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Option values of low carbon technologies policies.

How to combine irreversibility effects and learning effects?

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Content

1. Introduction

1. Model*

3. Option value with learning

4. Conclusion and policy implications

Because of learning effect, flexibility can increase with earlier investment.

1. Introduction

Issue of market pull deployment of low carbon technologies LCT

- Long and complex innovation chain for CCS, new nuclear, large scale renewables;
- They should cross the « death valley »;

→learning-by-doing should be expected from initial deployment of LCT after demo stage

→learning spill-over justify a policy intervention to trigger LCT deployment.

to be economically ready in case carbon price high

Uncertainty:

Numerous uncertainties surrounding the future competitiveness of LCT:

- on the cost and learning rate of LCT;
- on the costs of alternative technologies:

Uncertainty on climate policy and the price of carbon in the second period

Uncertainty on the price of fuel

1. Introduction

Literature

- Option value & irreversibility:

  Arrow & Fisher (74) , Henry (74):

  By replacing the initial random problem, even a risk-neutral decision maker facing a binary alternative is led to adopt an irreversible decision more often than he should

  Option value + Irreversibility = « irreversibility effect »

- Option value & investment:

Not investing keeps the option to invest later, and wait for information.

- literature on investment and uncertainty (McDonald and Siegel 1986, Pyndick 1991)
- Option value is the addition of the value to wait and the value of acquisition of the information

Literature

Option value on policies aiming to limit global warming

Ulph and Ulph (1997):

– Does option value imply more or less emissions today?

Kolstad (1996):

– « Irreversibility effect » justify to postpone investment in clean capital.

Loshel (2008):

With uncertainty on a backstop technology (CCS) and externalities due to technology diffusion of competing technologies (Renewables),

there is a negative value of information in a CCS policy

Schimmelpfennig (1995)

In another perspective it will be convenient to be ready with LCT if the CO2 cost is much higher than (Investment R&D)

2. Method

- A simple model with two time steps and two technologies:
  - LCT and Carbon technologies in elec systems*

- To identify the optimal investment of LCT during the first period:

LCT is not competitive during period 1 and could be so during the second period, thanks to quantity of LCT during period 1:

lower cost during period 2 and higher cost of alternative technolgies

- Comparison of a situation of non- acquisition of information in period 2 (*Myopic behaviour / ignorance of information acquisition*)

  with a situation in which we know in period 1 that information will be acquired in period 2

2. Model

- Two times periods : 1, 2

- Demand for electricity:

$$D_1,\ D_1+D_2$$

- Two technologies:

1. Low carbon technology LCT

   Marginal costs : c_1 and c_2

2. Carbon emitting technogy (called « alternative »)

   Marginal costs: γ_1 and $\gamma_2+\theta$ with uncertainty on θ

2. Model

- Learning by doing:

  Quantity of LCT built in the first period: x

  Second period cost depends upon quantity x of the first period:

  $c_2(x)$: *decreasing and convex.*

- Uncertainty:

  The second period cost of the alternative technology is random:

  $\gamma_2+\theta$

  $\theta=\theta_h>0$ with probability π

  or $\theta_l<0$ with probability $1-\pi$

  $E[\theta]=0$

2. Model

- First period:

  choice of *x* LCT plants

  → Cost of period 1: $c_1 x + \gamma_1 (D_1 - x)$

- Second period:

  choice of a technology for the remaining plants of a total capacity D2

  → Cost of period 2 : $\min\{ c_2(x), \gamma_2 + \theta \} D_2$

Total cost:

$$C(x, \theta) = c_1 x + \gamma_1 (D_1 - x) + \min\{ c_2(x), \gamma_2 + \theta \} D_2$$

3. Option value with learning

- Ignorance of acquisition of information in 2 (with certainty)

$$\text{Min } C(x, 0),$$

The decision maker considers the expected value cost of the alternative when making his choice;

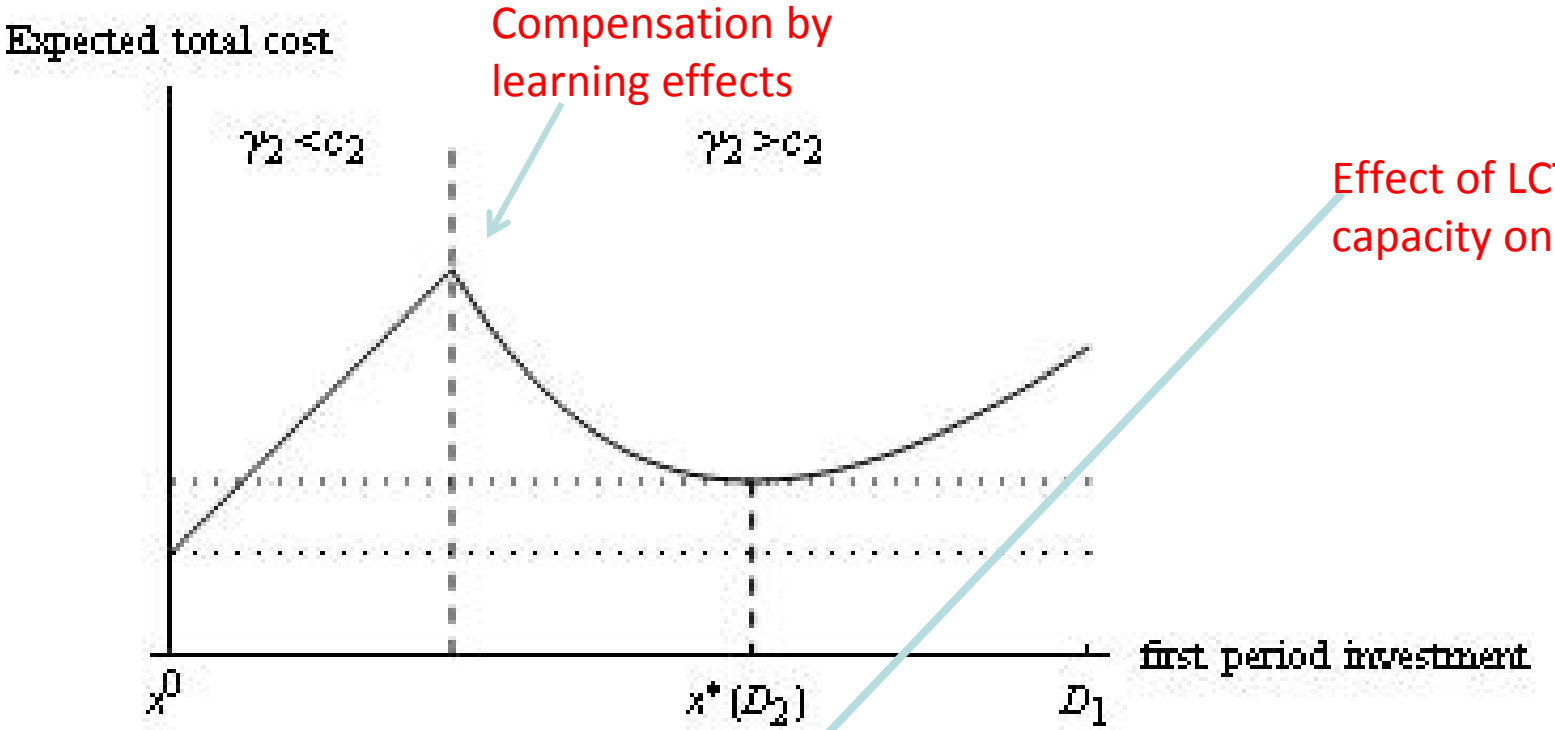
He does not anticipate that he could choose whether to use LCT or not knowing the **true** cost of the alternative.

- Acquisition of information in 2 (with uncertainty):

$$\text{Min } E[C(x, \theta)],$$

The decision maker anticipates that he will receive information before choosing.

Effects of learning by doing in situation of ignorance of information acquisition



There is a strictly positive quantity of LCTplants built if

$$\gamma_2 > \Gamma = c_2(x^*) + (c_1 - \gamma_1)\, x^* / D_2$$

Influence of the second period quantity

What effects of learning by doing ?

- Marginal comparison of costs is not sufficient .

  The condition: $\gamma_2 > \Gamma$ means that we need an overall comparison of costs : Non convexity due to learning

- A strictly positive quantity of LCT develops if learning effects are important to compensate for losses due to overcost of LCT during the first period

- Optimal LCT quantity x* depends both on learning rate and increase of demand D_2

Situation of uncertainty (acquisition of informations)

- If the alternative technology reveals itself cheaper than expected , then LCT are not competitive and the learning effects are « lost » (with LCT overcost period 1)

- But, if the alternative technology reveals itself more expensive than expected and LCTcompetitive,

  learning effects are « unexpectedly » valuable.

→ More or less LCT between case with info and myopic case?

From Myopic Case (without info) to case with info acquisition (uncertainty)

1. If $\gamma_2 < \Gamma$, LCT are developed without info.,
   there is less LCT with info than without info
   because the technology could reveal useless.

   The « irreversibility effect » hold.

From myopic case (without info) to case with info acquisition (uncertainty)

2 If $\gamma_2 > \Gamma$, LCT are not developed without info. acquisition ,

& there is a strictly positive quantity of LCT built **with info acquisition .**

Result holds when important learning rate ($C_2 > C_1$) and high demand growth D_2 : $C_2(x^*).D_2$

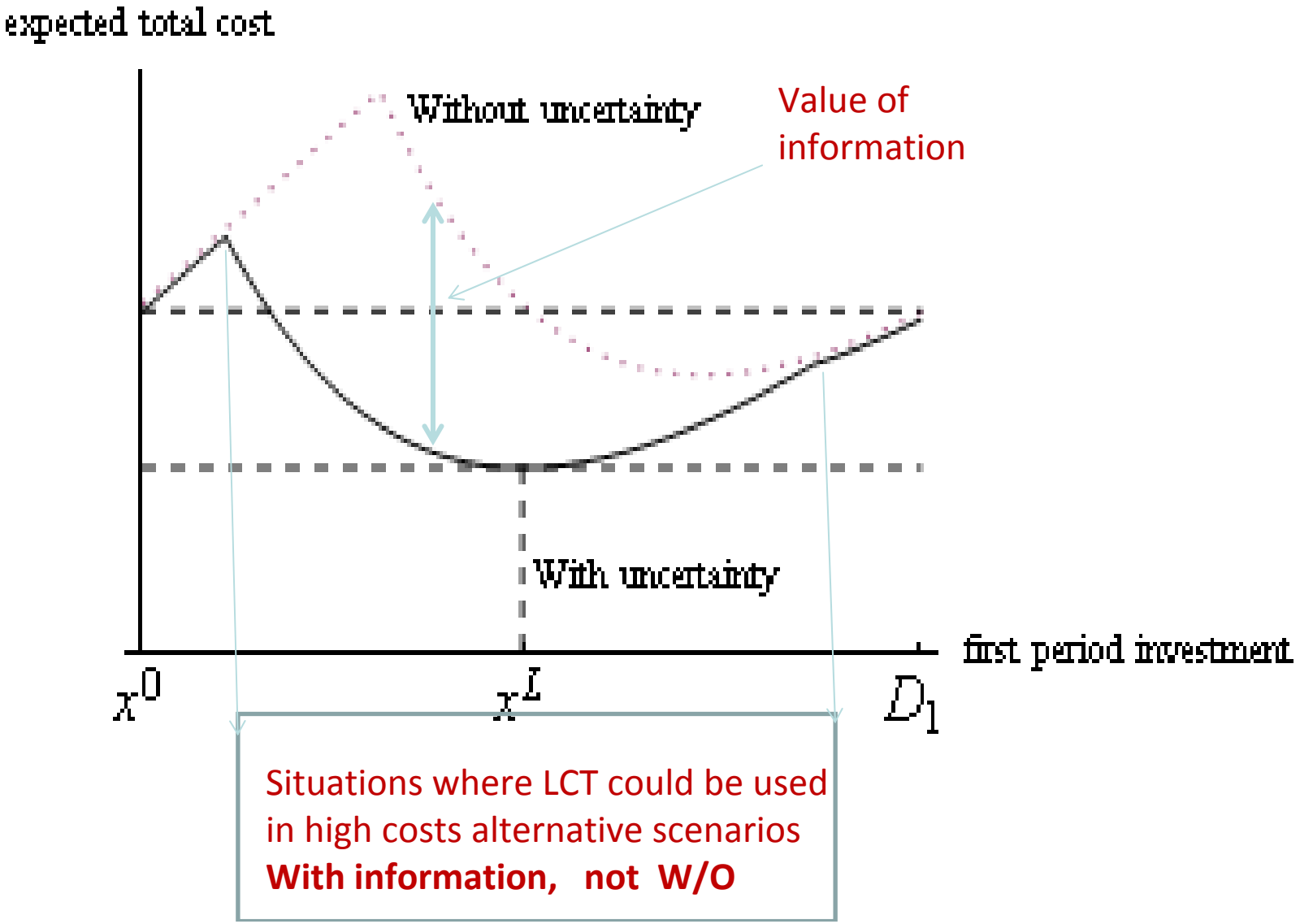
$$c_1 - \gamma_1 < \pi D_2 \frac{\partial c_2(0)}{\partial x}$$

$$\gamma_2 + \theta_l < c_2\left(x^*(\pi D_2)\right),$$

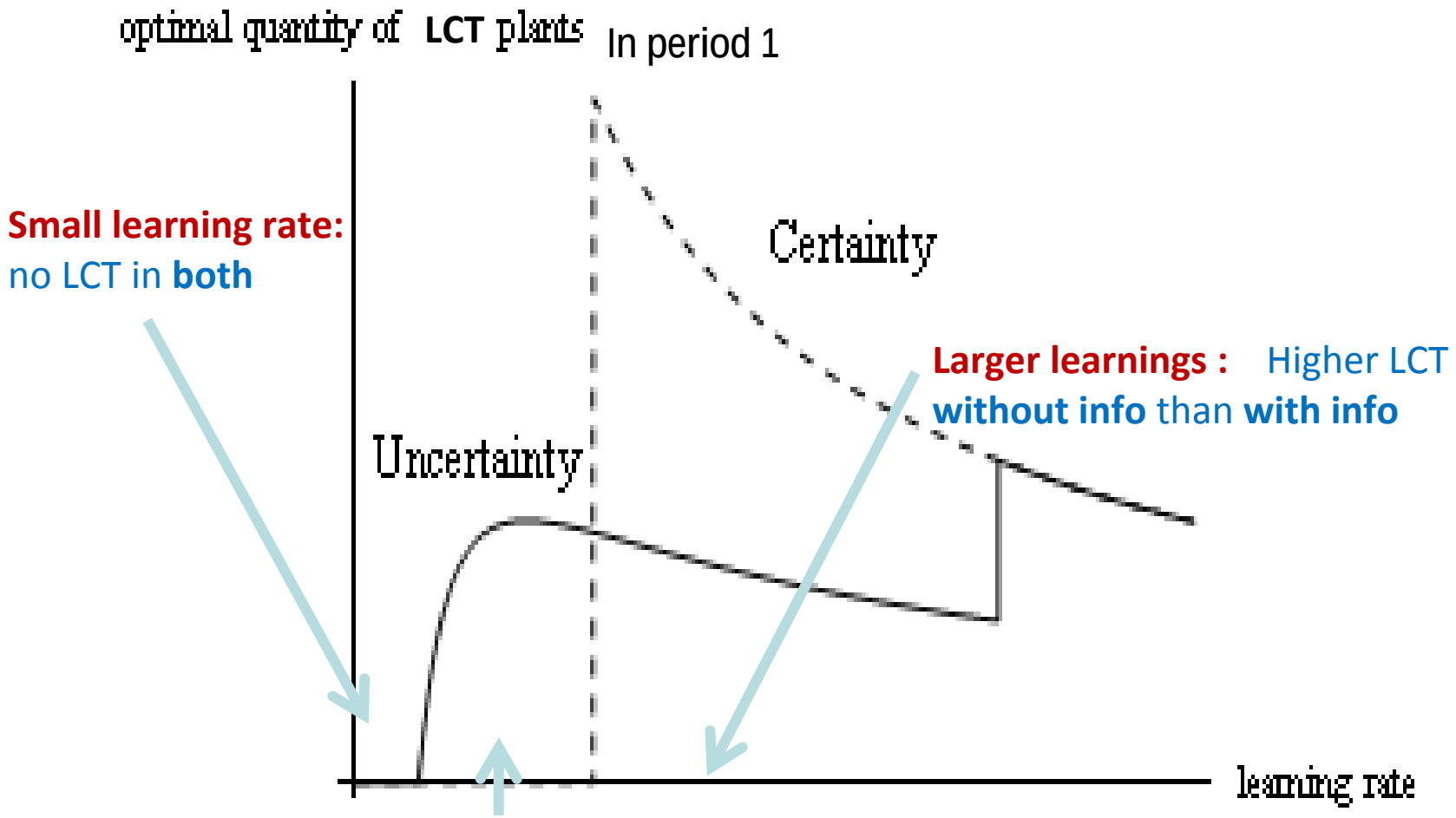
$$\gamma_2 + \theta_h > c_2\left(x^*(\pi D_2)\right) + \frac{c_1 - \gamma_1}{\pi D_2} x^*(\pi D_2)$$

There is an option value of having the possiblity to have economic LCT

With acquisition of info versus Without acquisition of info.



Effects of different learnings on LCT capacity invested in period1



Small learning rate:
no LCT in **both**

Larger learnings : Higher LCT **without info** than **with info**

Intermediate learnings:
- some LCT plants **with info,**
- no LCT plant **without info**

4. Conclusion 1

Application to another story : the CCS case fater demo stage

More stringent climate policy (urgency): phasing out all carbon thermal plants and banning on new capacities

CCS versus leading non-carbon technologies

(e.g. CCS vs Nuclear)

- Nuclear a priori less costly than CCS
- But what if new political restrictions on nuclear ?

(e.g. CCS vs large scale renewables)

- What if revelation of hidden costs, political acceptability, conflicts in land use ?

4. Conclusion 2

- Because of learning effect, flexibility can increase with investment in LCT pulled in the first period

  We create the option to do or not to do economically LCT

- The effect of uncertainty in its environment on the deployment of « young » technologies is not straightforward.
- But « uncertainty » could justify an early development of a technology benefitting from learning effects

- The learning effects as being externalities are not internalized : this justifies a policy of support:

  Obligation// investment subsidy// feed in subsidy// guarantee on the CO2 price , etc.