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Article

Impacts of the CAP 2014–2020 on the Agroenergy Sector in Tuscany, Italy

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Abstract: The agricultural sectors' contribution to the provision of energy is a central issue in Horizon 2020 strategies and has shaped the public and research debates on the future of the bioeconomy. The common agricultural policy (CAP) has been one of the main drivers of farmers' behavioural changes and represents the main agricultural policy instrument to address viability of rural areas and maintaining the profitability of the agricultural sector. To contribute to the ongoing policy debate towards CAP reform, this paper will provide an empirical model to simulate the impact of an alternative CAP mechanism on the provision of renewable energy. By applying a dynamic mathematical programming model, the paper tests the impact that new policy measures will have on the provision of a second-generation of bio fuel crops that represent a relevant option for Tuscan farmers. Results show that CAP reform positively impacts the supply of energy crops mainly due to the introduction of greening payments, which allows an enlarging of crop diversification. Model results stress also the income stabilisation effects of energy production introduction at farm level, due to reduction of farm exposure to market prices fluctuations.

Keywords: common agricultural policy; energy production; farm household model; mathematical programming model; biogas; short rotation coppice; real options

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1. Introduction

The increased use of fossil fuels is among the major causes for the growing emissions of greenhouse gases (GHGs) [1]. Cutting GHG emissions would help to moderate climate risks in the 21st century and contribute to climate-resilient pathways for sustainable development [2]. The energy supply sector is the largest contributor to global GHG emissions; thus, replacing fossil fuels with renewable energies (REs), such as bioenergy, can lower GHGs emissions [3]. When properly designed in terms of biomass choice and production methods, bioenergy crop systems can improve energy security, as well as lead to favourable carbon and energy balances and reduce GHG emissions [4].

Agroenergy is the function of agriculture that refers to the use of agricultural products, such as energy crops or livestock by-products, as RE sources. Thus, agro-energy contributes to the multifunctionality of farms [5] and can increase and stabilise farmers' incomes [6]. Agroenergy combines the return on investment with favourable effects in terms of food security, rural development, new start-ups, employment, land care and protection, sustainable management of agro forestry resources, local self-reliance, biodiversity conservation, climate change mitigation and improved energy supply and security [7–9]. A weakness of the cultivation of biomass is land use competition with food crops [10].

The European Union (EU) promotes bioenergy [11] and supports agroenergy (*i.e.*, bioenergy produced from cultivated feedstocks) via the Common Agricultural Policy (CAP) [12]. The CAP has been among the main drivers for change in farmers' behaviour as well as the main instrument to address the viability of rural areas and to support the profitability of the agricultural sector. The CAP is structured in two pillars. Pillar I covers market intervention measures and direct decoupled payments to farmers. Pillar II is directed at rural development policy and is co-financed between the EU budget and the Member States; it is based on strategic objectives set at EU level, *i.e.*, competitiveness, modernisation, environmental impact and social issues, which are implemented through national or regional multi-annual rural development programmes (RDPs). In Italy, the RDPs are implemented on a regional level and move from each region's priorities.

On 1 January 2015 the new CAP came into force. Both pillars have been adjusted to be in line with "Europe 2020" agenda, which prioritises the shift to affordable, secure, and green energy. Within that framework, agriculture has become a prominent supplier of REs. To the best of our knowledge, the impact of new CAP's measures on the production of feedstocks for biogas production in Italy has yet to be investigated. We had worked on this paper with the purpose of bridging that gap. Primarily, the paper attempts to assess the impact of new measures under the CAP 2014–2020 on introduction of the main available investment in energy production: introduction of Short Rotation Coppice (SRC) and implementation of biogas plants on farm. Thus, we propose a scenario analysis simulating the introduction of both the new basic payment scheme (BPS), with the regional model for endowment allocation, under Pillar I and two measures of RDP 2014–2020 that support the diffusion of agroenergy. We tested our model on the farms of the province of Pisa, one of the 10 Provinces of Tuscany and the one that shows the lowest diffusion of SRC and biogas plants, in spite of very large amount of available land that can be allocated to energy production [13]. Our results suggest that the new CAP can boost the agroenergy sector in Tuscany, thanks to the agro-environmental climatic payments and to the co-funding measure, which makes investments in biogas plants more affordable. Entering the agroenergy market can peg farmers' incomes, making it less dependent on the fluctuations in market prices.

The paper is structured as follows. In the first section, we set agroenergy within the European strategy addressing bioeconomy. Section two is dedicated to the chosen methodology and introduces the dynamic model based on mathematical programming that we propose for testing the impact of the CAP's measures under both pillars. The third section encompasses the description of the tested farm household model, *i.e.*, model specification, sample selection, and scenario analysis. The following paragraph is for showing and discussing our results. We conclude by summarising our findings, highlighting the strengths and weaknesses of our work, suggesting recommendations for policymakers, and providing inputs for further research.

2. Overview of the Agroenergy Framework within the EU Strategy towards Bioeconomy and the CAP 2014–2020

One the aims of "Horizon 2020", the Framework Programme for Research and Innovation of the EU is to tackle the "Energy Challenge" by establishing a bioeconomy in Europe. The term bioeconomy concerns the substitution of fossil fuels with biofuels in a number of production processes of goods and services (e.g., power and heating) [14]. The bioeconomy encompasses the agricultural production of biomass as well as its conversion into agroenergy [15].

In 2008, the EU adopted its first package on climate and energy measures setting 2020 targets. The energy and climate change objectives for 2020 were to reduce GHG emissions by 20% compared to 1990 levels, to increase the share of RE to 20% and to make 20% improvement in energy efficiency. Official data on key achievements of the "2020 strategy" date 2012. The 2020 strategy had allowed 18% reduction in GHG emissions. Further reductions by 24% and 32% are expected by 2020 and 2030, respectively. The share of RE with respect to the overall amount of energy consumed had increased by 13% and is projected to reach 21% by 2020 and 24% by 2030. By 2020, bioenergy is expected to increase with 44% compared to 2010 levels, with 90% growth in bio-based electricity, 22% growth in heat from biomass and 129% in biofuels [16]. The EU growth strategy towards 2020 sets the background to the CAP 2014–2020. Pillar I of the CAP can help REs to spread; that is suggested by research works focused on the CAP ante-2013. Supporting and stabilising farmers' incomes, the single payment scheme (SPS) had raised both the profitability of agriculture [17] and the demand for marginal land (see [18] for an analysis of the changes in land demand due to introduction of a new entitlement model). Single farm payment (SFP) had helped farmers to overcome risk aversion behaviours addressing issues such as differentiating the production by introducing energy crops or investing in biogas plants ([6,19]. Thanks to SFP, farmers could invest in a timelier manner [20]. Short rotation forestry (SRF) had provided farmers with direct payments based on medium to long-term contracts, which could reduce farmers' exposure to the fluctuations of market prices. Thus, introducing a short rotation coppice (SRC), such as willow, could be strategic for a farmer to increase his firm's utility [6].

Moving to the CAP 2014–2020, the two main novelties concern the multi-purpose targeting and the model for endowment allocation.

Concerning the first pillar, the Italian payment system shifts from "hystorical" to "regionalised", and relies on a system of multi-purpose payments with seven components. Four components are the most significant: (i) basic payment scheme (BPS) (58% national ceiling); (ii) greening payment (30% national ceiling); (iii) coupled payment (11% national ceiling); and payment to young farmers (1% national ceiling). Farmers are eligible if they received a SPS payment in 2013 or can provide evidence, such as receipts or accounts, that they were farmers in 2013. The "greening" is the most prominent component [21]; its primary purposes are boosting crops diversification and maintaining natural and semi-natural crop systems in Europe's rural landscapes [22].

Endowments are allocated on a regional, rather than historical, basis with partial convergence. Historical entitlements are extinguished and new ones allocated, one entitlement being awarded for each hectare of land. In Italy, thepayment system relies on the so-called "Irish model", which is based on the partial convergence mechanism. [23] highlighted five main features of this new model: (i) all cultivations are eligible (e.g., SRC, energy crops); (ii) 2015 is the reference year for the basic payment (BP); (iii) farmers' payments per hectare will be at least 60% of the national average BP, until 2019; (vi) the highest possible reduction of farmer payments will be 30% of the BP in 2015; (v) farmers whose BPs are between 60% and 90% of the national average will get an increase in their payments equal to one third of the difference between BPs and national average. According to a simulation by [23], the average BP will be 179 € per hectare, that is 58% of the total payment. Only farms that fulfil the cross-compliance requirements are eligible for the payments. Farmers are committed to comply with statutory management requirements (SMRs) and minimum requirements to maintain land in good agricultural and environmental conditions (GAECs); they also have to keep unchanged the existing permanent pasture).

Pillar II sets the long-term objectives and the priorities for the rural development in the EU. Farmers' investments in biogas plants are co-funded by Member States, with the purpose of helping the diversification of farms' income by reducing their investment costs. Thanks to the co-funding, farmers facing uncertainty can plan their entry into the agroenergy market [24,25]. On 21 July 2014, Tuscany's RDP 2014–2020 was approved. While the RDP 2007–2013 covered no measure with the purpose of boosting agroenergy in Tuscany [26], the new multi-annual programme 2014–2020 addresses the energy priority through seven measures designed to meet climate change mitigation objectives and to promote the transition toward a bioeconomy. The two measures are (i) investments in physical assets and (ii) agri-environment-climate. The former concerns the co-funding mechanism intended for covering the investment costs; the latter involves lump payments per hectare. SRF is expected to be one of the main agro-environmental climatic measures in the medium-long term. Our work aims at assessing the impacts of the measures (i) investments in physical assets and (ii) agri-environment-climate in the province of Pisa (Tuscany, Italy).

3. Methodology

Cultivating energy feedstock and implementing agroenergy plants on farm embodies a strategy for increasing a farm's profit. The strategy can be modelled as an extension of the optimisation models, based on mathematical programming. In recent years, the taxonomy of models based on mathematical modelling has grown thanks to research in the fields of agricultural and applied economics. In this paper, we apply a dynamic model based on mathematical programming in order to test the impact of alternative policy measures within both pillars of the CAP 2104–2020. The application of mathematical programming is consolidated as a method to assess policy impacts by simulating changes in relevant policy and market parameters [27].

We simulated the impacts of the CAP 2014–2020 on either the implementation of an anaerobic digester on farm or on the cultivation of SRC for selling the feedstock on the market. Both alternatives can be modelled as investment choices, considering an initial investment cost during the first year, and a multi-annual horizon of income. The decision variables of both alternatives are affected by uncertainty and irreversibility [28]. With these points in mind, real option models allow a more accurate simulation of the process of adoption of one of the two alternatives than other capital budget techniques. This is because real option models consider the timing of investments and the option to postpone investments due to the investment option value [24,29]. A number of research papers show that uncertainty significantly affect farmers' behaviour. Farmers have an adverse attitude towards risk, so they are keener on lower income but safer strategies than on more profitable but more unsecure options [6].

Moving from the policy framework, we simulated farmers' decisions either to implement a biogas plant on farm or to allocate part of their farmland to SRC over two time spans, *i.e.*, 2013–2019 and 2020–2040. We assumed that over the period 2013–2019, farmers know all parameters that can be affected by their decision, while for the period 2020–2040, they are uncertain about energy and feedstock prices on the market. In case of irreversible and uncertain investments, the real option approach allows to consider the deferring of the investment to the second period as an option. Following [29] and [25], the optimal farm strategy is the one that maximise the expected NPV, among the two alternatives diversified by the timing of investment. Formally, $NPV^* = \max(NPV_1, NPV_2)$ where:

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

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

Where:

cf_t = cash flows of a generic year t, with $t = t1$ or $t = t2$ if the years belong to the first or to the second time span, respectively;

k = cost of the investments in RE;

i = discount rate;

γ = probability to benefit of a state of nature favourable to the adoption of RE;

$\overline{cf_{t2}}$ = cash flow, assuming a state of nature favourable to the adoption of RE;

$\underline{cf_{t2}}$ = cash flow, assuming a state of nature unfavourable to the adoption of RE;

§ = subscript indicating a decision taken.

The model assumes that farmers know both the probabilities of favourable or unfavourable state of natures and the variance of uncertainty variables. A farmer can invest in RE at some point during the first period and stay in line with that decision in the second period. Alternatively, the farmer can wait for a favourable or unfavourable state of nature to make a safer decision with less uncertainty. Hence, basing on the expected value of the stochastic parameters, farmers make the investment in the first period in case of a higher NPV_1, while they prefer to wait and make decision once they know the state of nature when NPV_2 is higher. The difference between the two NPV represent the option value that measure the increase of investment profitability when a decision is postponed.

The decision to invest in RE is affected by uncertainty due to (i) energy price fluctuations at the consumption level; (ii) availability and cost of digest biomass alternative to energy crops (e.g., agriculture residues or by-products of the food industry); (iii) limits and costs for the disposal of the digestate; (vi) price paid to farmers for selling the energy; (v) cost of the agricultural inputs used in production process, *i.e.*, labour costs; and (vi) prices of the agricultural commodities.

We assume two stochastic variables, *i.e.*, labour costs and prices of the agricultural products. Bartolini and Viaggi (2012) suggest that both low labour cost and low prices of the agricultural products are favourable conditions for farmers' decisions to enter the agroenergy market. In contrast, high labour costs and high prices of the agricultural products can both be considered unfavourable conditions, as they are able to reduce the propensity to invest in RE and [6,25].

4. Model Specification

4.1. Farm Model Specification

We developed the model by applying a simplification of the farm-household model. Following [30], a farm's strategy relies on the choice of the optimal allocation of all productive factors between either on-farm or off-farm inputs. The allocation aims at getting enough utility in terms of consumption (C^*) and leisure time (L^*). The decision to supply RE and to cultivate the needed feedstock on a farm may be considered as the decision to allocate the agricultural inputs to these activities, which draws on a farm's strategy that is aimed at pursuing the highest possible NPV of the cash flows. High NPV guarantees adequate levels of utility with regard to consumption (C'), leisure, and rest (L'), thus affecting the allocation of labour, capital endowments and land demand. As a result, the optimal cash flow (cf_t^*) is equal to the sum of on-farm (Π^t_{onfarm}) and off-farm incomes ($\Pi^t_{offfarm}$) plus the savings from the year *t*–1 (s^{t-1}). Formally:

$$\max NPV = \sum_{t=1}^{n} \frac{cf_t^*}{(1+i)^t} \quad | \; U\left(L^*, C^*\right) - U\left(L', C'\right) \geq 0 \tag{3}$$

with

$$cf_t = \Pi^t_{onfarm} + \Pi^t_{offfarm} + s^{t-1} \tag{4}$$

On-farm income results from the sum of the income generated through the selling of crops (π_c^t), milk (π_m^t), and energy surpluses (π_e^t), plus the payments under Pillar I, *i.e.*, the basic payment (BP^t), the greening payment (GP^t), and the agri-environmental climate payment ($AECP^t$), the loan (if needed) to cover the investments in RE, minus the costs for purchasing labour off-farm (C_l^t), the costs for the household energy use (C_{eb}^t), and the investment costs in RE in case of a favourable decision ($\S$). Formally:

$$\Pi^t_{onfarm} = \pi_c^t + \pi_m^t + \pi_e^t + BP^t + GP^t + AECP^t - C_l^t - C_{eb}^t - \S k^t + Loan^t \tag{5}$$

Off-farm income results from the sum of the financial income (Fin^t) from investments in non-agricultural activities, the income from household labour in off-farm activities (Oin^t), and the annual cost of the loan (if present) to cover the investment in RE adjusted for the interests ($kloan^t$). Formally:

$$\Pi^t_{offfarm} = Fin^t + kloan^t + Oin^t. \tag{6}$$

4.2. Simulation of Investment in RE

We considered five kinds of anaerobic digesters and two types of SRCs. The five digesters (B1–B5) differ for the potential energy release (from 108 to 972 kW/h), for the investment costs, for the annual maintenance costs and for the labour requirements. The two SRCs (SRC1–SRC2) differ for plant intensity, for the tournament length, for the labour requirements, for the investment costs, and for the annual fixed costs. Table 1 summarises the main parameters used for simulations.

Table 1. Main parameters used in the simulation.

Parameters	**Biogas plant ***					**SRC ****	
	BP1	**BP2**	**BP3**	**BP4**	**BP5**	**SRC1**	**SRC2**
Investment costs (€)	1,578,000	1,955,000	2,192,000	2,320,000	3,700,000	3200	2300
Duration (years)	15	15	15	15	15	15	15
Harvest and selling of trunks (frequency of the tournament)	-	-	-	-	-	Every 3 years	Every 5 years
Annual costs (€)	200,000	350,000	400,000	550,000	600,000	850	720
Labur requirements (hours/year/ha)	50	70	80	100	150	23	14
Potential energy release (kW)	108	191	254	526	972	-	-
Yield (t/ha/year)	-	-	-	-	-	22	16

* The parameters used are from[25,31]; ** The parameters used are from [32–34]; SRC1 is the more intensive forestry system and SRC2 is the less intensive.

Following [6] and [25], both RE strategies are modelled as irreversible choices over a multi-annual plan. Hence, given that the choice is made in year *t*, the investment should be maintained over the upcoming years (*t*+1) and until the end of the reference period. Even though the model could seem quite static, the proposed approach simulate the right timing for the investment, *i.e.*, the investment cost in year *t* and the yield or the amount of energy produced since when the investment has been made. This model allows also to opt for making an investment in the first period and quitting it in the second time span, under a different state of nature. In addition, this model allows a better inclusion of the financial constraints into the simulation. When the savings from the previous years are not enough to be invested, the model simulate the option of covering the investment costs by means of a loan. As a result, uncertainty in relevant decision variables, the amount and the kind of the financial support received (e.g., lump sum, co-funding) have a prominent role in making an investment a profitable one.

4.3. Selection of Representative Farming Systems

The model was tested on the most representative farms of the province of Pisa (Tuscany, Italy), that we chose by means of a cluster analysis on official data from the Italian Census 2010 about the farming systems in Tuscany. We applied the cluster analysis on a subsample of Italian farms made of all 6760 farms of the province of Pisa. We selected that study area as RE are not widespread despite the availability of marginal land and of land that is suitable for SRF due to pedoclimatic features and water availability (40% utilised agricultural area (UAA) of the province of Pisa [13]). Arable, vegetable and livestock farming are the main farming systems of the studied area. The cluster analysis that we applied on those three farming systems returned 19 representative clusters of farms. Table 2 shows the main features and the frequencies of the clusters within the database.

Clusters were then classified using the following criteria: (i) farmland surface area; (ii) amount of household and/or off-farm labour employed; (iii) number of livestock; and (iv) amount of payments and entitlements. The first eight clusters cover most arable farms. Those clusters are highly different in terms of land size and amount SFP. Clusters number 4, 5, 6 and 7 involve part-time farming, having less than one full-time equivalent (FTE) worker from household labour. Clusters number 9, 10 and 11 practice vegetable farming. Even though their farmland is smaller than the arable farms, the vegetable clusters allocate higher amounts of household labour to on farm activities. The vegetable clusters get lower SFPs and have fewer entitlements than the arable clusters. Clusters from number 12 to number 19 cover livestock farms, which differ for the number of livestock. The breeding system is not homogenous, ranging from more extensive (e.g., eight LU over more than 200 ha UAA) to more intensive farming (e.g., 168 LU over less than 60 ha UAA). The 19 clusters differ for their distribution frequency over the surface area of the province of Pisa, with clusters number seven and six showing the highest frequencies (42% and 16% farms, respectively). Clusters number 2, 3, 18 and 19 also show significant frequencies. Data from the Italian Census 2010 highlight that RE are barely spread among all clusters, with no biogas plant being implemented in relatively recent years and SRF being practiced on few hectares by cluster number 15 only.

Table 2. Features and frequencies of the clusters.

Cluster code	Type of farming	UAA (ha)	Rented land (ha)	Labour		Dairy Cows (LU ** #)	SFP (€ Per Farm)	Entitlements (# Per Farm)	Renewable Energy		Frequency of cluster
				From household (FTE * #)	External wage earners (FTE * #)				SRC (ha)	Biogas (#)	
1	arable	116	71	1.66	-	-	29,234.60	70	-	-	0.025
2	arable	193.54	143.54	1.66	-	-	41,820.40	50	-	-	0.015
3	arable	72	27	1.45	-	-	23,834.00	65	-	-	0.052
4	arable	6.15	-	0.82	0.82	-	-	-	-	-	0.006
5	arable	2292.08	-	-	0.75	-	-	-	-	-	0.001
6	arable	17	-	0.91	-	-	5833.00	21	-	-	0.167
7	arable	2.6	-	0.48	-	-	181.2	1	-	-	0.425
8	arable	36.5	-	1.36	-	-	12,716.80	31	-	-	0.083
9	vegetable	18.33	5.68	1.59	0.44	-	2210.10	16	-	-	0.006
10	vegetable	1.11	-	1.64	-	-	-	-	-	-	0.055
11	vegetable	7	3	1.82	0.53	-	319.4	2	-	-	0.012
12	livestock	153.96	-	3.02	-	128	27,308.80	120	-	-	0.004
13	livestock	1.3	-	1.66	-	2	-	-	-	-	0.074
14	livestock	52.33	15.43	1.94	-	32	7817.80	53	-	-	0.017
15	livestock	259.12	-	-	2.82	168	-	-	-	5.4	0.003
16	livestock	78.24	8.05	2.75	-	56	11,009.60	56	-	-	0.013
17	livestock	35.43	6.73	3.66	-	62	234.1	1	-	-	0.006
18	livestock	7.02	1.75	2.25	-	13	2613.80	4	-	-	0.012
19	livestock	20	-	1.66	-	24	4546.80	16	-	-	0.024

(*) FTE: Full Time Equivalent; (**) LU: Livestock unit; (#): Number.

4.4. Scenario Analysis

The paper analyses the impact of the CAP 2014–2020 on the decision of the farmers from the province of Pisa (Tuscany, Italy) to enter the agroenergy market, by simulating two alternative options: (i) implementing a biogas plant on farm and selling energy on the market or (ii) allocating a share of their farmland to SRC and selling the feedstock on the market RE energy from dedicated feedstocks. We identified five policy scenarios, each framing a different combination of some features of the selected measures of CAP's first and second pillar. We provide an operational definition for the scenarios implemented through the model, as well as each scenario's specification.

Five policy scenarios were identified by combining the parameters related to the mentioned policies: (i) Baseline 2005; (ii) CAP-post 2013; (iii) Full Convergence in 2015; (iv) Full convergence in 2020; and (v) CAP abolishment (Table 3).

Table 3. Policy parameters for each scenario.

Scenario	**Baseline 2005(BA)**	**Post 2013 CAP(BA1)**	**Full convergence 2015 (RE1)**	**Full Convergence 2019 (RE2)**	**CAP-Abolishment (NO)**
SFP mechanism	Historical	Regionalised	Regionalised	Regionalised	No payments
Entitlements	Current entitlements	No entitlement, payment per eligible area	No entitlement, payment per eligible area	No entitlement, payment per eligible area	No entitlements
Amount of SFP or BP	Current payments	Irish model (partial convergence at 2020)	179 € per ha since 2015	Baseline until year 2019 and then 179 € per ha	No payments
Value of the BP	-	58% of national ceiling	58% of national ceiling	58% of national ceiling	No payments
Convergence	-	Partial to 2019	Full 2015	Full 2019	No payments
Eligible land	COP(*) only	All crops	All crops	All crops	No eligible crops
Cross compliance	Existing	Existing	Existing	Existing	Abolishment
Greening	No-greening	30% of basic payments	30% of basic payments	30% of basic payments	No-greening

(*) COP: Cereals, oilseeds and protein crops.

The Baseline scenario (BA) includes the measures under the CAP ante-2013. The reference year is 2005, when a hundred per cent decoupling was in place. Under BA, we assume the SPS, with endowments being allocated on a historical basis, besides cross compliance. No additional measure of the CAP 2014–2020 is considered.

The CAP post-2013 scenario (BA1) frames the new model adopted by Italy and originates from the system of payments' partial convergence in 2019 ("Irish model").

The two "regionalisation" scenarios, *i.e.*, RE1 and RE2, simulate the introduction of the regionalised SPS as an alternative to the Irish model. While RE1 simulates the full convergence in 2015, RE2 encompasses the full convergence in 2020. RE1 and RE2 differ for the amount of SFP and for the year when the regionalised payment would be adopted. RE1 and RE2 were the two main policy options for the CAP post-2013.

Under the "CAP-abolishment" scenario (NO), we assume that the CAP would cease to exist by the end of 2013, with no CAP's measure being in place from 1 January 2014.

Cross compliance mechanism is maintained in all scenarios with payments. Some authors pointed out that major constraints related to cross-compliance encompass manure spread and the maintenance of permanent pasture, while other constraints are minor (*i.e.*, compliance costs are about 5–10 €/ha) [35,36].

Tuscany's RDP ante-2013 included no measure supporting agroenergy. Due to "Europe 2020" priorities, the new RDP 2014–2020 encompasses two measures explicitly aimed sustaining the diffusion of RE from agriculture. The measures are (i) investments in physical assets (art.17) and (ii) agri-environment-climate (art.28) [26] and are based on different policy instruments. The former involves the co-funding of the investment costs to set up agroenergy plants, e.g., biogas plants; the latter foresees annual payments per hectare of land allocated to energy feedstock production, e.g., SRC. Our purpose was to disentangle the impact of the shift to the new BPS from the impact of the two rural development measures; thus, firstly we simulated policy scenarios without considering the new RDP measures and then we performed a sensitivity analysis of the introduction of the two new policy instruments.

5. Results

The outcomes of our model are shown in Tables 4–6. Table 4 displays the results of the simulations per cluster. The sensitivity analyses of the impacts of the co-funding measure and of the support to agro-environmental climate practices show differences among clusters. Tables 5 and 6 show the results of the sensitivity analysis of the impacts of the former and of the latter measure, respectively.

Table 4. Baseline (data per cluster).

Cluster	BA				BA1				RE1				RE2				NO			
	NPV	UAA	bp (*)	SRC	NPV	UAA	bp (*)	SRC	NPV	UAA	bp (*)	SRC	NPV	UAA	bp (*)	SRC	NPV	UAA	bp (*)	SRC
1	2,888,630	124	-	-	2,198,106	124	-	-	2,233,115	124	-	-	2,880,933	124	-	-	2,131,088	122	1 ξ	-
2	3,298,760	191	-	-	2,950,047	201	-	-	3,036,854	201	-	-	3,304,786	193	-	-	2,430,885	201	-	-
3	1,249,107	76	-	-	1,973,032	80	-	-	1,980,608	80	-	-	2,376,761	80	-	-	773,271	71	-	-
4	361,049	15	-	-	451,221	16	-	-	451,221	16	-	-	592,538	16	-	-	361,049	15	-	-
5	3,202,521	2,297	-	-	4,901,605	2,297	-	-	4,971,231	2,297	-	-	5,659,079	2,297	-	-	3,202,521	2,297	-	-
6	599,782	26	-	-	563,452	25	-	0.35	671,221	25	-	-	889,631	25	-	-	466,575	20	-	-
7	361,388	3	-	-	501,888	13	-	-	530,855	13	-	0.06	528,187	14	-	0.06	352,730	3	-	-
8	706,627	37	-	-	1,142,491	49	1	-	859,913	37	-	0.10	1,117,104	37	-	0.10	689,662	37	-	-
9	819,339	25	-	-	879,254	27	-	-	952,207	27	-	-	861,813	20	-	-	786,546	24	-	-
10	275,596	1	-	-	484,943	11	-	-	496,596	11	-	-	461,805	10	-	-	275,596	1	-	-
11	584,789	7	-	-	879,253	16	-	-	925,282	16	-	-	1,019,329	16	-	-	527,657	7	-	-
12	4,398,473	160	-	-	4,438,359	154	-	-	4,629,134	154	-	-	5,445,997	154	-	-	3,967,555	154	-	-
13	377,244	2	-	-	569,392	9	-	-	585,030	9	-	-	992,964	9	-	-	369,353	2	-	-
14	1,184,288	51	-	-	1,186,323	53	-	0.02	1,713,684	55	-	-	1,519,659	52	-	-	1,026,142	51	-	-
15	1,168,274	264	-	0.16	6,271,889	292	1 ξ	0.25 ξ	5,317,231	292	1 ξ	0.28 ξ	6,842,570	292	1	0.12	1,168,274	264	-	0.16
16	2,275,871	74	-	-	2,207,690	81	-	-	2,402,875	85	-	-	2,940,770	81	-	-	2,129,823	74	-	-
17	2,225,381	37	-	-	1,967,230	37	-	-	3,445,427	44	-	-	2,505,229	41	-	-	2,107,058	36	-	-
18	603,188	8	-	-	712,761	17	-	-	712,670	17	-	-	963,177	16	-	-	529,857	7	-	-
19	1,062,970	21	-	-	1,726,388	29	-	-	1,734,903	29	-	-	942,914	28	-	-	784,373	20	-	-

ξ = decision taken during the first period ($NPV_1 > NPV_2$).

Table 5. The diffusion of SRC consistent with the introduction AECP (UAA allocated to SRC).

Cluster	**BA**				**BA1**				**RE1**				**RE2**				**NO**			
	0	**100**	**200**	**300**	**0**	**100**	**200**	**300**	**0**	**100**	**200**	**300**	**0**	**100**	**200**	**300**	**0**	**100**	**200**	**300**
1	-	-	-	0.05	-	-	-	0.15	-	-	-	015	-	-	-	-	-	-	-	0.15
2	-	-	0.02	0.29 $^{\xi}$	-	-	0.03	0.29	-	-	-	0.20	-	-	-	-	-	-	-	0.17
3	-	-	-	-	-	-	-	0.24	-	-	-	0.24	-	-	-	-	-	-	-	0.22
4	-	-	-	0.15	-	-	-	-	-	-	-	-	-	-	-	0.14 $^{\xi}$	-	-	-	0.14
5	-	-	0.13	0.29 $^{\xi}$	-	-	0.13	0.29 $^{\xi}$	-	-	0.13	0.29 $^{\xi}$	-	-	-	-	-	-	0.13	0.29 $^{\xi}$
6	-	-	0.01	-	0.15	0.15	0.18 $^{\xi}$	0.19 $^{\xi}$	-	-	0.18	0.19	-	-	0.19	0.19	-	-	0.18	0.19
7	-	-	0.01	0.13	-	-	-	-	0.06	0.13	0.05 $^{\xi}$	0.13 $^{\xi}$	0.16	0.19	0.19	0.22	-	-	-	0.26
8	-	-	-	-	-	-	0.21	0.21	0.10	0.19	0.23	0.25	0.10	0.19	0.21	0.21	-	-	0.21	0.21
9	-	-	-	0.36	-	-	0.24	0.24	-	-	0.24	0.24	-	-	0.22	0.22	-	-	0.23	0.24
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	0.01	-	-	-	0.07	0.08	-	-	0.07	0.09	-	-	-	-	-	-	0.05	0.07
12	-	-	0.09	0.28	-	-	0.30	0.38	-	-	0.30	0.12 $^{\xi}$	-	-	-	0.13	-	-	0.24	0.39
13	-	-	-	-	-	-	-	0.16	-	-	-	-	-	-	-	0.16	-	-	-	-
14	-	-	-	-	0.02	0.14	0.36	0.36	-	-	0.36	0.36	-	-	0.38	0.37	-	-	0.08	0.06
15	0.16	0.10 $^{\xi}$	0.10 $^{\xi}$	0.10 $^{\xi}$	0.25 $^{\xi}$	0.28 $^{\xi}$	0.33 $^{\xi}$	0.42 $^{\xi}$	0.28 $^{\xi}$	0.31 $^{\xi}$	0.37 $^{\xi}$	0.46 $^{\xi}$	0.12	0.15	0.09 $^{\xi}$	0.09 $^{\xi}$	0.16	0.10 $^{\xi}$	0.10 $^{\xi}$	0.10 $^{\xi}$
16	-	-	-	0.18	-	-	-	0.09	-	-	-	-	-	-	-	0.37	-	-	-	0.17
17	-	-	-	-	-	-	0.09	0.09	-	-	0.09	0.09	-	-	-	-	-	-	0.02	0.02
18	-	-	-	-	-	-	-	0.00	-	-	0.00	-	-	-	-	-	-	-	0.06	0.04
19	-	-	-	-	-	-	0.15	0.16	-	-	-	-	-	-	-	-	-	-	0.02	0.02

ξ = Decision taken during the first period ($NPV_1 > NPV_2$).

Table 6. Diffusion of biogas plants in case of alternative co-funding measures (Number of plants).

Cluster	**BA**				**BA1**				**RE1**				**RE2**				**NO**			
	0	**0.25**	**0.50**	**0.75**	**0**	**0.25**	**0.50**	**0.75**	**0**	**0.25**	**0.50**	**0.75**	**0**	**0.25**	**0.50**	**0.75**	**0**	**0.25**	**0.50**	**0.75**
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1^{ξ}	1^{ξ}
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1^{ξ}	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	1	1^{ξ}	1^{ξ}	1^{ξ}	1	1^{ξ}	1^{ξ}	1^{ξ}	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1^{ξ}	1^{ξ}	-	-	-	-
14	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	1^{ξ}	1^{ξ}	1^{ξ}	1^{ξ}	1^{ξ}	1^{ξ}	1^{ξ}	1^{ξ}	1	1	1^{ξ}	1^{ξ}				
16	-	-	-	-	-	-	-	-	-	1	1	1^{ξ}	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	1	1	1^{ξ}	-	-	-	-	-	-	1	1
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ξ = Decision taken during the first period ($NPV_1 > NPV_2$).

Our results show that under BA entering the agroenergy market would be profitable for cluster number 15 only, which would be eager to allocate a relatively high share of UAA to SRC. Cluster number 15's demand for land would consequently increase due to the profitability of SRC as a farming activity. Cluster number 15 would decide to implant the SRC in the first period rather than in the second one, hence, the simulated uncertainties do not seem to affect the cluster's decision. Under BA, cluster 15 gets no CAP payment and does not need to allocate any land to COP to earn the entitlements. According to our results, all clusters, but number 15, are not willing to change their production systems or to get involved into the agroenergy market. Under BA, the model show amounts of UAA relatively close to the current surface of land operated, thus returning a quite reliable model validation.

Moving to Ba1, that mirrors the CAP post-2013 reform, the model show that three clusters (C6, C14, C15) would decide to increase the share of land allocated to SRC and that two clusters (C8, C15) would decide to implement a biogas plant on farm. The models show different timings for the adoption of the new activities at the clusters' level. While cluster 15 would decide for prompt adoptions of both biogas plant and SRC, cluster 8 would decide to implement a biogas plant in the second period and clusters 6 and 14 would decide to implant a the SRC in the second period as well. The outcomes of the model show that clusters 14, 15, and 6 would allocate different shares of UAA to SRC, respectively 2%, 25% and 35%. With respect to cluster 15, the decision to implement a biogas plant can be explained with the availability payments under Pillar I. The BP is a source of liquidity ready to be reinvested in agriculture, thus allowing to avoid loans. Cluster 8's unitary entitlements are over 30% reference payment; such a high BP payment raises the willingness to pay for additional land to be cultivated with feedstock for biogas production.

The "regionalised" scenarios (RE1, RE2) show the outcomes of two alternative systems of BP convergence. The model highlight few differences between RE1 and RE2 due to the levelling of the BPs in 2020. The shift to regionalised payments would raise the profitability of SRC for two arable clusters (C7, C8) and for a livestock cluster (C15). Clusters 7 and 8 show a 12 hectare reduction in the operated land. Cluster number 8 would decide rather to allocate a share of its UAA to SRC than to implement a biogas plant on farm, due to lower unitary payments during the first period which bring the willingness to pay for additional land down. For cluster 7 cultivating SRC on a notable share of UAA would not be profitable until the beginning of the second period, due to higher payments. Cluster 15 only would find both options (*i.e.*, dedicating a share of the UAA to SRC and implementing a biogas plant on farm) profitable at the same time; however, the two options would be set in place with different timings. In fact, RE2 do not encompass any payment within the first period; the subsequent decrease in farmers' liquidity would negatively affect their decision to undertake timely investments. On the contrary, under RE1, cluster number 15 would invest in biogas plants in the first period.

Moving to CAP-abolishment scenario (NO), our results show that farms within cluster 1 only would find profitable to implement a biogas plant on farm. With no CAP, farms would reduce the share of UAA dedicated to COP, due both to the lack of entitlements and to the abolishment of cross-compliance commitments, such as, for example, the maintenance of permanent grassland and nitrogen uses constraints. The lack of those compulsory commitments and the less profitability of COP decrease the opportunity cost of the cultivation of feedstock for biogas plants.

Table 5 displays the effects of the introduction of payments in support to SRC under the measure "agro-environmental climate" of the RDP 2014–2020, in terms of percentage of UAA allocated to SRC per farm.

The introduction of AECP can significantly boost the diffusion of SRC in the farms of the province of Pisa. Conversely, SRC struggles to spread without the payments.

According to the results of our work, the policy scenario is able to affect the attractiveness of SRC for farmers, as level of support is tightly linked to the SPS applied. Hence, thanks to the introduction of the AECP, BA1 would raise the share of land allocated to SRC per farm. SRC would increase in most arable clusters, *i.e.*, C1, C2, C3, C5, C6. Those clusters are sensitive to the AECP measure and gradually increase the share of SRC within their UAA. Clusters 1 to 3 would decide to allocate a share of UAA to SRC in the second period, while clusters number 5 and 6 would adopt the new type of farming in the first time span, due to high payments. Waiting to see how the state of nature evolves would be less profitable with higher AECPs, thus determining a more timely decision. Farms owing to cluster 5 would promptly adopt SRC, as during the first period their type farming had allowed payments; the resultant liquidity would be used to realise an investment.

Due to the higher returns for vegetable and fodder crops, SRC is viable over marginal land or in case of higher payments per hectare UAA only. As a result, SRC is barely spread among livestock and vegetable clusters. Only raising the payments up to 300 € per hectare would boost the diffusion of SRC.

The outcomes of the model show that the shift from the historical to the regional model and higher AECPs would make more profitable to anticipate the investments in SRC, even if the share of UAA allocated to SRC is low. In fact, waiting for the state of nature to evolve has no option value.

For clusters number 5, 7, 12, and 15, higher payments would allow to anticipate the adoption of SRC in the first period, as the investment would be more profitable and uncertainty would not significantly affect the profitability.

The results of our research suggest that the abolishment of the CAP (NO) would be able to promote the diffusion of SRC only if tied to a simultaneous raise in AECPs. Providing SRC with higher support would help this type of farming to widespread, while lowering COP's profitability. Linking NO with higher AECPs would raise up to 39% the share of UAA that arable clusters allocate to SRC.

Table 6 displays the effects of the co-funding measure (article 17) of Tuscany's RDP 2014–2020 [26] on the decision of the farms of the province of Pisa (Tuscany, Italy) to implement a biogas plant on farm. Our results show the ability of that policy measure to boost the implementation of biogas plants on farm and agree with the findings of [25]. Under the conditions of our simulation, the co-funding measure would lead only arable and livestock clusters to build biogas plants on farm. Under Ba1, clusters 8 and 15 only would find such an investment profitable, assuming a low share of co-funding; however, the investments would have different timings. A higher share of co-funding would improve the timing of the adoption of the new technology. The combination of an increased confidence provided by the BPs with lower investment costs reduce farmers' uncertainty. Our results suggest that raising the co-funding to 50% investment costs would make the implementation of a biogas on farm profitable for cluster 14 as well. However, the investment should be delayed to the second period.

Under both "regionalised" scenarios, most livestock farms would find profitable to implement an anaerobic digester on farm even with low share of co-funding. The analysis of both scenarios illustrates that increasing the level of co-funding to 50% investment costs would raise the profitability of biogas plants for cluster 2 as well. A further increase to 75% investment costs would anticipate the decision to adopt the biogas plant in the first period.

Compared to the SPS, the payment based on the regionalised model would grant more extensive farms higher payments. In fact, under that scheme the entitlements are allocated for each hectare UAA; as a result, investing in the implementation of an anaerobic digester on farm would be more profitable for extensive than for intensive farms. According to our results, the implementation of a biogas plant on farm depend on the availability and on the amount of payments under Pillar I. The payments allow liquidity that is ready to be reinvested. Our work confirm the research findings of [25]. Our results show that no cluster, but numbers 1 and 17, would find profitable to invest in biogas plants. Clusters 1 and 7 would find such an investment profitable due to the abolishment of some cross-compliance requirements, *i.e.*, the maintenance of natural grassland and the limits on the spread of manure fixed by a ratio between the number of livestock and the hectares of UAA).

6. Discussion

On 1 January 2015 the CAP 2014–2020 would be in place. Thus, to date, we have observed the outcomes of the CAP 2007–2013, drawn on the 2003 reform. Mainly, the CAP ante-2013 was designed to open the market to European agricultural products and to remove the coupled payments. Even though that policy involved the promotion of RE, to date the spread of agroenergy in Tuscany is extremely low. According to the Italian Census 2010, no biogas plant is operated within the province of Pisa and SRC is practiced on few hectares only. The CAP 2007–2013 missed a measure aimed at promoting the bioeconomy and agroenergy as a way to boost the multifunctionality of agriculture.

The results of our research confirm that under the CAP ante-2013 few farm types only were interested in entering the agroenergy market, even in case of specific payments or co-funding systems. That was mainly due the lack of liquidity for financing the investment; actually, the farms operated within a costly and imperfect capital market. Farmers' lack of interest in agroenergy was also due to the allocation of entitlement on a historical basis, which raised COP's profitability.

The European growth strategy towards 2020 strongly supports the bioeconomy and the diffusion of agroenergy. Drawing on "Europe 2020", the CAP 2014–2020 sustains agroenergies. According to our results, investing in agroenergy would become a profitable option for the farmers of the province of Pisa (Tuscany, Italy) due to higher liquidity. The profitability is even higher for those farms which are being awarded BP entitlments for the first time. That is because the a hundred per cent old historical entitlements would be replaced by new "regional" entitlements. One entitlement would be allocated for each hectare of UAA.

The model results highlight that cultivating SRC as a cash crop to be sold to the agroenergy market is a viable strategy for farmers that operate under uncertain inputs' costs or outputs' prices; that strategy allows higher income stability and lowering the dependence on the seasonality and the fluctuation of prices.

With respect to arable farms, SRC is a relevant option for differentiating the production while complying with the "greening" requirements. However, for those farms investing in anaerobic digesters on farm is less profitable than for the livestock farms, whereby potential demand for biogas plants is relatively high. Having a biogas plant on farm can benefit livestock farmers by allowing them to use manure and slurry as feedstocks for the digester. Feeding the digester with such byproducts avoid land use competition by first generation energy crops. However, the implementation of a biogas plant on farm does not solve the issue of adding value to marginal land, when the farm uses livestock byproducts as feedstock. The ability to add value to marginal land has been one of the main arguments in favour of the diffusion of biogas [13].

The provision of a static picture is a methodological flaw of our approach. This avoids the proper simulation of all the dynamics that drive the changes in land prices, as the model is based on fixed parameters. An increase in land demand for energy feedstocks affects the rental prices of land. Cultivating land with energy feedstocks allows a supply for agroenergy plants. An increase in the willingness to pay for land to be cultivated with biomass intended for supplying biogas plants would increase land rental prices; an additional outcome is the high probability of an increasee in the cost of energy feedstocks.

Moreover, the static nature of the model does not allow a clear picture of the contribution of the measures under Tuscany's RDP 2014–2020 to the diffusion of agroenergy in the province of Pisa for two main reasons. Firstly, we assumed that Tuscan farmers would not compete for RDP funds. Secondly, we presumed no transaction costs, such as participation costs, that could prevent farmers to apply for RDP funds. When one or both hypotheses are not verified, farmers would fail in getting public support, and agroenergy would undergo a sub-optimal diffusion.

Our research show that most farmers who would invest in agroenergy would take the decision in the second of the proposed time spans. This is due to the higher option value of the waiting strategy compared to the decision to anticipate the investment. Waiting for a favourable state of nature allows higher confidence in the investments. This result is not surprising if we consider that in recent years agricultural prices have been affected by high volatility and that agriculture has lower margins than other sectors.

7. Conclusions

We analysed the potential impact of the CAP post-2013 by simulating the changes in both the first and second pillars and prospecting five scenarios. Within Pillar I, we focused on the shift from historical to regionalized payments, while within Pillar II, we investigated the introduction of both the agri-environmental-climate payments and the co-funding system for investments in biogas plants on farm.

Our results highlight that the CAP can significantly affect the diffusion of RE and is in line with existing research literature. Thus, we confirmed that the policies under both Pillar I and II can help farmers entering the agroenergy market and stressed the difference between the adoption of alternative types of farming.

According to our research, the farms owing to the arable cluster would be eager to allocate a share of UAA to SRC. Conversely, non-arable farms would rather keep the *status quo* and consider SRC as a mere option for cultivating marginal land. Thus, including SRC in arable farms would be viable. The strategy to earn as much as possible from AECPs can lead farms to allocate a high share of their UAA to SRC. Within the province of Pisa (Tuscany, Italy), the option to implement an anaerobic digester for biogas production on farm is relevant and viable for livestock farms only.

The diffusion of renewable energies is among the Europe 2020 objectives. Our research suggests that the new instruments of the CAP 2014–2020 can increase the share of renewable energies in Tuscany. Our paper highlights that a more liberal strategy at the EU level, with the abolishment of the CAP, would lead to even higher shares of RE. Abolishing the CAP would negatively affect the farms' income, thus investing in agroenergy would be strategic to ensure the profitability of the agricultural systems.

Some positive externalities of biogas plants on farm are as follows: (i) the anaerobic digestion of crops residues and manure prevents nutrient leaching; (ii) the agricultural application of the digestate as a fertiliser reduces the need for chemical fertilisers; (iii) the solid and fibrous fraction of the digestate may be used as a soil conditioner to increase the organic content of depleted soils [37].

The main shortcomings of our work are due to the type of agent simulated and to the rigidity of the model. We simulated the clusters which are not able take into account farmers' features and pathways, thus failing to take into account all the existing variability within all types of farming of the area under study. Consequently, we were not able to highlight the correct farm strategy, as it encompassed taking into account the social capital and the networks with other famers. Moreover, we considered two time spans. That decision is coherent with the policy framework, but creates rigidity within the model.

Further research in this field should simulate the decision on an annual basis, thus evaluating the decisions about different investment options over multiple time spans.

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Author Contributions

Fabio Bartolini wrote Sections 3 "Methodology; 4.1 "Farm model specification" and 5 "Results"; Luciana G. Angelini, wrote Section 4.2 "Simulation of Investment in RE"; Gianluca Brunori wrote the Sections 4.3 "Selection of Representative Farming Systems" and 4.4 "Scenario Analysis"; Oriana Gava wrote sections 2 "Overview of the Agroenergy Framework within the EU Strategy towards Bioeconomy and the CAP 2014–2020" and 6 "Discussion". Introduction and conclusion are common to all Authors.

Annex: Nomenclature

Acronym	Meaning	Acronym	Meaning
GHG	Greenhouse Gas	U	Utility
RE	Renewable Energy	$\prod$	Income
EU	European Union	s	Savings
CAP	Common Agricultural Policy	GP	Greening Payment
RDP	Rural Development Programme	AECP	Agro-environment-climate Payment
BPS	Basic Payment Scheme	Fin	Financial income
SPS	Single Payment Scheme	Oin	Off-farm activities
SFP	Single Farm Payment	kloan	Annual payment of loan received

SRF	Short Rotation Forestry	UAA	Utilised Agricultural Area
SRC	Short Rotation Coppice	FTE	Full-time Equivalent worker
BP	Basic Payment	LU	Livestock Unit
NPV	Net Present Value	BA	Baseline scenario
cf	Cash flows	BA1	CAP-post 2013 scenario
K	Cost of investments in RE	Re1	Regionalised scenario 1: full Convergence in 2015
I	Discount rate	Re2	Regionalised scenario 2: full convergence in 2020
	Probability to benefit a state of nature favourable to the adoption of RE	NO	CAP-abolishment scenario
§	Subscript indicating that a decision was taken	COP	Cereals, Oilseeds and Protein crops
C	Consumption time	bp	Biogas Plant
L	Leisure time		

Conflicts of Interest

The authors declare no conflict of interest.

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