CAP-IRE

Assessing the multiple Impacts of the Common Agricultural Policies (CAP) on Rural Economies
(FP7 SSH - 216672)

Real Option Models for simulating digester system adoption on livestock farms in Emilia-Romagna

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Outline

- Objective
- Background
- Theoretical model
- Empirical Analysis
- Discussion

Objective

- To develop a dynamic farm household model able to simulate the methane digester system adoptions under uncertainty in the decision variables and prices volatility
- To assess the impact of policy changes on the methane digester system adoptions

Background (1)

- New technology adoption and innovation diffusion are two elements of the firm development and growth process

- Innovation adoption and the re-organization of agri-food chains are two priorities of the Health Check.
- With Health Check Climate change issues and bio-energy production have been included in the environmental EU priorities
- Bio-energy production
  - Represents a topic of increasing importance in the European Policy Agenda
  - Priority topic for experts involved in the Local Participatory Network within WP4 (innovation and structural changes) CAP-IRE project
  - At farm level represent an opportunity to increase, differentiate and stabilize farm income

Background (2)

- Adoption of innovation /new technology simulated under two different approaches:
  - Econometric Models
  - Mathematical Programming Models

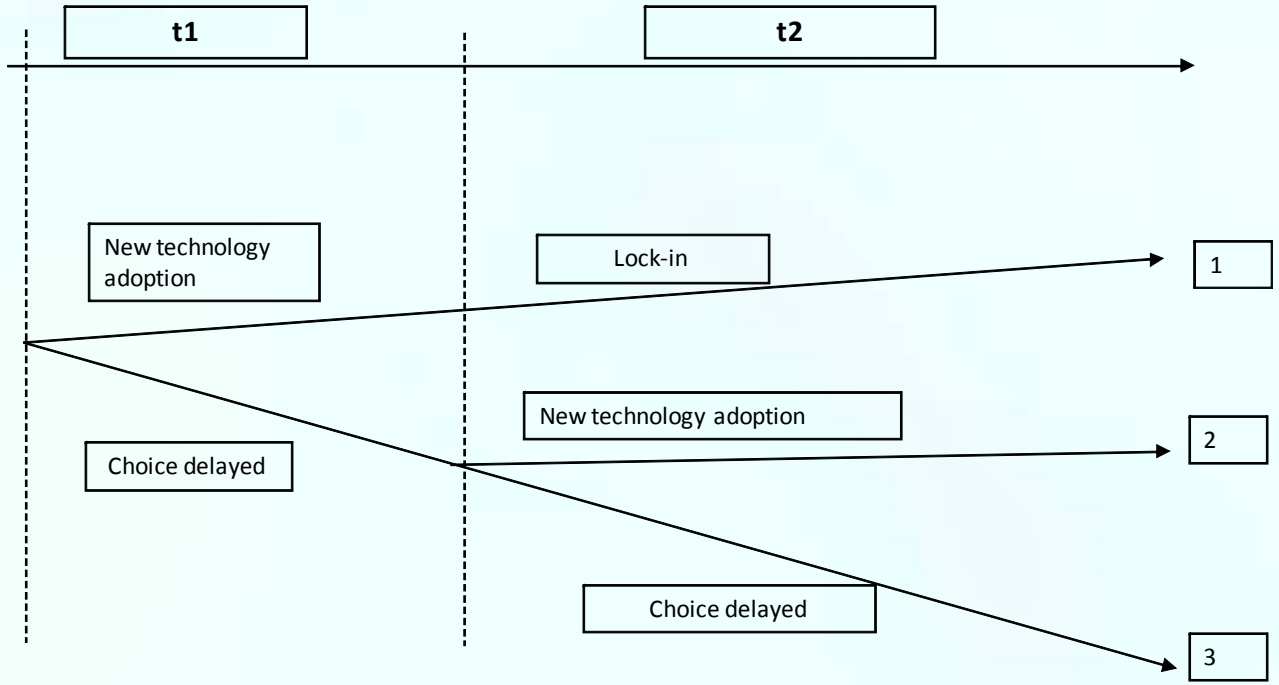
- Among the mathematical programming models, Real Options is an arising topic
- RO improve the investment decision analysis when decisions concern the adoption of new investment are undertaken under uncertainty in decision variable and the innovation has degree irreversibility (high investment cost, sunk costs...)

- With RO the adoption of new technology is treated as a financial call option (adoption is postponed until the DM has more information)
  - The opportunity to postpone the investment until circumstances become favourable can determine an increment of investment value (option value)
  - Enables combining the classical capital budgeting approach with the decision concerning the optimal timing for the adoption of a new technology

Theoretical model (1)

Two time on which to adopt a new technology (period 1 and period 2)

Decision variables value : know in t1 and stochastic in t2



Theoretical model (2)

Choice determined by:

$$\mathrm{NPV} = \max\left(NPV_1, NPV_2, NPV_3\right)$$

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

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

$$NPV_3 = \sum_{0}^{t1} \frac{cf^{t1}}{(1+i)^t} + \sum_{t1+1}^{t2} \frac{\gamma \overline{cf^{t2}} + (1-\gamma)\underline{cf^{t2}}}{(1+i)^{t1+t}}$$

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;

γ = probability to have a methane digester favourable state of nature

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

inn = subscript that means the adoption of the methane digester

Empirical Analysis

- Adoption of a methane digester system among 5 alternative typologies diversified by maximum energy power produced:
  - Min. 108 kW/h
  - Max. 972 kW/h
- Model tested in representative farm households specialised in livestock production in province of Bologna
- 3 representative farm households have been identified using Cluster Analysis

Empirical Analysis
Representative FH characteristics

Group Code	Dairy Cows (#)	Beef Cows (#)	hh labour (# full time equivalent)	Non-hh labour (# full time equivalent)	Land owned (ha)	Land rented-in (ha)	# of Farm – hh in DB (%)
c_1	6.67	4.96	1.96	0.25	12.46	10.13	77.42
c_2	-	130.00	3.50	1.00	192.50	10.00	6.45
c_3	126.00	2.00	2.30	1.50	45.20	36.00	16.13
All	49.96	37.29	2.18	1.05	48.00	21.81	100.00

Empirical Analysis
Model specialisation

- Farm Household model

Max NPV of cash flows $$cf_t = \Pi^t_{onfarm} + \Pi^t_{offfarm} - C^t_r$$

With: $$\Pi^t_{onfarm} = \theta\pi^t_c + \pi^t_m + \theta\pi^t_e + RDP^t + \theta SFP^t - C^t_l - C^t_{eb}$$

$$\Pi^t_{offarm} = Fin^t + Pens^t + Oin^t$$

- Time horizon until 2030
- Two period model
  - t1 2010-2013
  - t2 2014-2030

Empirical Analysis
Treatment of uncertainty (1)

- Three stochastic parameters have been assumed:
  - Energy price
  - Crop prices
  - Amount of SFP
- Amount of parameters for a generic year t follow this relation:

$$S^{t2} = S^{e} dt \pm \sigma dz$$

S^{t2} is the parameter value during the year *t*;

S^{e} is the expected parameter value (known at the first period)

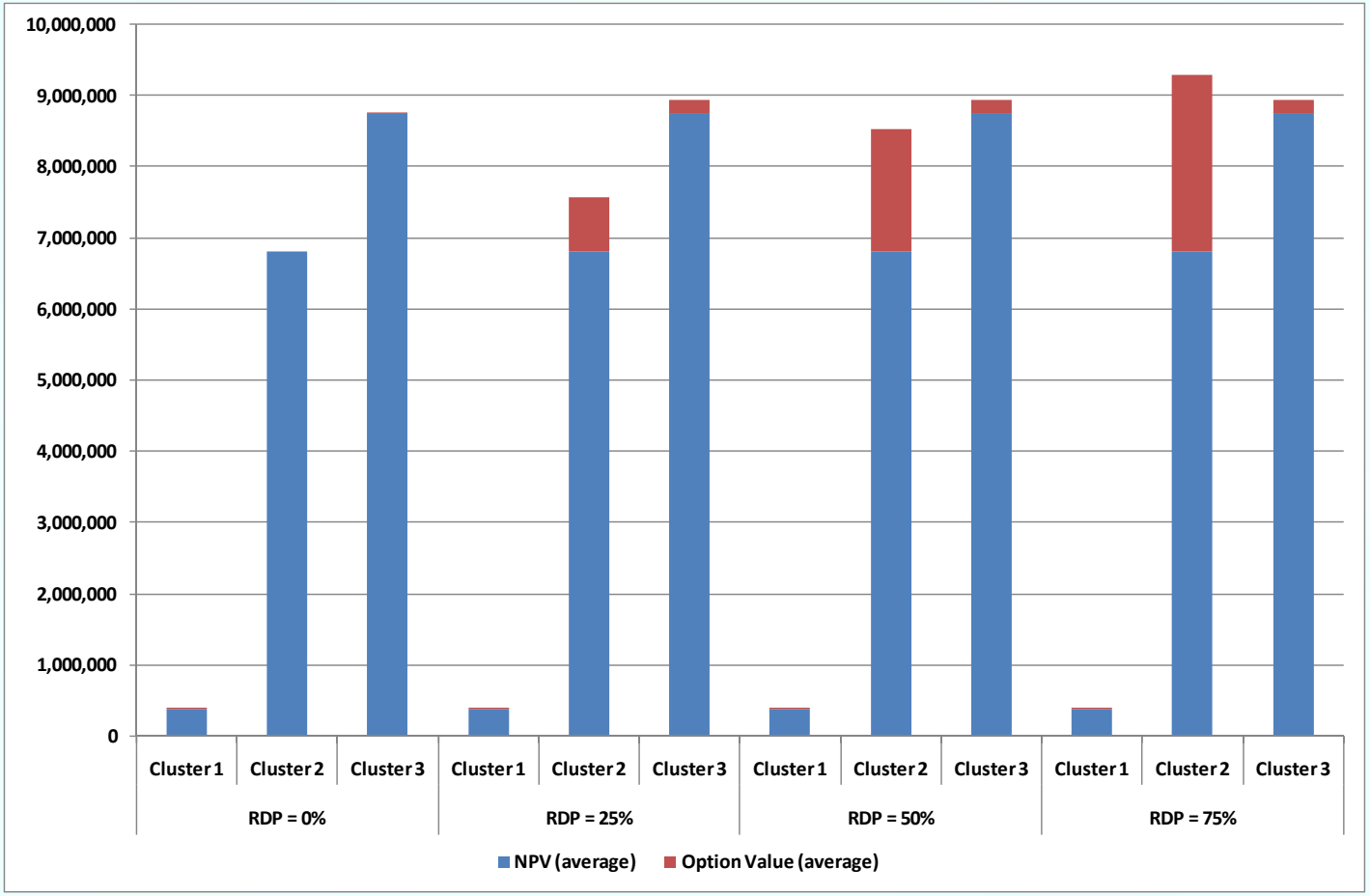
σ is the oscillation (known at the first period)

dz is the random variable uniformly distributed with minimum value 0 and maximum value 1 (simulated *via* Montecarlo Model)

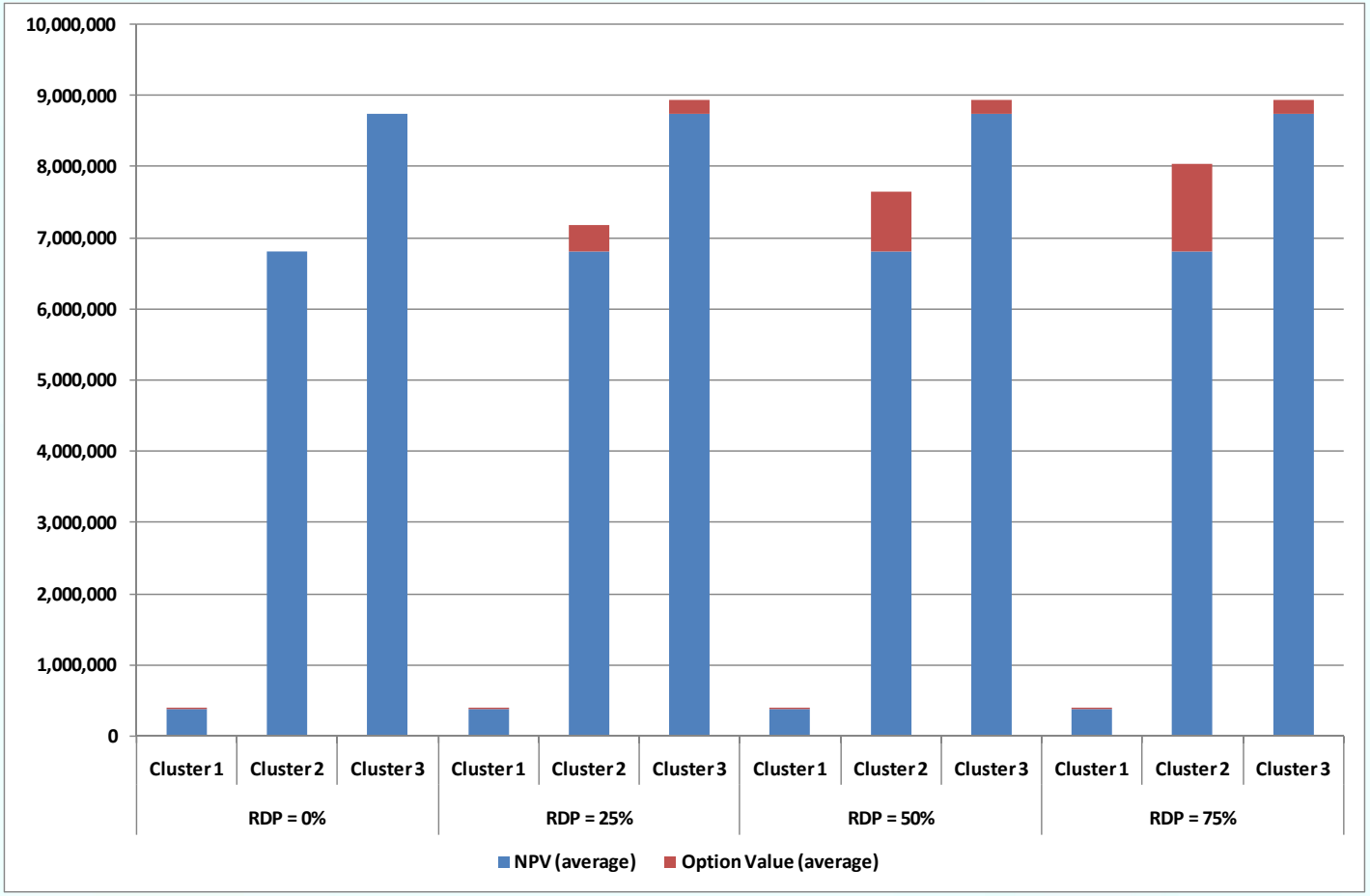
Empirical Analysis
Treatment of uncertainty (2)

- SFP
  - Average value ½ of current amount
  - Oscillation between current and 0
  - Change in the second period
- Energy price
  - Follow minimum guaranteed price set by Italian government, not lower than 0.22 per kW
  - Average price is current price (0.28 per kW)
  - oscillation = 0.06 € per kW
  - Renegotiation every three years
- Crop prices
  - Average value from Outlook of Agricultural Prices for the next 10 years
  - Oscillation = SD of prices value from Outlook of Agricultural Prices
  - Change each year

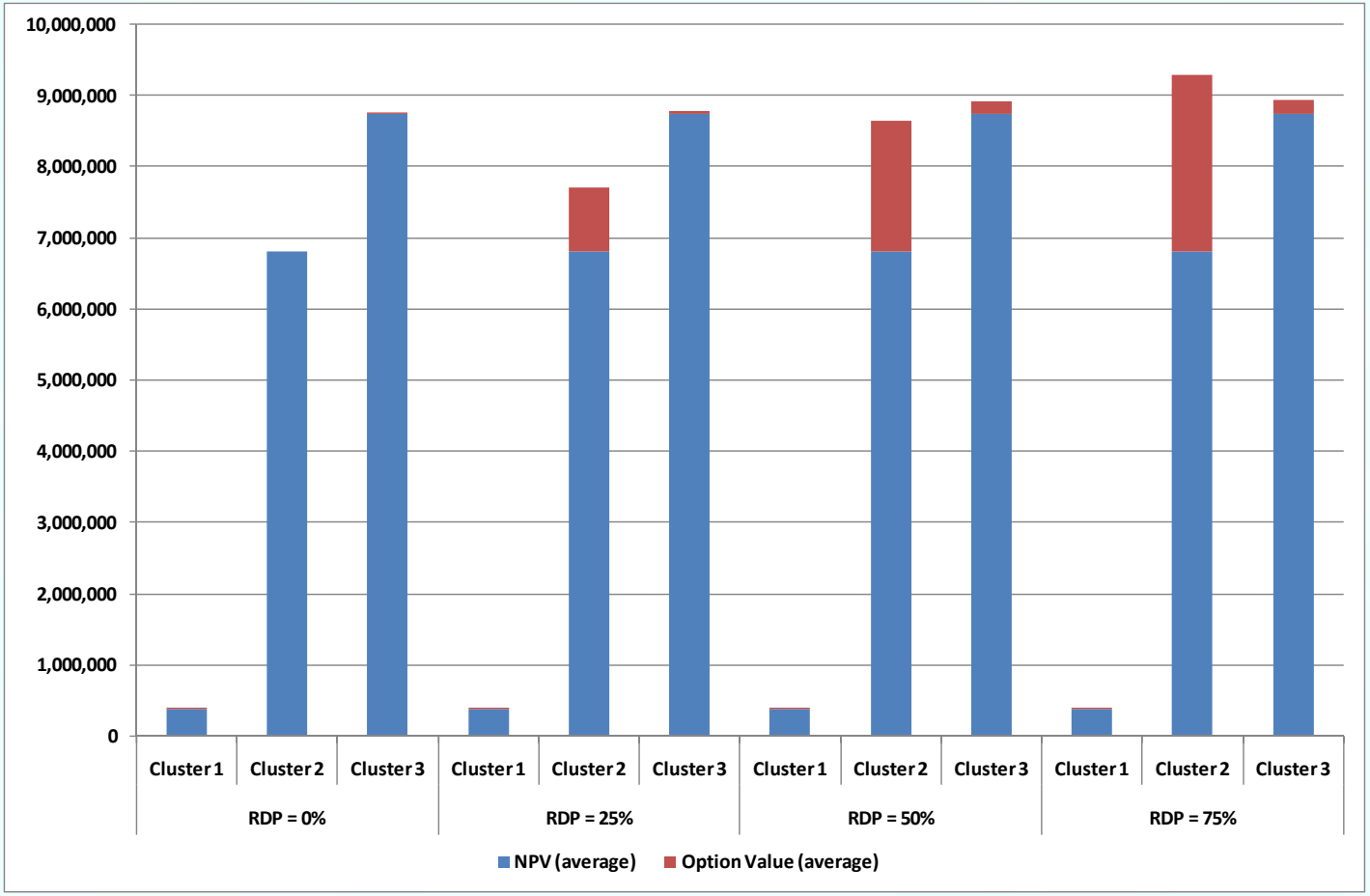
Results
Uncertainty in SFP



Results
Uncertainty in crop prices



Results
Uncertainty in energy prices



Discussion

- Model with strong assumption in timing and in uncertainty (two situations)
- Relevance of uncertainty in SFP and energy prices in determining the timing of adoption
- Uncertainty has the effect of postponing the investment until farmers have more information
- Positive effect of the RDP payment in the adoption of methane digester
- RDP needed for adoption of Methane Digester or specific policy (low farm-household liquidity and high cost of loan with respect to farm profit)

Future development

- Improve the logical structure of the decision with more articulated choice option
  - Decision in more than two period
- Improve the model in:
  - Adding volatility in the milk prices
  - Simulating different investment costs and methane digester efficiency over time
  - Improving the RDP participation (adding different participation and transaction costs and a probability to be excluded by the payments)

Thank-you for your attention

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