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ASSESSING THE IMPACT OF DIFFERENT RURAL DEVELOPMENT POLICY DESIGN OPTIONS ON THE ADOPTION OF INNOVATION ACROSS FIVE CASE STUDIES IN EU

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ABSTRACT

Innovation and new technology adoption represent two central elements for the enterprise and industry development process in agriculture. The objective of the paper 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. The model implemented is based on a real option approach that includes investment irreversibility and stochasticity in SFP. The results show the relevance of uncertainty in determining the timing of adoption and emphasise the importance of predictability as a major component of policy design.

Keywords: real options; innovation; rural development policy; single farm payments; uncertainty

INTRODUCTION AND OBJECTIVES

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.

The objective of the paper 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 study has been conducted in the framework of the 7th EU Framework Programme project CAP-IRE (‘Assessing the multiple Impacts of the Common Agricultural Policies (CAP) on Rural Economies’). The case study areas considered are Emilia Romagna Region (Italy), Noord-Holland (the Netherlands); Podlaskie (Poland); South-East Planning (Bulgaria); Midi-Pyrénées (France).

The paper 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.

CONCEPTUAL FRAMEWORK

This paper addresses 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).

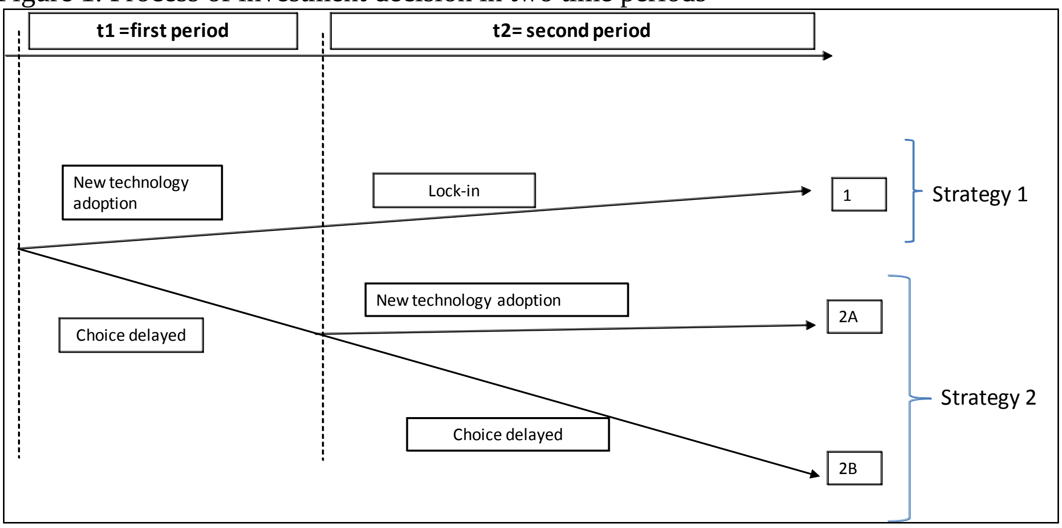
Several authors have developed methodologies based on the RO approach in order to simulate the decision to invest in specific new technologies. Some examples in agriculture are Stokes et al. (2008) and Bartolini et al. (2010) for an application to methane digester systems adoption, Engel and Hyde (2003) 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 1. 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 (t1 and t2), 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 t2 (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: $\text{NPV} = \max(NPV_1, NPV_2)$; 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.

$$NPV_1 = -k + \sum_{0}^{t1} \frac{cf_{inn}^{t1}}{(1+i)^t} + \sum_{t1+1}^{t2} \frac{\gamma\, \overline{cf_{inn}^{t2}} + (1-\gamma)\underline{cf_{inn}^{t2}}}{(1+i)^{t1+t}} \tag{1}$$

$$NPV_2 = \sum_{0}^{t1} \frac{cf^{t1}}{(1+i)^t} + \left(\gamma \left(\frac{-k}{(1+i)^{t1+t}} + \sum_{t1+1}^{t2} \frac{\overline{cf_{inn}^{t2}}}{(1+i)^{t1+t}} \right) + (1-\gamma) \sum_{t1+1}^{t2} \frac{\underline{cf^{t2}}}{(1+i)^{t1+t}} \right) \tag{2}$$

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;

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

$\underline{cf_{inn}^{t2}}, \underline{cf^{t2}}$ = 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 Pyndick (1994) we assumed that the annual cash flows follow a Brownian Motion with drift, so that $dcf^t = \mu cf^t\, dt + \sigma cf^t\, dz$, where dcf^t is the instantaneous value of the cash flow; $\mu^t cf^t\, dt$ 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 t2. This approach enables to maintain a constant expected value, and to change only the amount of uncertainty in the second period.

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.

IDENTIFICATION OF RELEVANT INNOVATION AND THE REPRESENTATIVE FARM

The simulation of the innovation adoption model has been tested to a representative farm household 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 innovations[1] considered have been identified as the most relevant in each CSA by the consultation of local networks of stakeholders. Such innovations are:

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

The representative farm households have been obtained using cluster analysis starting from the CAP-IRE[2] database. For each CSA a farm households subsample was selected in order to identify the specific farm typology addressed by the innovations. In table 1 the composition of the subsamples is presented.

Table 1. 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	10.33
Noord-Holland (NL)	Dairy livestock	151	50.33
Podlaskie (PL)	Dairy livestock	98	39.36
South-East Planning (BG)	Dairy livestock	71	26.01
Midi Pyrénézs (FR)	Arable crops	22	14.19

Applying a Cluster Analysis[3] in each CSA using its subsample, representative farm typologies were identified for each CSA. In each CSA the largest farm typology has been considered and simulated. The characteristics of the farm household simulated are presented in table 2.

Table 2. Characteristics of the representative farm-household simulated

CSA	Cows (#)	hh labour (# full time	no-hh labour (# full time	Land owned	Land rented-in	Weight of the cluster with

[1] 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".

[2] 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.

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

		equivalents)	equivalents)	(ha)	(ha)	respect to the subsample (%)
IT	130	2.30	1.50	45.20	36.00	16.13
NL	214	1.79	2.75	94.14	42.43	4.56
PL	69	2.95	0.37	59.73	30.77	13.00
BG	95	1.11	5.11	10.51	63.24	23.94
FR	-	2.00	1.33	259.00	53.33	13.64

Note: 'hh' means 'household'.

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 five representative farm-households presented in table 2 are the largest farm-households in each CSA (considered in terms of land and of animals reared). The selection of such farm typology has been motivated by two reasons. Firstly, it is expected that a large farm household should have more interest in adopting a new technology rather than a small farm, and secondly this farm typology is the one that receives highest SFP/SAP compared to the other farm typologies.

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

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 ($t1$) includes the years 2010-2013, and the second ($t2$) 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^t_{onfarm}), off-farm income ($\Pi^t_{offfarm}$) minus the eventual loan repayment (C^t_r). Formally: $cf_t = \Pi^t_{onfarm} + \Pi^t_{offfarm} - C^t_r$

On-farm income is obtained by summing the crop production incomes (π^t_c), the milk production income (if present) (π^t_m), and energy production income (if present) (π^t_e), 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^t_l). Formally, the on-farm income is $\Pi^t_{onfarm} = \pi^t_c + \pi^t_m + \pi^t_e + RDP^t + \theta SFP^t - C^t_l$.

Where the notation ϑ 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 $\Pi^t_{offfarm} = Fin^t + Pens^t + Oin^t$

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: $cf_{inn}^{n1} = \Pi_{onfarm}^{t1\_i} + \Pi_{offfarm}^{t1} - C_r^{t1}$ and $cf_{inn}^{t2} = \Pi_{onfarm}^{t2\_i} + \Pi_{offfarm}^{t2} - C_r^{t2}$

Where:

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

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

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: $cf^{t1} = \Pi_{onfarm}^{t1} + \Pi_{offfarm}^{t1} - C_r^{t1}$ 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:

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

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

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

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.

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 x 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 summarised[4] for SFP/SAP as follows: $\overline{SFP}^{t2} = S^{e}dt + \sigma dz$; $\underline{SFP}^{t2} = S^{e}dt - \sigma dz$;.

RESULTS

The results of the models are presented in table 3, with each result having been parameterised on different levels of RDP support (expressed as a percentage of investment costs covered).

Table 3. Results

CSA	Variable		RDP cost coverage (%)			
			0	25	50	75
IT	NPV		12,689,326	16,825,532	19,262,084	21,258,597
	Value of Option		1,454,690	-	-	-
	Adoption	t1 (% of N)	84	100	100	100
		t2 (% of N)	26	-	-	-
NL	NPV		11,761,560	12,121,053	12,480,546	12,840,038

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

	Value of Option		1,066,155	592,426	276,638	63,861
	Adoption	t1 (% of N)	-	-	-	-
		t2 (% of N)	-	100	100	100
PL	NPV		547,165	577,362	592,574	623,660
	Value of Option		108,778	76,355	59,678	31,486
	Adoption	t1 (% of N)	-	-	-	28
		t2 (% of N)	3	9	34	72
BG	NPV		4,633,081	4,666,685	4,700,289	4,733,892
	Value of Option		-	-	-	-
	Adoption	t1 (% of N)	100	100	100	100
		t2 (% of N)	-	-	-	-
FR	NPV		4,447,854	4,455,302	4,462,749	4,470,196
	Value of Option		16,218	8,771	1,443	-
	Adoption	t1 (% of N)	-	-	17	100
		t2 (% of N)	-	-	83	-

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

For each CSA, 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 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.

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 due to the different innovations considered. The only exception is the Italian CSA: in this case there is a higher increase of NPV linked with RDP changes because the investment cost in methane digester is higher than the other ones. The option value is not present in every CSA, so in some cases it is not convenient to delay the decision, for example in Bulgaria. 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.

In Emilia Romagna it is profitable to adopt immediately the methane digester system in almost all the cases, except for 26% of interactions without RDP coverage, in which it is convenient to delay the decision until the second period.

The possibility to postpone the decision is the best choice in Noord-Holland for every value of RDP coverage, and no AMS investments are made during the first period. AMS will be adopted in the second period if the RDP covers at least 25% of their cost. This implies that without RDP in this cluster, the AMS will never be adopted, even with more information about SFP/SAP.

The optimal strategy in Podlaskie often 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 number of adoptions increases with higher RDP support. Only in 28% of the interactions, with RDP cost coverage of 75%, it is more profitable to carry out the investment in 2010.

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 the levels of

RDP support. 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. For this reason, the investment is profitable only with RDP cost coverage higher than 50%, and this variable also influences the timing of the decision. With a 50% coverage, the adoption is delayed in the 83% of interactions, while it is always done in 2010 with a 75% cost coverage.

DISCUSSION

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 (through decoupling), and reducing the risk exposure, through the co-funding of investment. The results highlight that uncertainty about the future of the CAP after 2014 has a significant impact on decisions to delay innovation implementation, with some consequence of delaying the adoption of new technologies on farm profitability.

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 amount of 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.

The main limitation of the model is its strong simplification compared with reality, at least concerning the timing of the process, the treatment of uncertainty and the consideration of farm heterogeneity. In particular, the fact that some farms in the groups analysed show interest in investment in new technologies even at lower co-funding rates than shown by the simulation, may reveal that a relevant heterogeneity even within the cluster considered is not accounted for in the model.

This suggested a number of potential developments in the direction of improving both the timing of decisions, including uncertainty in other decision variables (investment costs, technological development, prices of factors and products), and the simulation of uncertainty using different combinations of uncertain parameters with an explicit correlation between each other. Another option could be the use of scenarios to model changes in CAP payments following the next policy proposal for the post-2013 CAP.

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