Part-time or seasonal employees or any other forms.

¹⁸ Including any paid or profitable labour or activity

¹⁹ Here and in the following land = UAA + non-UAA, like in question 3.9

... farm endowment of machinery	Increase No change Decrease Do not know Comments _____	Increase No change Decrease Do not know Comments _____
INNOVATION		
Would there be any of the following major innovations?	Robotisation and/or precision farming (Yes/No) _____ New irrigation systems (Yes/No) _____ e-commerce (Yes/No) _____ Energy crops or production of energy (Yes/No) _____ Other _____	Robotisation and/or precision farming (Yes/No) _____ New irrigation systems (Yes/No) _____ e-commerce (Yes/No) _____ Energy crops or production of energy (Yes/No) _____ Other _____

ANNEX 2 – LIST OF OTHER RELEVANT INNOVATION IN THE FARM

OTHER INNOVATION	BASELINE	NO CAP SCENARIO
Organic farming	24	2
Innovation in farm management (office Organization, software etc)	14	2
Building / Housing	7	3
Direct sale	7	5
compliance to environmental standards	1	0
Crop pattern	3	2
Methanisation	4	2
Tourism activity	2	1
valorisation of crop residues	2	1
Photovoltaic energy	3	1
extend sheep husbandry and breeding	1	0
New energy	1	1
no tillage	1	1
work services	1	1
timber	1	1
not specified	12	21
TOTAL	84	44

ANNEX 3 – ADDITIONAL QUESTIONS

Which innovations have you applied on your farm in the last ten years?

Source	Specify innovation	Year of adoption	Reasons for adopting (possible multiple answers, but put first the main reason)	Who provide the information about innovation (possible multiple answers, but put first the main channel)	Do you received payments from RDP? (Yes/Not)
Farming System (organic, rural tourism, etc)					
Mechanical (eg new tractor, robotisation, precision farming, biofuel etc.)					
Biological innovation (eg new seed, new crop variety, energy crop)					
Agronomic innovations (eg rotation, no tillage, water management, greenhouse)					
Chemical innovations (eg change in fertilising, pesticides, etc.)					
Biotechnological innovations (eg. GMO, cloned animals)					
Marketing innovation (eg direct selling, e-commerce, farmer market)					
Processing innovations (eg vertical contract, cooperation, etc.)					

- a) Yield increasing
- b) Higher prices
- c) Diversify revenue
- d) Cost reducing
- e) Quality enhancing
- f) Risk reducing
- g) Environmental benefit
- h) Shelf life Enhancing
- i) Compulsory by contract
- j) Consequences of the structural change (eg land, labour)
- k) Other

- a) Public Administration
- b) Farm association
- c) Cooperative
- d) Buyers - Downstream processing
- e) Inputs Providers
- f) Private Advice Service
- g) Neighbors
- h) Networking with a group of farmers
- i) Networking with other sources
- j) Personally (eg technical review specialized fair or directly collected)
- k) other

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