Online supplementary materials to:

*Continuous versus discrete time in dynamic common pool resource game experiments*

This document presents the detailed solutions of the theoretical paths, some additional tables and figures, as well as the experimental instructions (translated from French) for the four treatments.

# Contents

# 1 Theoretical Solutions

Solutions are presented for the continuous time model. Solutions for the discrete time model are similar. In Appendix A we show that the discrete time model is a good approximation of the continuous time model. In the experiment we use solutions from the continuous time model as the benchmarks.

The developments to find the theoretical solutions are standard and do not represent theoretical contributions. Hence, they are presented in these supplementary materials and not in the core paper.

## 1.1 Theoretical Solutions for the Optimal Control Problem (Sole Agent Problem)

Here we describe the two types of behaviors in the case of one agent exploiting the groundwater resource. In the optimal behaviour the agent takes into account the impact of extraction today on the future evolution of the resource and decides this optimal extraction considering the complete evolution of the resource. In the myopic behavior the agent only sees the state of the resource at each instant and decides his optimal extraction. Both problems are described and solved in the following subsections.

### 1.1.1 The Optimal Solution

A farmer adopts an optimal behavior when his extraction decision allows him to maximize his discounted net payoff (with $r$ the discount factor) in order to keep the resource at an efficient level. His maximization problem is then :

$$\max_{w(.)} \int_0^{\infty} e^{-rt} \left[ aw(t) - \frac{b}{2} w(t)^2 - \max(0,\ c_0 - c_1 H(t)) w(t) \right] dt \tag{1}$$

s.t

$$\begin{cases} \dot{H}(t) = R - \alpha w(t) \\ H(0) = H_0 \geq 0,\ H_0\ \ given \\ H(t) \geq 0 \\ w(t) \geq 0 \end{cases}$$

**Condition 1.** *: We suppose that*

$$\frac{R}{\alpha} < \frac{a}{b}, \quad \frac{R\alpha c_1 + Rbr - a\alpha r + \alpha c_0 r}{\alpha c_1 r} > \frac{c_0}{c_1}.$$

This condition is to insure that the steady state of the optimal solution is

$$H^{\infty} = \frac{c_0}{c_1}.$$

With the parameters chosen for the experience, this will allow us to better differentiate the to types of behavior. In fact, as we are going to see, when the resource is lesser than $\frac{c_0}{c_1}$ and not so small, optimal level of the water table increases to $\frac{c_0}{c_1}$, while myopic solution goes down to its steady state.

**Theorem 1.** *Under condition 1 the steady state of the optimal solution is*

$$H^{\infty,Op} = \frac{c_0}{c_1}, \quad w^{\infty,Op} = \frac{R}{\alpha}.$$

*Optimal resource path has two regimes: it increases to this steady state when $H_0 < \frac{c_0}{c_1}$ (decreases when $H_0 > \frac{c_0}{c_1}$) till a certain time $T$ where $H(t) = \frac{c_0}{c_1}$ for all $t \geq T$. Optimal rate of extraction follows the same kind of behavior towards its steady state, that is, the rate of extraction increases till $T$ and then it is equal to $R/\alpha$. The extraction rate during the initial periods can be null depending on the parametrization.*

To prove theorem 1, we first prove that under condition 1 it is not possible to have a steady state different from $\frac{c_0}{c_1}$. To do that we consider separately the case where the optimal solution lies in the regime with $H$ smaller than $\frac{c_0}{c_1}$ and the case with $H$ greater than $\frac{c_0}{c_1}$. The two regimes are differentiated by the cost function.

**Proposition 1.** *When $H(t) < c_0/c_1$ for all $t$.The steady state of the problem*

$$\max_w \int_0^{\infty} e^{-rt} \left[ aw - \frac{b}{2}w^2 - (c_0 - c_1 H)w \right] dt, \quad \dot{H} = R - \alpha w, \quad H(0) = H_0,$$

*is*

$$H^{\infty} = \frac{R\alpha c_1 + Rbr - a\alpha r + \alpha c_0 r}{\alpha c_1 r}, \quad w^{\infty} = \frac{R}{\alpha}.$$

*Proof.* The associated Hamiltonian is

$$Hamiltonian = aw - \frac{b}{2}w^2 - (c_0 - c_1 H)w + \lambda(R - \alpha w),$$

where $\lambda$ is the adjoint variable. First order conditions at the steady state give the result. $\square$

Then, this steady state cannot be a steady state of our problem because by condition 1 it is greater than $c_0/c_1$.

**Proposition 2.** *There is no steady state in the regime $H(t) > \frac{c_0}{c_1}$.*

*Proof.* Suppose a solution with $H(t) > c_0/c_1$ for all $t$. The maximization problem is:

$$\max_w \int_0^\infty e^{-rt}\left[aw - \frac{b}{2}w^2\right] dt, \quad \dot{H} = R - \alpha w, \quad H(0) = H_0.$$

First order conditions of the Hamiltonian

$$Hamiltonian = aw - \frac{b}{2}w^2 + \lambda(R - \alpha w),$$

where $\lambda$ is the adjoint variable, gives

$$w(t) = \frac{a - \alpha\lambda_0 e^{rt}}{b}.$$

It is not possible to maintain the resource greater than $c_0/c_1$ if $\lambda_0 \leq 0$. Note that if $\lambda_0 = 0$ condition 1 gives $\dot{H} < 0$. It is not possible to have $w \geq 0$ if $\lambda_0 > 0$. □

These two propositions show that the steady state of the optimal problem is

$$H^{\infty,Op} = \frac{c_0}{c_1}, \quad w^{\infty,Op} = \frac{R}{\alpha}.$$

Now to prove theorem 1 we must obtain the complete path. To do that we must solve first order conditions considering the Hamiltonian of the problem and taking into account the constraints. For $H_0 < \frac{c_0}{c_1}$, the Lagrangian of the problem is:

$$L = aw - \frac{b}{2}w^2 - (c_0 - c_1 H)w + \lambda(R - \alpha w) + \mu\left(\frac{c_0}{c_1} - H\right) + \nu w,$$

where $\lambda$ is the adjoint variable and $\mu$ and $\nu$ the Lagrange multipliers associated to the constraints $H \leq \frac{c_0}{c_1}$ and $w \geq 0$ respectively. For $H_0 > \frac{c_0}{c_1}$, the Lagrangian of the problem is:

$$L = aw - \frac{b}{2}w^2 + \lambda(R - \alpha w) + \mu\left(H - \frac{c_0}{c_1}\right).$$

The time of change of regime are obtained using the continuity of the adjoint variable, the state variable and the control.

### 1.1.2 The Constrained Myopic Solution

The myopic solution is given by a situation where the farmer is only interested in the maximization of his current payoff. The constrained myopic problem faced by the farmer is :

$$\max_w \left[aw - \frac{b}{2}w^2 - \max(0,\ c_0 - c_1 H)w\right] \tag{2}$$

for each level of the water table. This maximization problem provides a solution $w(H)$ constrained to

$$\begin{cases} \dot{H}(t) = R - \alpha w(H(t)) \\ H(0) = H_0 \geq 0,\ H_0 \ given \\ H(t) \geq 0 \\ w(t) \geq 0 \end{cases}$$

**Condition 2.** *: We suppose that*

$$a > c_0, \quad \frac{R}{\alpha} - \frac{a - c_0}{b} > 0.$$

This condition is to insure the positivity of the steady state and the extraction of the constrained myopic solution.

**Theorem 2.** *Under condition 2 the steady state of the constrained myopic problem is*

$$H^{\infty,my} = \frac{b}{c_1}\left(\frac{R}{\alpha} - \frac{a - c_0}{b}\right), \quad w^{\infty,my} = \frac{R}{\alpha}.$$

*When $H_0 > H^{\infty,my}$ the constrained myopic path decreases to the steady state. Moreover, the constrained myopic extraction is then given:*

$$w^{my}(H) = \begin{cases} \dfrac{a}{b} & \text{if } H > \dfrac{c_0}{c_1} \\ \\ \dfrac{a - c_0 + c_1 H}{b} & \text{if } 0 \leq H \leq \dfrac{c_0}{c_1} \end{cases}$$

Note that condition 1 implies that $H^{\infty,my} < \dfrac{c_0}{c_1}$. In our experiment the difference $\dfrac{c_0}{c_1} - H^{\infty,my}$ is going to be big enough to differentiate the two behaviors.
The proof of theorem 2 is straightforward. Considering the different possibilities for $H$ ($H$ $<>=$ to $\frac{c_0}{c_1}$) we obtain the myopic extraction path. We can see that if $H < \frac{c_0}{c_1}$, the resolution of the differential equations gives

$$H(t) = H^{\infty,my} + (H_0 - H^{\infty,my})e^{-\frac{\alpha c_1}{b}t}.$$

with steady state

$$0 < H^{\infty,my} = \frac{b}{c_1}\left(\frac{R}{\alpha} - \frac{a - c_0}{b}\right) < \frac{c_0}{c_1}$$

by conditions 1 and 2. If $H > \frac{c_0}{c_1}$, as extraction is $a/b$, conditions 1 implies that $\dot{H} < 0$ and then in finite time the trajectory enters in the region with $H < \frac{c_0}{c_1}$ and the reasoning for $H < \frac{c_0}{c_1}$ applies.

## 1.2 Theoretical Solutions for the Game

We consider now that two farmers exploit the resource. Gains and costs are the same of the one of the problem of a single farmer and they are the same for both players. But now the evolution of the water table is the following:

$$\dot{H} = R - \alpha(w_1 + w_2), \quad H(0) = H_0, \quad \text{given.}$$

As before the farmer's problem is to choose at time $t$, for all $t \in [0, \infty]$, the extraction rate $w_i(t)$. We consider two non-cooperative types of behaviors. A look-forward farmers that maximize a discounted sum of their instantaneous payoffs over time taking into account the evolution of the dynamics, we compute here the feedback equilibrium, and myopic farmers that maximize instantaneous payoff. For sake of comparison we consider also the joint maximization problem, call also the cooperative solution. We do that because we want to know if some kind of "tacit" cooperation can emerge without negotiation.

### 1.2.1 The Nash Feedback solution

Now we consider that farmers adopts a non cooperative behavior and he maximizes his own net payoff (with $r$ the discount factor) taking into account the evolution of the resource. For each agent maximization problem is then :

$$V^i(H_0) := \max_{w_i} \int_0^\infty e^{-rt} \left[ a w_i(t) - \frac{b}{2} w_i(t)^2 - \max(0,\ c_0 - c_1 H(t)) w_i(t) \right] dt \tag{3}$$

s.t

$$\begin{cases} \dot{H}(t) = R - \alpha(w_1(t) + w_2(t)) \\ H(0) = H_0 \geq 0,\ H_0 \ \ given \\ H(t) \geq 0 \\ w_i(t) \geq 0 \end{cases}$$

We compute the feedback Nash equilibrium (farmers follow strategies depending on dynamics)[1]. We must consider the following condition,

**Condition 3.** *: We suppose that*

$$Rb + 2\alpha^2 A_2 - 2\alpha(a - c_0) > 0, \quad \frac{Rb + 2\alpha^2 A_2 - 2\alpha(a - c_0)}{c_1 - \alpha A_3} < \frac{c_0}{c_1}, \quad a - c_0 - \alpha A_2 > 0,$$

*Where*

$$A_2 = \frac{(a - c_0)(-c_1 + 2\alpha A_3) - RbA_3}{-rb - 2c_1\alpha + 3A_3\alpha^2},$$

[1] We consider here only the case of linear state strategies.

*and $A_3$ is the solution of*

$$-\frac{3\alpha^2}{2b}A_3^2+\frac{rb+4c_1\alpha}{2b}A_3-\frac{c_1^2}{2b}=0,$$

*with $-c_1+\alpha A_3<0$.*

Conditions $Rb+2\alpha^2A_2-2\alpha(a-c_0)>0$, $\frac{Rb+2\alpha^2A_2-2\alpha(a-c_0)}{c_1-\alpha A_3}<\frac{c_0}{c_1}$ insure that the steady state of the feedback path is positive and in the regime where cost is positive. Condition $a-c_0-\alpha A_2>0$ insures that extraction is always positive. We compute the Nash feedback equilibrium and we have the following theorem

**Theorem 3.** *Under condition 3 the steady state of the feedback equilibrium is*

$$H^{\infty,f}=\frac{Rb+2\alpha^2A_2-2\alpha(a-c_0)}{2\alpha(c_1-\alpha A_3)},\quad w_i^{\infty,f}=\frac{R}{2\alpha}.$$

*Resource increases to this steady state when $H_0<H^{\infty,f}$ (decreases when $H_0>H^{\infty,f}$). Rate of extraction follows the same kind of behavior towards its steady state.*

To prove theorem 3 we are going to consider the case when $H_0\le c_0/c_1$ and the case where $H_0>c_0/c_1$.
When $H_0\le c_0/c_1$ condition 5 guarantees the positivity of an extraction path for all $t$ and that the Nash feedback trajectory remains in the region where $H<c_0/c_1$. The Nash equilibrium can be found solving the HJB equation

$$rV_{R_1}^i(H)=max_{w_i}\left[(aw_i-\frac{b}{2}w_i^2-(c_0-c_1H)w_i-(V_{R_1}^i)'(H)(R-\alpha(w_i+w_j(H))\right].$$

We solve the problem proposing $V_{R_1}^i(H)=A_1+A_2H+\frac{A_3}{2}H^2$, $w_j=a_iH+b_i$ and finding $A_1,A_2,A_3,a_1,b_1$. We obtain $A_3$ the solution of

$$-\frac{3\alpha^2}{2b}A_3^2+\frac{rb+4c_1\alpha}{2b}A_3-\frac{c_1^2}{2b}=0,$$

with $-c_1+\alpha A_3<0$.

$$A_2=\frac{(a-c_0)(-c_1+2\alpha A_3)-RbA_3}{-rb-2c_1\alpha+3A_3\alpha^2},$$

$$A_1=\frac{3\alpha^2A_2^2+(2Rb-4\alpha(a-c_0)A_2+(a-c_0)^2}{2br},$$

$$a_1=\frac{c_1-\alpha A_3}{b},\quad b_1=\frac{a-c_0-\alpha A_2}{b}.$$

The evolution of the water table for $H_0$ given is

$$H(t) = e^{\frac{2\alpha(-c_1+\alpha A_3)}{b}t}(H_0 - H^{\infty,F}) + H^{\infty,F}, \quad H^{\infty,F} = \frac{Rb + 2\alpha^2 A_2 - 2\alpha(a-c_0)}{2\alpha(c_1 - \alpha A_3)}.$$

When $H_0 > c_0/c_1$ the problem is a bit different. We must take into account the following facts. First, that there are no stationary steady state in the region with $H > c_0/c_1$. As a consequence the Nash feedback solution will leave the zone $H > c_0/c_1$ to goes to the steady state $H^{\infty,F}$. Second, our problem is an autonomous problem, then the solution in this case is also the solution of HJB equation of the form

$$rV^i_{R_2}(H) = max_{w_i}\left[(aw_i - \frac{b}{2}w_i^2 - (V^i_{R_2})'(H)(R - \alpha(w_i + w_j(H))\right]. \tag{4}$$

For the first point the solution of this last HJB equation is constrained to the condition

$$V^i_{R_2}(c_0/c_1) = V^i_{R_1}(c_0/c_1). \tag{5}$$

We solve equation (4) the maximization in $w_i$ gives

$$w_i(H) = \frac{a - \alpha(V^i_{R_2})'(H)}{b},$$

replacing this in equation (4) and taking into account that $w_j(H) = w_i(H)$, we obtain the following differential equation for $V^i_{R_2}(H)$.

$$V^i_{R_2}(H) = \frac{C}{2}\,[(V^i_{R_2})'(H)]^2 + B\,(V^i_{R_2})'(H) + A, \quad C = \frac{-\alpha^2 + 4\alpha}{br}, B = \frac{2Rb - 4\alpha}{2br}, A = \frac{a^2}{2br}.$$

Differentiating with respect to $H$, we finally must solve

$$U(H) = B\,U'(H) + C\,U(H)U'(H), \quad U(H) = (V^i_{R_2})'(H).$$

The solution of this last equation is

$$U(H) = e^{-\frac{-H + BLambertW(x) - Cte}{B}}, \quad x = \frac{Ce^{\frac{H}{B}} + \frac{Cte}{B}}{B}.$$

Where LambertW is the Lambert W function. The constant $Cte$ is found using (5).

### 1.2.2 The Constrained Myopic Solution

As in the single agent model, the myopic solution is given by a situation where each farmer is only interested in the maximization of his current payoff. The constrained myopic problem faced by the farmer $i$ is :

$$\max_{w_i}\left[aw_i-\frac{b}{2}w_i^2-\max(0,\ c_0-c_1H)w_i\right] \tag{6}$$

for each level of the water table. This maximization problem provides a solution $w(H)$ constrained to the evolution of the water table exploited for the two symmetric farmers,

$$\begin{cases} \dot{H}(t)=R-2\alpha w(H(t)) \\ H(0)=H_0\geq 0,\ H_0\ \ given \\ H(t)\geq 0 \\ w(t)\geq 0 \end{cases}$$

**Condition 4.** *: We suppose that*

$$a>c_0,\quad \frac{R}{2\alpha}-\frac{a-c_0}{b}>0.$$

This condition is to insure the positivity of the steady state and the extraction of the constrained myopic solution. The proof of the following theorem is similar to the case of a sole agent myopic solution.

**Theorem 4.** *Under condition 4 the steady state of the constrained myopic problem is*

$$H^{\infty,my}=\frac{b}{c_1}\left(\frac{R}{2\alpha}-\frac{a-c_0}{b}\right),\quad w^{\infty,my}=\frac{R}{2\alpha}.$$

*When $H_0>H^{\infty,my}$ the constrained myopic path decreases to the steady state. Moreover, the constrained myopic extraction is then given:*

$$w^{my}(H)=\begin{cases} \dfrac{a}{b} & H>\dfrac{c_0}{c_1} \\ \\ \dfrac{a-c_0+c_1H}{b} & 0\leq H\leq\dfrac{c_0}{c_1} \end{cases}$$

### 1.2.3 The Cooperative Solution

Farmers adopts a cooperative behavior when extraction decisions maximize the joint discounted net payoff (with $r$ the discount factor) in order to keep the resource at an efficient level. Maximization problem is then :

$$\max_{w_1(.),w_2(.)} \int_0^\infty e^{-rt} \sum_{i=1}^{2} \left[ a w_i(t) - \frac{b}{2} w_i(t)^2 - \max(0,\ c_0 - c_1 H(t)) w_i(t) \right] dt \tag{7}$$

s.t

$$\begin{cases} \dot{H}(t) = R - \alpha(w_1(t) + w_2(t)) \\ H(0) = H_0 \geq 0,\ H_0\ \ given \\ H(t) \geq 0 \\ w_i(t) \geq 0 \end{cases}$$

**Condition 5.** *: We suppose that*

$$\frac{R}{\alpha} < \frac{a}{b}, \quad \frac{2R\alpha c_1 + Rbr - 2a\alpha r + 2\alpha c_0 r}{2\alpha c_1 r} > \frac{c_0}{c_1}.$$

As in the single agent case, this condition is to insure that the steady state of the optimal solution is

$$H^\infty = \frac{c_0}{c_1}.$$

**Theorem 5.** *Under condition 5 the steady state of the optimal solution is*

$$H^{\infty,Op} = \frac{c_0}{c_1}, \quad w_i^{\infty,Op} = \frac{R}{2\alpha}.$$

*The optimal resource path has two regimes: it increases to this steady state when $H_0 < \frac{c_0}{c_1}$ (decreases when $H_0 > \frac{c_0}{c_1}$) till a certain time $T$ where $H(t) = \frac{c_0}{c_1}$ for all $t \geq T$. Optimal rate of extraction follows the same kind of behavior towards its steady state. The extraction rate during the initial periods can be null depending on the parametrization.*

The proof of this theorem follows the same structure that the proof of the optimal solution of one agent problem (because both problem are optimal control problems). In order to understand condition 5 note that in the game problem the steady state of

$$\max_{w_1(.),w_2(.)} \int_0^\infty e^{-rt} \sum_{i=1}^{2} \left[ a w_i(t) - \frac{b}{2} w_i(t)^2 - (c_0 - c_1 H(t)) w_i(t) \right] dt,$$

$$\dot{H}(t) = R - \alpha(w_1(t) + w_2(t)),$$

is

$$H^\infty = \frac{2R\alpha c_1 + Rbr - 2a\alpha r + 2\alpha c_0 r}{2\alpha c_1 r}, \quad w_i^\infty = \frac{R}{2\alpha}.$$

**Remark 1.** *Our parameters verifies conditions 1, 2, 3 and 4.*

## 2 Additional Tables

Table M.1: Control versus game in discrete time

| | Agent and group average resource levels | | | Fisher exact test | |
|---|---|---|---|---|---|
| | Mean | S.D. | N | Odds ratio | Exact prob |
| Control | 17.572 | 0.267 | 89 | 7.078 | 0.000 |
| Game | 9.06 | 0.868 | 46 | - | - |
| | Agent and group average extraction levels | | | Mann-Whitney test | |
| | Mean | S.D. | N | z-stat | Exact prob |
| Control | 0.497 | 0.006 | 98 | -7.380 | 0.000 |
| Game | 0.69 | 0.018 | 46 | - | - |
| | Number of agents and groups extraction changes | | | Mann-Whitney test | |
| | Mean | S.D. | N | z-stat | Exact prob |
| Control | 34.122 | 1.778 | 98 | -6.167 | 0.000 |
| Game | 52.587 | 1.447 | 46 | - | - |
| | Agents and groups with smaller $MSD^c_{my}$ than $MSD^c_{op}$ | | | Fisher exact test | |
| | Yes | No | N | Odds ratio | Exact prob |
| Control | 13 | 89 | 102 | 0.134 | 0.000 |
| Game | 24 | 22 | 46 | - | - |

Table M.2: Control versus game in continuous time

| | Agent and group average resource levels | | | Fisher exact test | |
|---|---|---|---|---|---|
| | Mean | S.D. | N | Odds ratio | Exact prob |
| Control | 17.144 | 0.326 | 102 | 6.371 | 0,.000 |
| Game | 12.149 | 0.64 | 49 | - | - |
| | Agent and group average extraction levels | | | Mann-Whitney test | |
| | Mean | S.D. | N | z-stat | Exact prob |
| Control | 0.501 | 0.007 | 102 | -6.592 | 0.000 |
| Game | 0.616 | 0.014 | 49 | - | - |
| | Number of agents and groups extraction changes | | | Mann-Whitney test | |
| | Mean | S.D. | N | z-stat | Exact prob |
| Control | 44.902 | 4.705 | 102 | -7.415 | 0.000 |
| Game | 143.225 | 13.623 | 49 | - | - |
| | Agents and groups with smaller $MSD^c_{my}$ than $MSD^c_{op}$ | | | Fisher exact test | |
| | Yes | No | N | Odds ratio | Exact prob |
| Control | 6 | 92 | 98 | 0.334 | 0.047 |
| Game | 8 | 41 | 49 | - | - |

Table M.3: Extraction changes at the beginning of the game

| | Initial players' extraction level | | | Mann-Whitney test | |
|---|---|---|---|---|---|
| | Mean | S.D. | N | z-stat | Exact prob |
| Discrete time | 0.667 | 0.069 | 92 | -0.920 | 0.390 |
| Continuous time | 0.577 | 0.062 | 98 | - | - |
| | Time to first change in extraction | | | Mann-Whitney test | |
| | Mean | S.D. | N | z-stat | Exact prob |
| Discrete time | 29.444 | 6.110 | 90 | -0.358 | 0.721 |
| Continuous time | 24.161 | 2.664 | 93 | - | - |
| | Extraction level after first change | | | Mann-Whitney test | |
| | Mean | S.D. | N | z-stat | Exact prob |
| Discrete time | 0.605 | 0.062 | 90 | -1.511 | 0.131 |
| Continuous time | 0.482 | 0.055 | 93 | - | - |

Note that 7 players keep a constant extraction level during the whole experimental stage, which explains the lower number of observations in the two last statistics.

Table M.4: Heuristic analysis of undetermined groups profiles

| | Statu quo groups | | | Fisher exact test | |
|---|---|---|---|---|---|
| | Yes | No | N | Odds ratio | Exact prob |
| Discrete time | 8 | 38 | 46 | 0.727 | 0.613 |
| Continuous time | 11 | 38 | 49 | - | - |
| | Convergent groups | | | Fisher exact test | |
| | Yes | No | N | Odds ratio | Exact prob |
| Discrete time | 3 | 43 | 46 | 0.614 | 0.716 |
| Continuous time | 5 | 44 | 49 | - | - |
| | Low resource groups | | | Fisher exact test | |
| | Yes | No | N | Odds ratio | Exact prob |
| Discrete time | 12 | 34 | 46 | 1.376 | 0.628 |
| Continuous time | 10 | 39 | 49 | - | - |

Table M.5: Groups with extraction levels at the end of the game greater or lower than the natural recharge ($R = 0.56$) by categories (continuous and discrete time)

| | E<R | | E>R | |
|---|---|---|---|---|
| | Continuous | Discrete | Continuous | Discrete |
| Optimal | 1 | 2 | 0 | 0 |
| Feedback | 5 | 6 | 1 | 0 |
| Myopic | 1 | 11 | 2 | 3 |
| Undetermined | 32 | 17 | 7 | 7 |
| Total | 39 | 36 | 10 | 10 |

## 3 Additional Figures

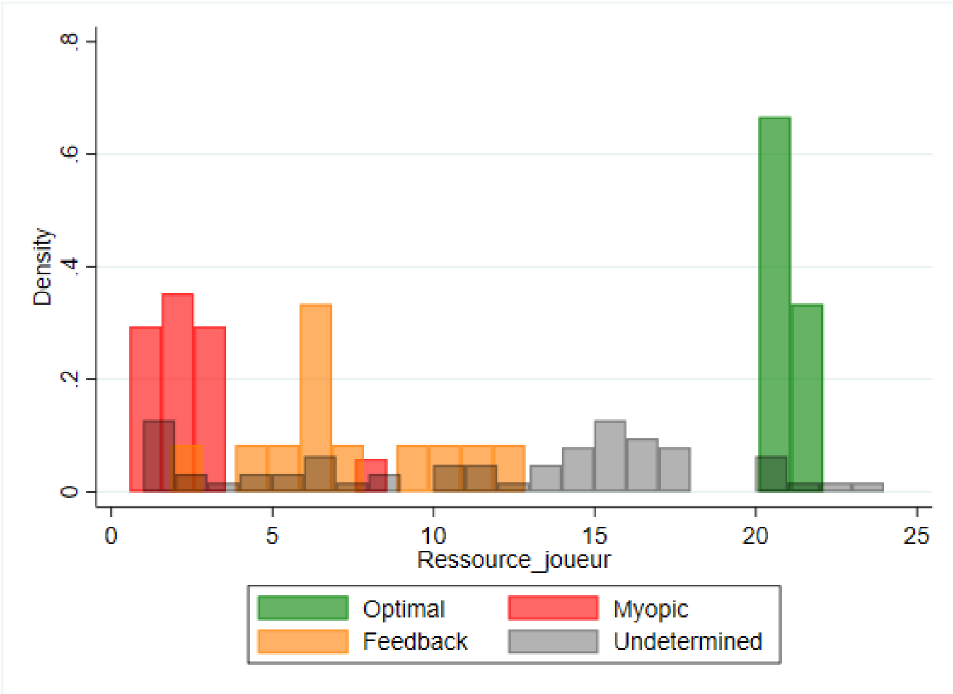



Figure S.1: Resource level at the end of the game by categories (continuous and discrete time)

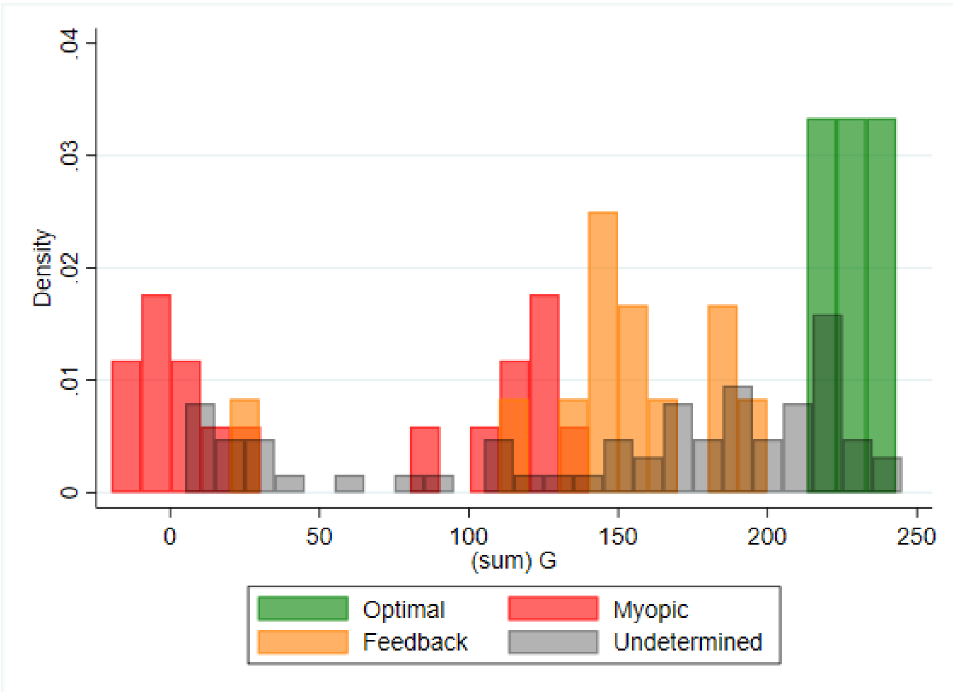



Figure S.2: Total payoffs at the end of the game by categories (continuous and discrete time)

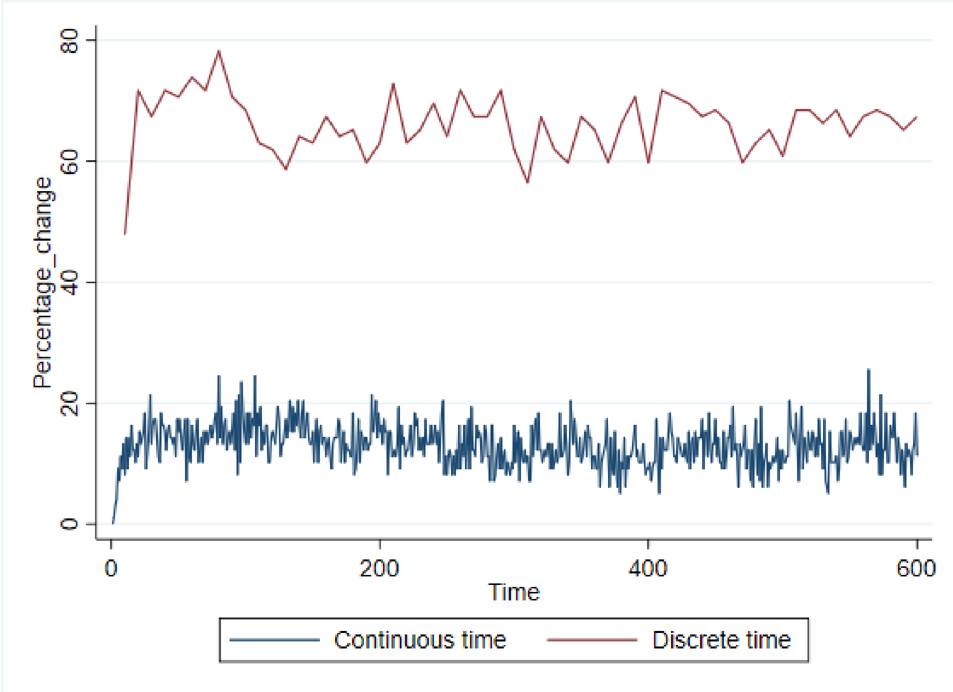



Figure S.3: Proportion of subjects changing extraction levels at each period/instant

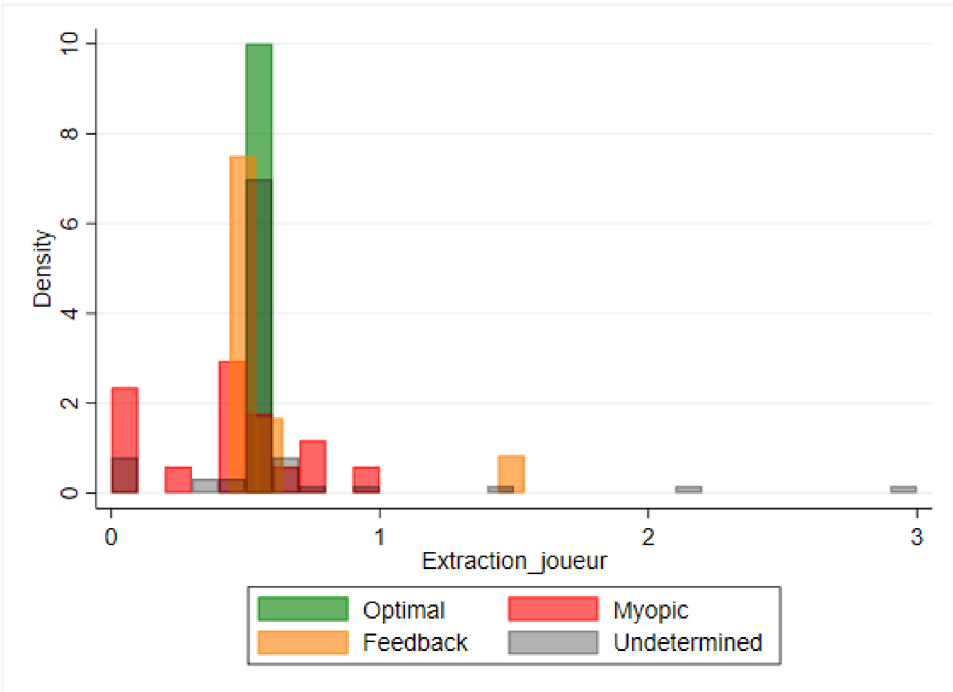



Figure S.4: Extraction level at the end of the game by categories
(continuous and discrete time)

# 4 Instructions for the Optimal Control (Sole Agent)

*Translated from French.*

## 4.1 Continuous Time Instructions

You are about to participate in a decision-making experiment. We ask you to carefully read the instructions in order to better understand the experiment. An experimenter will proceed to read these instructions out loud when all participants have finished. All of your decisions will be anonymously treated. You will specify your choices using the computer in front of which you are seated. For the remainder of the experiment, we ask you to remain quiet. If you have any questions, raise your hand and an experimenter will come and speak with you privately.

Earnings are in experimental currency units (ECU). The exchange rate of ECU to euros is specified in the instructions. The experiment includes a $10$-minute training phase and a $10$-minute experimentation phase. The final payoff of the experimentation phase is the one taken into account for your remuneration.

### General framework

You initially have $15$ resource units. At any time. you can extract between $0$ and $2.8$ resource units with up to two-decimal points of precision. This means that you are free to choose the extraction rate you want, namely $0$, $0.01$, $0.02$ $\ldots 2.79$, $2.8$. You will move a slider similar to that depicted in Figure S.5 to make your choice. The value displayed below the slider when you release it is automatically taken into account and sent to the central computer which updates the information.

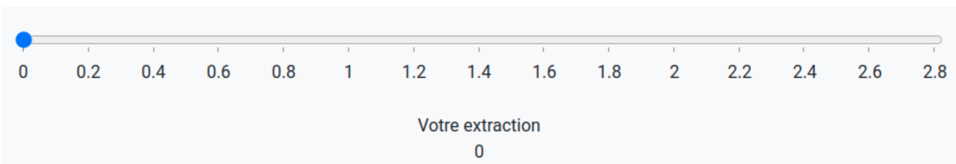



Figure S.5: Slider for decision-making

### Resource dynamics

The available resource continuously evolves. Its evolution depends on two elements : (i) your extraction rate at instant $t$ denoted $E_t$ and (ii) a fixed rate of $0.56$ automatically added at each instant $t$.

Thus the resource evolves as follows :

- when your extraction rate is higher than the fixed rate, the resource decreases
- when your extraction rate is lower than the fixed rate, the resource grows
- when your extraction rate is equal to the fixed rate, the resource is stable

A graph on your screen will show you the resource's evolution in real time.

*If your action is such that it brings the resource to zero, your extraction rate will be set to zero by the computer.*

### Payoff

When you extract the resource, you get a total revenue but also incur a cost. The cost depends on the amount of the available resource: the less resource available, the higher the cost.

### Total revenue from extraction

At the instant $t$, for an extraction rate $E_t$, the total revenue denoted $REC_t$ is equal to:

$$REC_t = 2.5E_t - 0.9E_t^2$$

Figure S.6 below shows the total revenue according to the extraction rate.

**Example**

Let's assume that at a given instant $t$ your extraction rate is $1.4$, the total revenue will then be $1.736$ units.

### Cost of extraction

At the instant $t$ for an available amount of resource $R_t$, the unitary cost $c_t$ is equal to:

$$c_t = \begin{cases} (2 - 0.1R_t) \text{ if } 0 \leq R_t < 20 \\ 0 \text{ if } R_t \geq 20 \end{cases}$$

Thus,

✓ cost increases when the available resource decreases

✓ cost is positive when the available resource is strictly lower than 20 units and cost is null when the available resource is bigger than or equal to 20 units

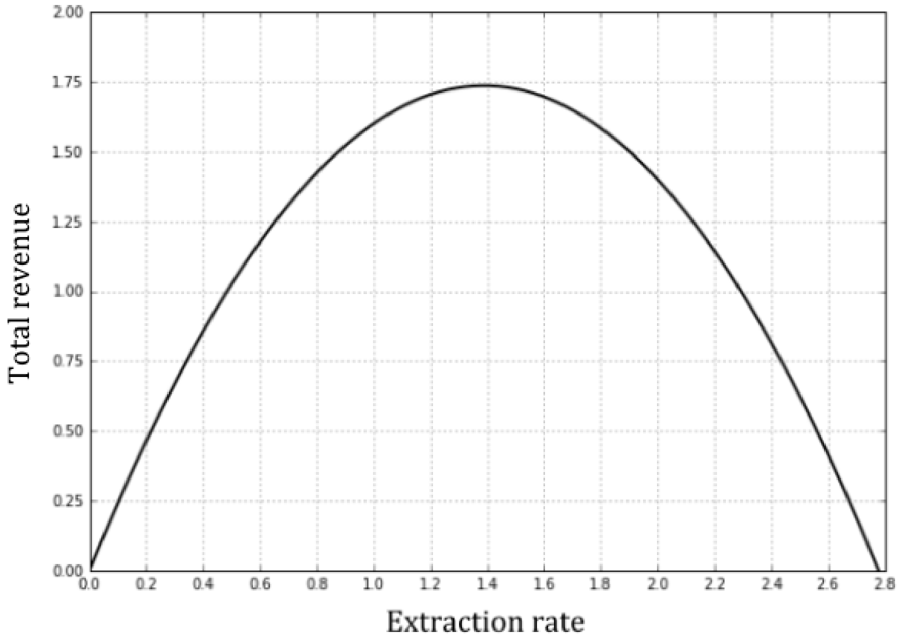



Figure S.6: Total revenue from extraction

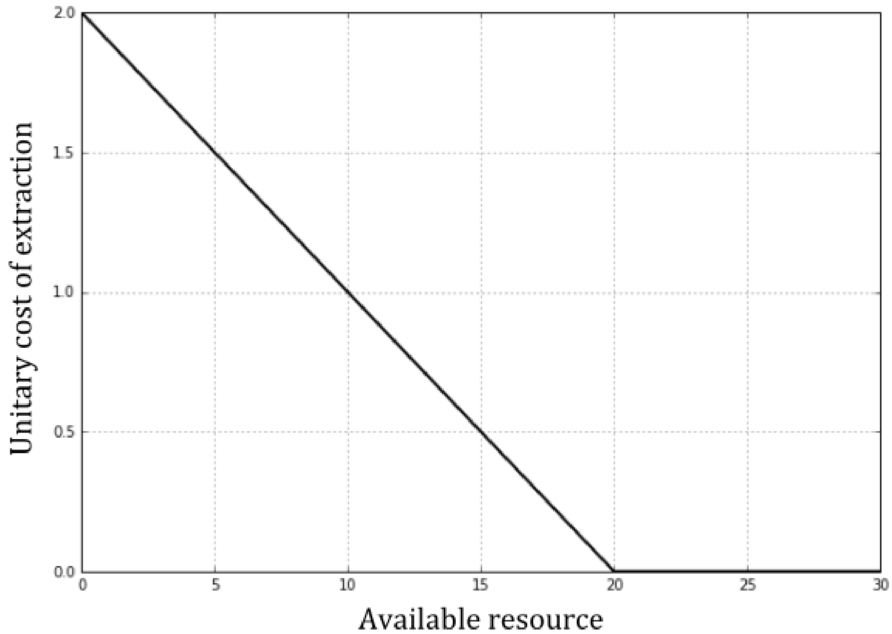



Figure S.7: Unitary cost of extraction

Figure S.7 shows the unitary cost according to the available resource.
Total cost of extraction $C_t$, is equal to the extraction rate times the unitary cost, that is:

$$C_t = E_t \times c_t$$

#### Discounted instantaneous payoff

Each instant, the instantaneous payoff ($G_t$), which is equal to the difference between total revenue and total cost ($G_t = REC_t - C_t$), is multiplied by a discount factor, allowing us to determine the present value of the payoff perceived in the future. The discount rate equals $0.5\%$ and concretely means that the instant $t$ payoff is multiplied by $e^{-0.005\times t}$. Thus, a same instantaneous payoff has a different discounted value according to the instant.

**Example**
Let's take a same payoff $G_t = 0.5$ at $4$ different instants.
At instant $t = 0$ the discounted payoff equals $0.5 \times e^{-0.005\times 0} = 0.5$
At instant $t = 1$ the discounted payoff equals $0.5 \times e^{-0.005\times 1} = 0.4975$
At instant $t = 10$ the discounted payoff equals $0.5 \times e^{-0.005\times 10} = 0.4756$
At instant $t = 60$ the discounted payoff equals $0.5 \times e^{-0.005\times 60} = 0.3704$

What one should remember from this discounting principle is that the payoffs of the first instants have greater impact on the payoff of the experiment than those of the last instants.

#### Payoff for the experiment

Your payoff for the experiment includes two elements: (i) your cumulated payoff from discounted instantaneous payoffs since the beginning of the experiment (instant $t = 0$) until the present instant ($t = p$), and (ii) your "continuation payoff", which is your payoff if the experiment were to go on forever (from the present instant $t = p$ to instant $t = \infty$) with your extraction rate being fixed to the present instant $p$.

Your remuneration for the experiment is your payoff for the last instant of the experiment. This payoff corresponds to your cumulated payoff over all the instants of the experiment, to which is added the payoff computed as if the part continued indefinitely with your extraction rate fixed at that of the last instant.

#### How the experiment works

Before the experiment starts you should decide on an initial extraction rate which will apply at the beginning of the experiment. Then, as soon as the experiment begins you can, when you wish, change this rate by moving the slider on the window displayed on your screen. Once you release the slider, the value taken into account is the one displayed below the slider. When you do not move the slider, the value that is considered at each instant is the last one you set. Be careful not to click on the slider bar but to move the slider with the mouse, then release it so that the value is taken into account.

The computer performs the calculations every second, and the data displayed on your screens is updated every second as well. A second corresponds to $0.1$ instant in what has been described previously. Thus, $10$ minutes corresponds to $600$ seconds and to $60$ instants.

The decision screen includes four areas, in addition to the decision area with the slider. Three of these areas are graphic areas and the fourth is a text area. Figure S.8 on page xxi gives you a shot of the decision screen. Description of the areas is as follows:

- ✓ graphic at the top left: your extraction rate
- ✓ graphic at the top right: the available resource
- ✓ graphic at the bottom left: your payoff of the experiment, which is composed as explained previously of your cumulative payoff up to the present instant, to which is added your payoff if your extraction is applied indefinitely
- ✓ text area at the bottom right: the same information as the curves but in the form of text, namely for each instant, your extraction rate, the available resource, your discounted instantaneous payoff and your payoff for the experiment

**Final details**

The exchange rate of ECUs to euros is as follows: $10$ ECUs $= 0.5$€.

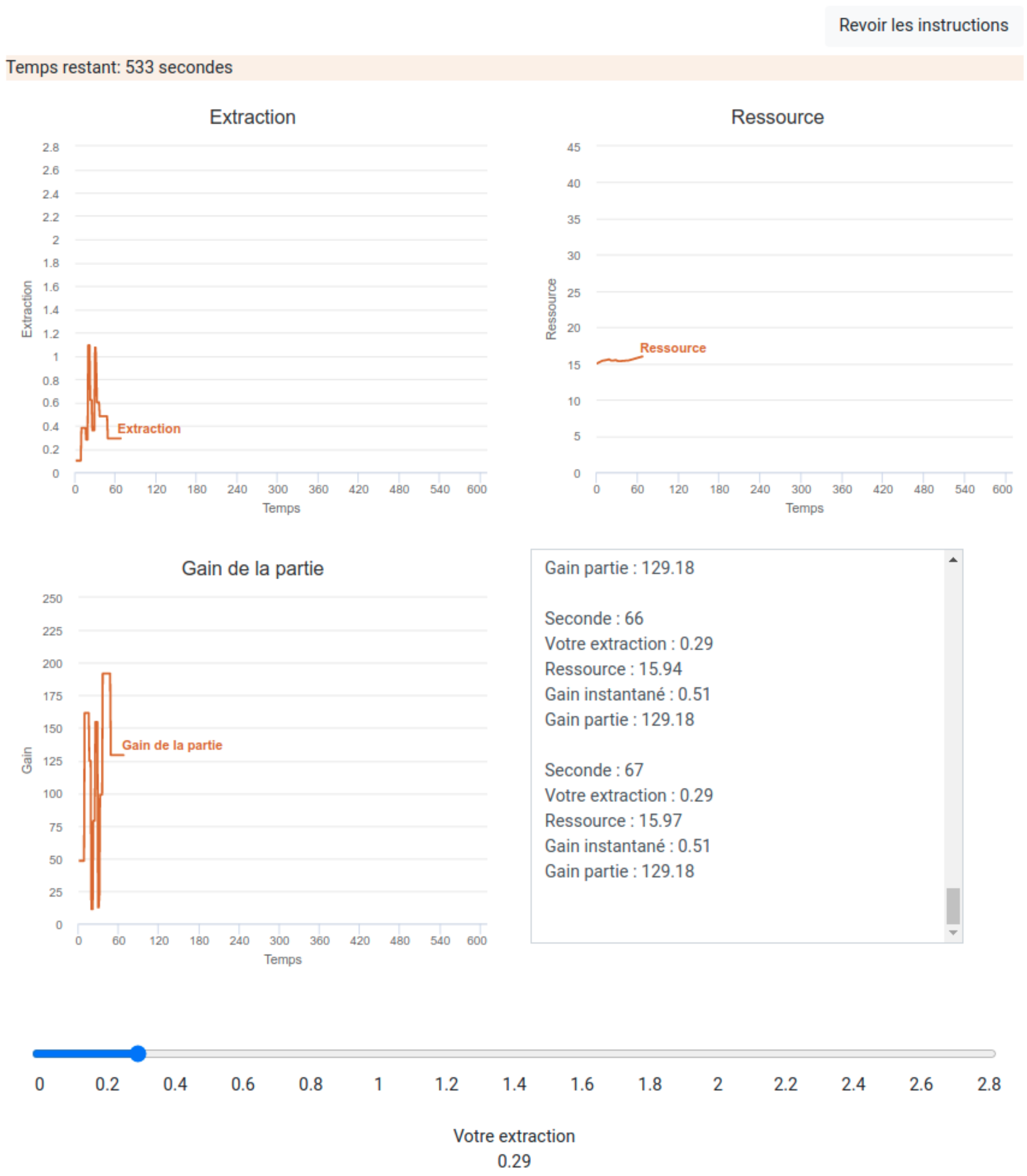



Figure S.8: Decision-making screen shot. We follow a hypothetical subject who chooses his extraction rate at random

## 4.2 Discrete Time Instructions

You are about to participate in a decision-making experiment. We ask you to carefully read the instructions in order to better understand the experiment. An experimenter will proceed to read these instructions out loud when all participants have finished. All of your decisions will be anonymously treated. You will specify your choice using the computer in front of which you are seated. For the remainder of the experiment, we ask you to remain quiet. If you have any questions, raise your hand and an experimenter will come and speak with you privately.

Earnings are in experimental currency units (ECU). The exchange rate of ECU to euros is specified in the instructions. The experiment includes a $10$-minute training phase and a $10$-minute experimentation phase. The final payoff of the experimentation phase is the one taken into account for your remuneration.

### General framework

You initially have $15$ resource units. Each period, you can extract an amount between $0$ and $2.8$ resource units with up to two decimal points of precision. This means that you are free to choose the amount you want to extract, namely $0$, $0.01$, $0.02 \ldots 2.79$, $2.8$. You will move a slider similar to that depicted in Figure S.9 to make your choice. You have $10$ seconds to make your choice. At the end of these $10$ seconds, the value below the slider is automatically taken into account, and is sent to the central computer which updates the information. Then the next period begins and you have again $10$ seconds to change your extraction level.

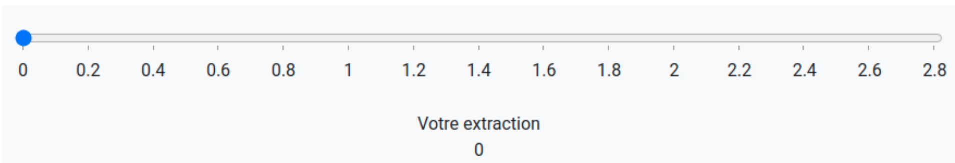



Figure S.9: Slider for decision-making

### Resource dynamics

The available amount of the resource evolves during each period. Its evolution depends on two elements: (i) the amount of resource you extract at each period $n$, denoted $E_n$, and (ii) a fixed amount of $0.56$ automatically added at each period. By denoting $R_n$ the amount of resource available at period $n$, the dynamics of the resource is as follows:

$$R_{n+1} = R_n - E_n + 0.56$$

A graph on your screen will show you the resource's evolution at each period.

*If at period $n$ your action is such that it brings the resource to zero, your extraction level for this period will be set to zero by the computer.*

**Example**

Suppose that at period $n$ the amount of resource available is $15$ units and that your extraction level is $0.30$ units. At period $n+1$ the amount of resource available will then be: $R_{n+1} = 15 - 0.30 + 0.56 = 15.26$ units.

### Payoff

When you extract the resource, you get a total revenue but also incur a cost. The cost depends on the amount of the resource available: the less the amount of resource available, the higher the cost.

### Total revenue from extraction

At period $n$, for an extracted amount $E_n$, the total revenue denoted $REC_n$ is equal to:

$$REC_n = 2.5E_n - 0.9E_n^2$$

Figure S.10 below shows the total revenue according to the extraction level.

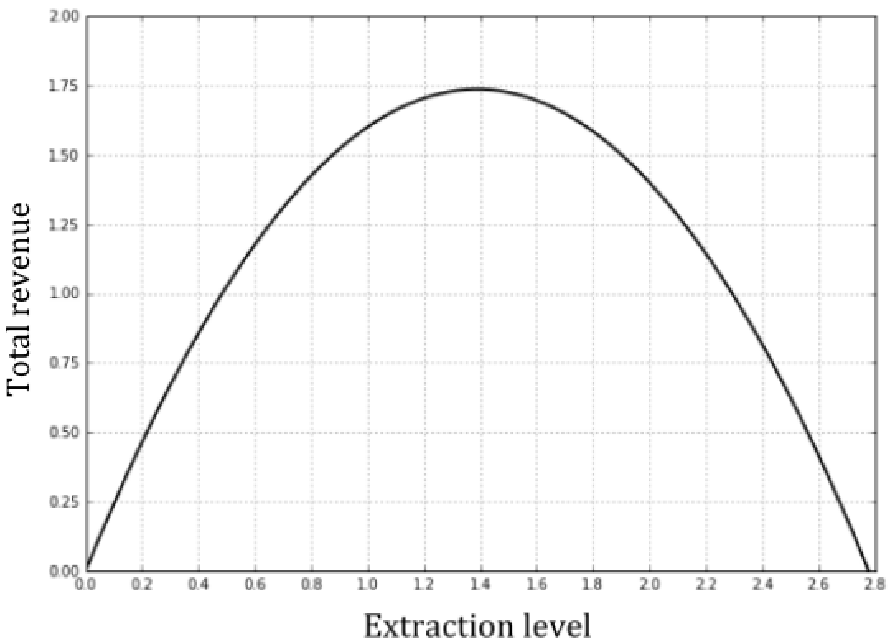



Figure S.10: Total benefit from extraction

**Example**

Let's assume that at a given period $n$ your extraction level is $1.4$, the total revenue will then be $1.736$ units.

**Cost of extraction**

At period $n$ for an available amount of resource $R_n$, the unitary cost $c_n$ is equal to :

$$c_n = \begin{cases} (2 - 0.1R_n) \text{ if } 0 \leq R_n < 20 \\ 0 \text{ if } R_n \geq 20 \end{cases}$$

Thus,

✓ cost increases when the available amount of the resource decreases

✓ cost is positive when the available amount of the resource is strictly lower than $20$ units and the cost is null when the available amount of the resource is greater than or equal to $20$ units

Figure S.11 shows the unitary cost according to the available resource.

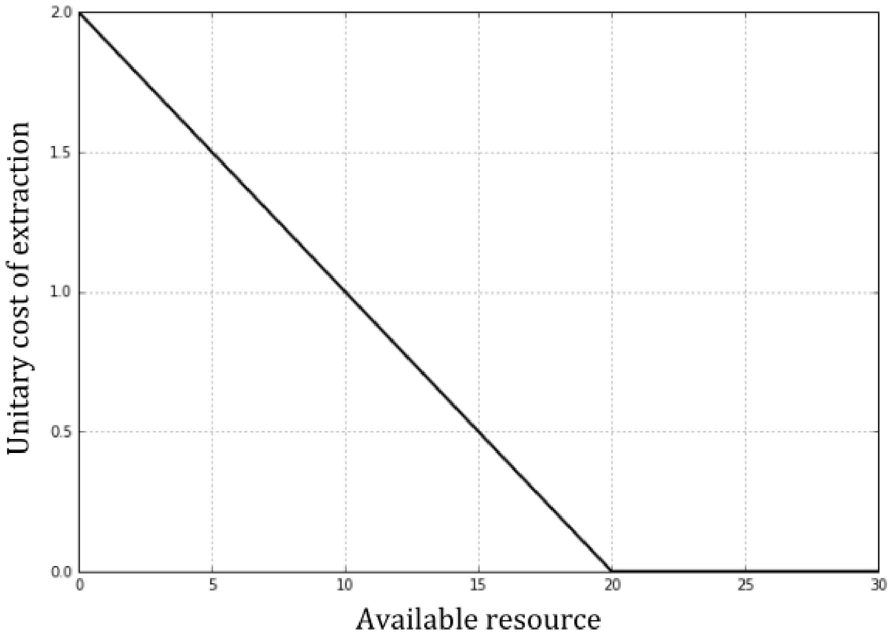



Figure S.11: Unitary cost of extraction

Total cost of extraction $C_n$, is equal to the amount extracted times the unitary cost, that is:

$$C_n = E_n \times c_n$$

**Discounted period payoff**

Each period, the payoff of the period ($G_n$), which is equal to the difference between total revenue and total cost ($G_n = REC_n - C_n$), is multiplied by a discount factor, allowing us to determine the present value of the payoff perceived in the future. The discount factor equals $0.995$ and in concrete terms means that the payoff of period $n$ is multiplied by $0.995^n$. Thus, a same payoff at $n$ has a different discounted value according to the period.

**Example**
Let's take a same payoff $G_n = 0.5$ at $4$ different periods.
At period $n = 0$ the discounted payoff equals $0.5 \times 0.995^0 = 0.5$
At period $n = 1$ the discounted payoff equals $0.5 \times 0.995^1 = 0.4975$
At period $n = 10$ the discounted payoff equals $0.5 \times 0.995^{10} = 0.4755$
At period $n = 60$ the discounted payoff equals $0.5 \times 0.995^{60} = 0.3701$

What one should remember from this discounting principle is that the payoffs for the first period has a greater impact on the payoff of the experiment than those of the later periods.

**Payoff for the experiment**

Your payoff for the experiment includes two elements: (i) your cumulated payoff (the discounted sum of each period payoff) from the beginning of the experiment $(n = 0)$ until the present period $(n = p)$, and (ii) your "continuation payoff", which is your payoff if the experiment went on forever (from $n = p$ to $n = \infty$) with your extraction level being fixed to the present period.

Your remuneration for the experiment is your payoff for the last period of the experiment. This payoff corresponds to your cumulated payoff over all the periods of the experiment, plus the payoff computed as if the experiment continued indefinitely with your extraction level fixed at the level of the last period.

**How the experiment works**

Before the experiment starts you should decide upon an initial extraction level which will apply at the beginning of the experiment $(n = 0)$. Then during each period you have $10$ seconds to change this extracted amount by moving the slider on the window displayed on your screen. When you do not move the slider, the value considered in each period is the last one you set.

The decision screen includes four areas, in addition to the decision area with the slider. Three of these areas are graphic areas and the fourth is a text area. Figure S.12 on page xxvii gives you a shot of the decision screen. Description of the areas is as follows :

- ✓ graphic at the top left: your extraction level at each period
- ✓ graphic at the top right: the available resource at each period
- ✓ graphic at the bottom left: your payoff of the experiment, which, as explained previously, is composed of your cumulative payoff up to the present period, plus your payoff if your extraction is applied indefinitely
- ✓ text area at the bottom right: the same information as the curves but in text form, namely, for each period your extraction level, the available resource, your discounted period $n$ payoff and your payoff for the experiment

**Final details**

The exchange rate of ECUs to euros is as follows: $10$ ECUs $= 0.5$€.

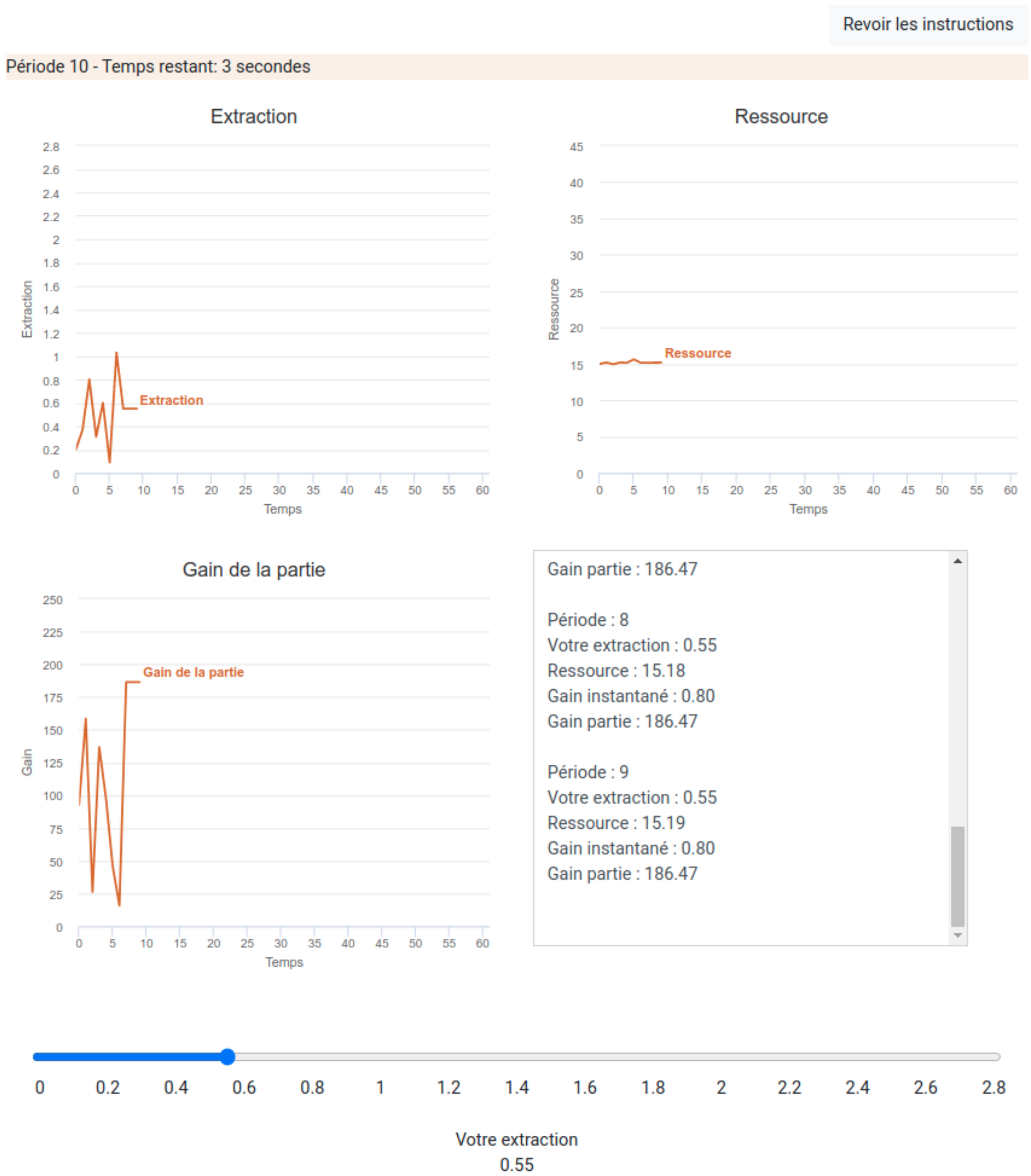



Figure S.12: Decision-making screen shot. We follow a hypothetical subject who chooses his extraction rate at random

# 5 Instructions for the game (multiple agents)

*Translated from French.*

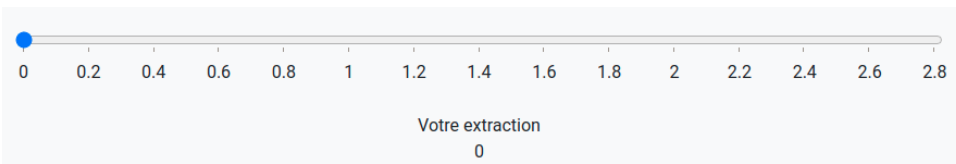
## 5.1 Continuous Time Instructions

You are about to participate in a decision-making experiment. We ask you to carefully read the instructions in order to better understand the experiment. An experimenter will proceed to read these theses instructions out loud when all participants have finished. All your decisions will be anonymously treated. You will indicate your choice using the computer in front of which you are seated. From now on, we ask you to remain quiet. If you have any questions, just raise your hand and an experimenter will come and answer you privately.

Earnings are in experimental currency units (ECU). The exchange rate of ECU into euros is specified in the instructions. The experiment includes a $10$-minute training phase and a $10$-minute experimentation phase. The final payoff of the experimentation phase is the one taken into account for your remuneration.

### General framework

At the beginning of the experiment, the central computer will randomly form pairs of 2 players. Each pair initially has $15$ resource units, and at any time both players can extract between $0$ and $2.8$ resource units with up to two-decimal points of precision. You and the other player are free to choose the extraction rate you want, namely $0$, $0.01$, $0.02$ …$2.79$, $2.8$. To make your choice, each player must move a slider similar to the one below.




### Resource dynamics

The available resource continuously evolves. Its evolution depends on two elements:

(i) the total extraction rate of the two players at each instant $t$, that is: $(E_{1,t} + E_{2,t})$, where $E_{1,t}$ is the Player $1$'s extraction rate and $E_{2,t}$ is the Player $2$'s extraction rate, and

(ii) a fixed rate of $0.56$ automatically added at each instant $t$.

Thus the resource evolves as follows:

- when the extraction rate of the two players is higher than the fixed rate, the resource decreases
- when the extraction rate of the two players is lower than the fixed rate, the resource grows
- when the extraction rate of the two players is equal to the fixed rate, the resource is stable

A graph on your screen will show you the resource's evolution in real time.

*If the extraction rate of both players is higher than the available resource, both players' extraction rates are set to zero. You must choose another extraction rate compatible with the available resource.*

**Payoff**

When you extract the resource, you get a total revenue but you also incur a cost. Your revenue only depends on your extraction rate, while the cost depends both on the available resource and indirectly on the extraction rate of both players.

**Total revenue from extraction**

At the instant $t$, the total revenue denoted $REC_t$ is equal to:

$$REC_t = 2.5E_t - 0.9E_t^2$$

where $E_t$ is your extraction rate. Thus, it does not depend on the extraction rate of the other player.

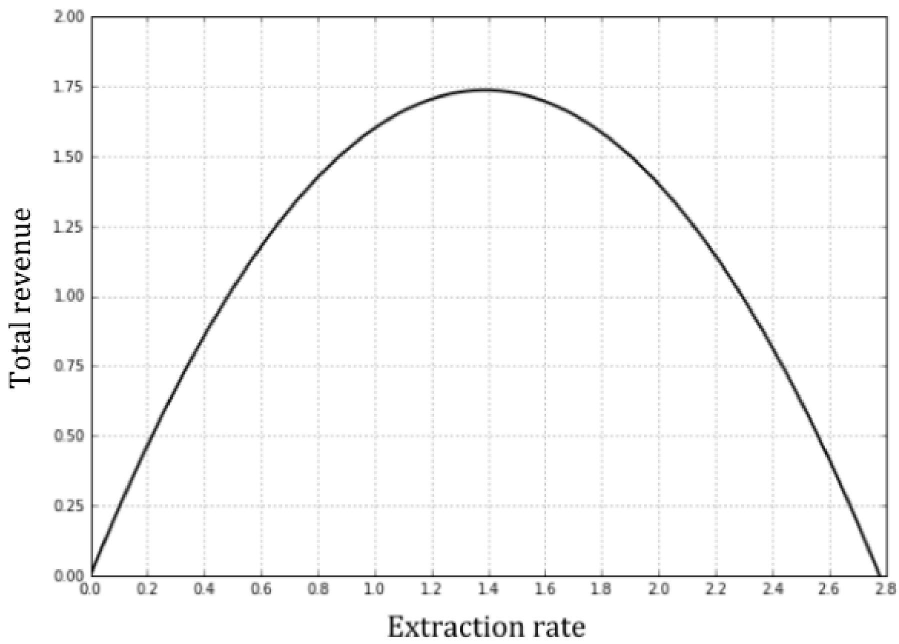
The figure below shows the total revenue according to the extraction rate.

**Example**

Let's assume that at a given instant $t$ your extraction rate is $1.4$, the total revenue will then be $1.736$ units.

**Cost of extraction**

At the instant $t$ for an available amount of resource $R_t$, the unitary cost $c_t$ is equal to:




$$c_t = \begin{cases} (2 - 0.1R_t) \text{ if } 0 \leq R_t < 20 \\ 0 \text{ if } R_t \geq 20 \end{cases}$$

Thus,

✓ cost increases when the available resource decreases

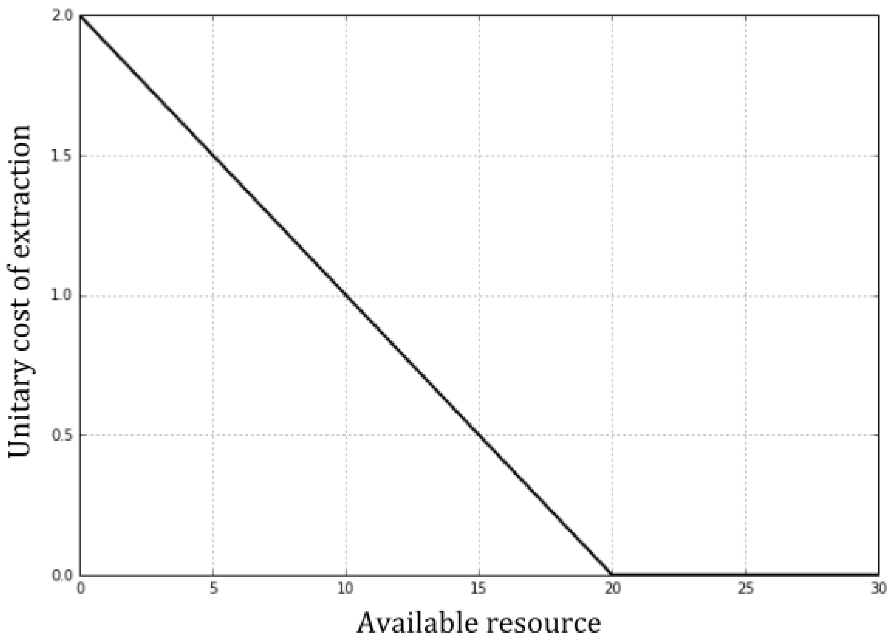
✓ cost is positive when the available resource is strictly lower than $20$ units and the cost is null when the available resource is greater than or equal to $20$ units

✓ **cost depends indirectly on the total extraction rate of the two players through the available resource**

Figure below shows the unitary cost according to the available resource.
Total cost $C_t$ is equal to the extraction rate times the unitary cost: $C_t = E_t \times c_t$

### Discounted instantaneous payoff

Each instant, for each of the two players, the instantaneous payoff ($G_t$), which is equal to the difference between total revenue and total cost ($G_t = REC_t - C_t$), is multiplied by a discount factor, allowing us to determine the present value of the payoff perceived in the future. The discount rate equals $0.5\%$ and in concrete terms means that the instant $t$ payoff is multiplied by $e^{-0.005\times t}$. Thus, the same instantaneous payoff has a different discounted value according to the instant.




**Example**

Let's take a same payoff $G_t = 0.5$ at 4 different instants.
At instant $t = 0$ the discounted payoff equals $0.5 \times e^{-0.005\times 0} = 0.5$
At instant $t = 1$ the discounted payoff equals $0.5 \times e^{-0.005\times 1} = 0.4975$
At instant $t = 10$ the discounted payoff equals $0.5 \times e^{-0.005\times 10} = 0.4756$
At instant $t = 60$ the discounted payoff equals $0.5 \times e^{-0.005\times 60} = 0.3704$

What one should remember from this discounting principle is that the payoffs of the initial instants have a greater impact on the payoff of the experiment than those of the later instants.

**Payoff for the experiment**

Your payoff for the experiment, as well as that of the other player, includes two elements: (i) your cumulated payoff from the discounted instantaneous payoffs from the beginning of the experiment (instant $t = 0$) until the present instant ($t = p$), and (ii) your "continuation payoff", which is your payoff if the experiment were to go on forever (from the present instant $t = p$ to instant $t = \infty$) **with your extraction rate and that of the other player** being fixed to the present instant ($t = p$).

Your remuneration for this experiment is your payoff for the last instant of the game. This payoff corresponds to your cumulated payoff over all the instants of the game, plus the payoff computed as if the game continued indefinitely using your extraction rate and that of the other player's fixed at the rate of the last instant.

### How the experiment works

Before the experiment starts, you and the other player should each decide upon an initial extraction rate. This rate will apply at the beginning of the experiment. As soon as the experiment has started, each of you can change this rate whenever you want by moving the slider in the window displayed on your screen. When you do not move the slider, the value that is considered at each instant is the last one that each of you set.

The computer performs the calculations every second, and the data displayed on your screens is updated every second as well. A second corresponds to $0.1$ instant, as has been described previously. Thus, $10$ minutes corresponds to $600$ seconds and to $60$ instants.

The decision screen includes four areas, in addition to the decision area with the slider. Three of these areas are graphic areas and the fourth is a text area. The Figure below gives you a shot of the decision screen. Description of areas is as follows :

- ✓ graphic at the top left: your extraction rate and the total extraction rate of both players
- ✓ graphic at the top right: the available resource
- ✓ graphic at the bottom left: your payoff of the experiment, which, as explained previously, is composed of your cumulative payoff up to the present instant, plus your payoff if your extraction and that of the other player were applied indefinitely
- ✓ text area at the bottom right: the same information as the curves but in text form, namely for each instant, your extraction rate, the total extraction rate of both players, the available resource, your discounted instantaneous payoff and your payoff of the experiment

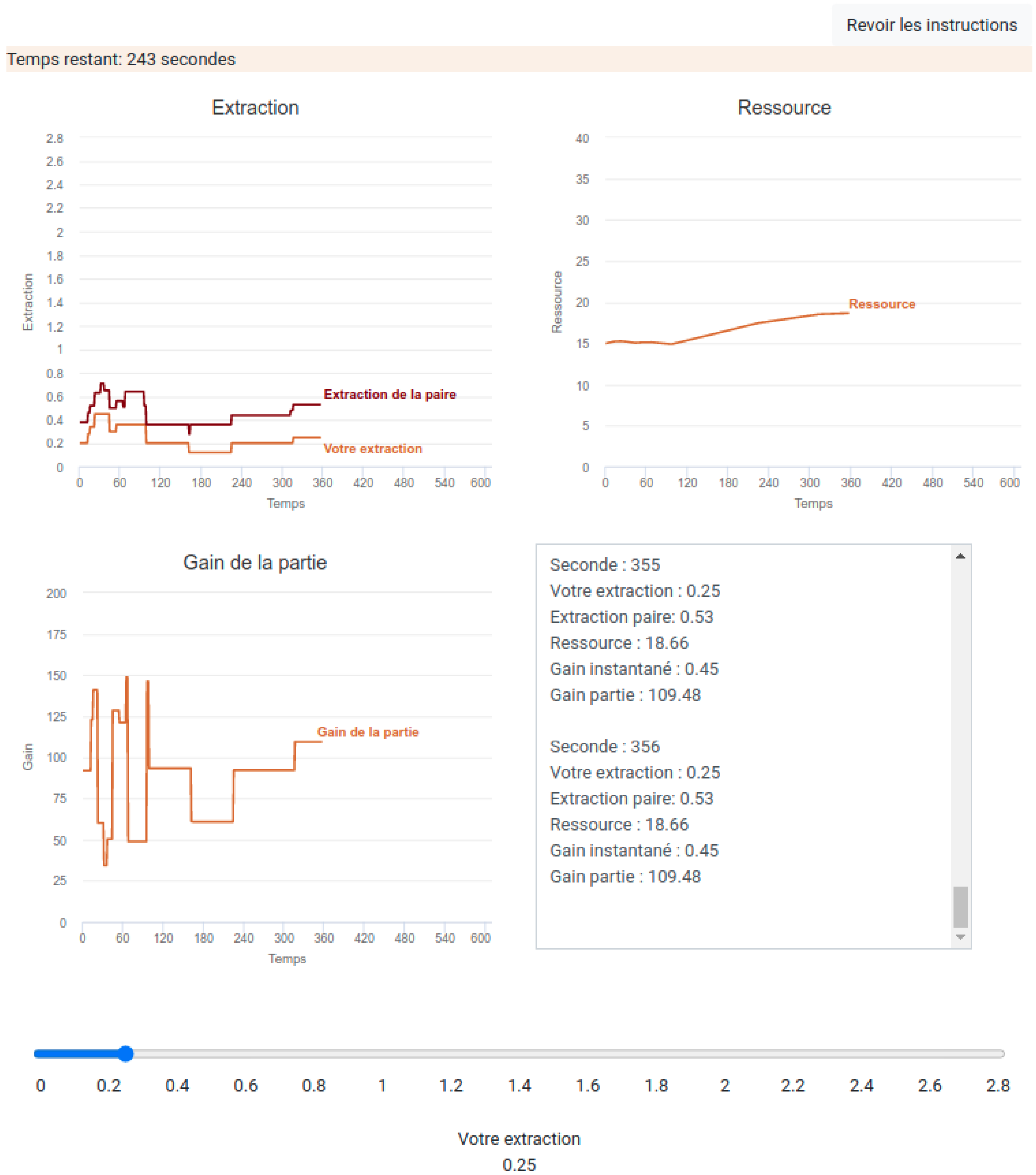



Figure S.13: The game screen shot

## Final details

This experiment includes a 10-minute training phase and a 10-minute experimentation phase. It's your payoff for the experiment that will be taken into account for your remuneration in euros. The exchange rate of ECUs to euros is as follows: 10 ECUs = 0.5€.

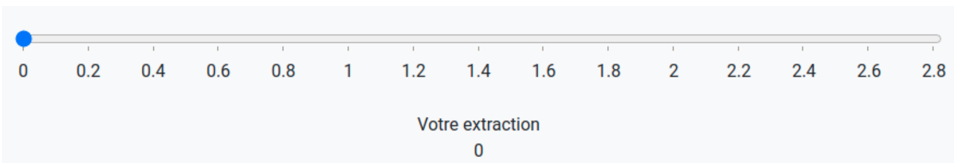
## 5.2 Discrete Time Instructions

You are about to participate in a decision-making experiment. We ask you to carefully read the instructions in order to better understand the experiment. An experimenter will proceed to read these theses instructions out loud when all participants have finished. All your decisions will be anonymously treated. You will indicate your choice using the computer in front of which you are seated. From now on, we ask you to remain quiet. If you have any questions, just raise your hand and an experimenter will come and answer you privately.

Earnings are in experimental currency units (ECU). The exchange rate of ECU into euros is specified in the instructions. The experiment includes a 60-period training phase and a 60-period experimentation phase, each corresponding to 10 minutes. The final payoff of the experimentation phase is the one taken into account for your remuneration.

### General framework

At the beginning of the experiment the central computer will randomly form pairs of 2 players. Each pair initially has 15 resource units, and each of the two players of the pair can extract an amount between 0 and 2.8 resource units with up to two decimal points of precision. You and the other player are free to choose how much you want to extract, namely 0, 0.01, 0.02 …2.79, 2.8. To make your choice, each player must move a slider similar to the one below.




You each have 10 seconds to make your choice. At the end of these 10 seconds the value below the slider is automatically taken into account, it is sent to the central computer which updates information. Then the next period begins and you, as well as the other player, have again 10 seconds to change your extraction level.

### Resource dynamics

The available amount of resource evolves each period, and its evolution depends on two elements:

(i) the total amount of resource extracted by you and your partner at each period $n$, and

(ii) a fixed amount of $0.56$ units automatically added at each period $n$. By denoting $R_n$ the amount of resource available at period $n$, the dynamics of the resource is as follows:

$$R_{n+1} = R_n - (E_{1,n} + E_{2,n}) + 0.56$$

where $E_{1,n}$ is the amount extracted by Player 1 and $E_{2,n}$ the amount extracted by Player 2.

**Example**

Suppose that at period $n$ the amount of resource available is $15$ units, that your extraction level is $0.30$ units and that the extraction level of your partner is $0.22$ units. The amount of resource available at period $n+1$ will then be : $R_{n+1} = 15 - (0.30 + 0.22) + 0.56 = 15.04$ units.

A graph on your screen will show you the resource's evolution in real time.

*If the total amount extracted by you and your partner is higher than the available resource, each layer's extraction is set to zero. You must choose another extraction compatible with the available resource.*

**Payoff**

When you extract the resource, you get a total revenue but also incur a cost. Your revenue only depends on your extraction level, while the cost depends on the available resource and indirectly on the extraction level of both players.

**Total revenue from extraction**

At period $n$, the total revenue denoted $REC_n$ is equal to:

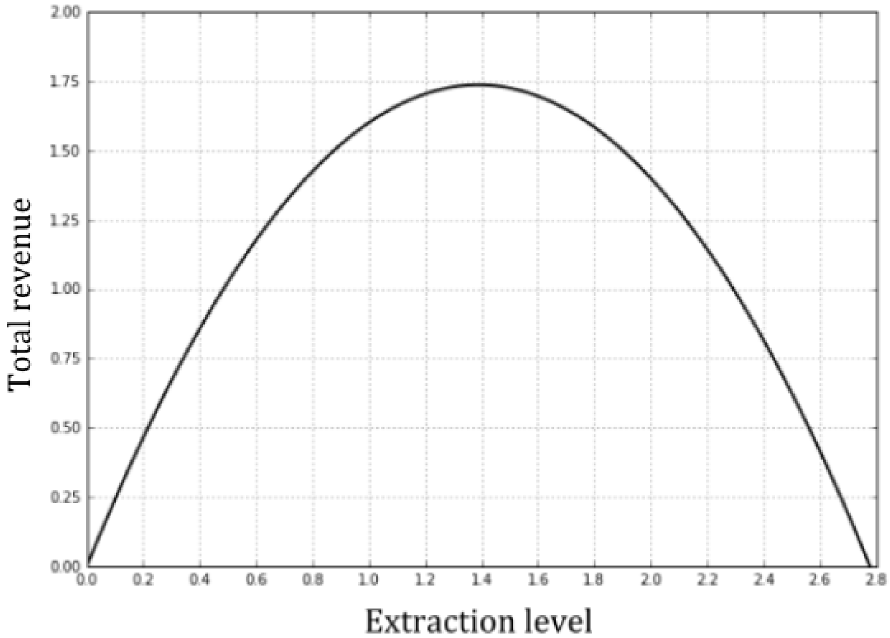
$$REC_n = 2.5E_n - 0.9E_n^2$$

where $E_n$ is your extraction level. Thus, it does not depend on the extraction level of the other player.

The figure below shows the total revenue according to the extraction level.

**Example**

Let's assume that at a given period $n$ your extraction level is $1.4$. The total revenue will then be $1.736$ units.




**Cost of extraction**

At period $n$, for an available amount of the resource $R_n$, the unitary cost $c_n$ is equal to:

$$c_n = \begin{cases} (2 - 0.1R_n) \text{ if } 0 \leq R_n < 20 \\ 0 \text{ if } R_n \geq 20 \end{cases}$$

Thus,

✓ cost increases when the available resource decreases

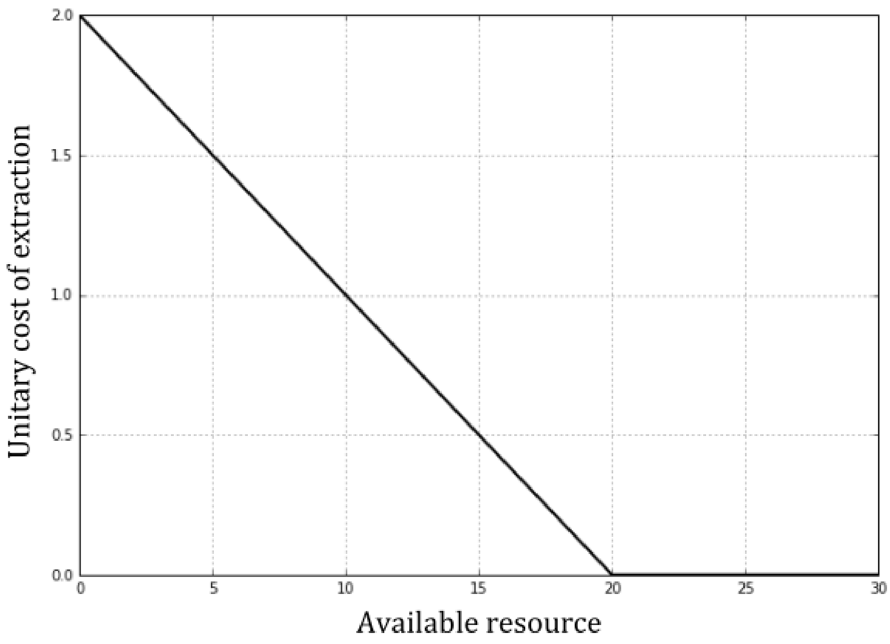
✓ cost is positive when the available resource is strictly lower than $20$ units and cost is null when the available resource is greater than or equal to $20$ units

✓ **cost depends indirectly on the total extraction level of both players through the available resource**

The figure below shows the unitary cost according to the available resource.

Total cost of extraction $C_n$, is equal to the amount extracted times the unitary cost, that is:

$$C_n = E_n \times c_n$$




**Discounted instantaneous payoff**

Each period, for each of the two players, the payoff of the period ($G_n$), which is equal to the difference between total revenue and total cost ($G_n = REC_n - C_n$), is multiplied by a discount factor, allowing us to determine the present value of the payoff perceived in the future. The discount factor equals $0.995$ and concretely means that the payoff of period $n$ is multiplied by $0.995^n$. Thus, a same payoff at $n$ has a different discounted value according to the period.

**Example**
Let's take a same payoff $G_n = 0.5$ at $4$ different periods.
At period $n = 0$ the discounted payoff equals $0.5 \times 0.995^0 = 0.5$
At period $n = 1$ the discounted payoff equals $0.5 \times 0.995^1 = 0.4975$
At period $n = 10$ the discounted payoff equals $0.5 \times 0.995^{10} = 0.4755$
At period $n = 60$ the discounted payoff equals $0.5 \times 0.995^{60} = 0.3701$

What one should remember from this discounting principle is that the payoffs of the initial periods have greater impact on the payoff of the experiment than those of the last periods.

**Payoff for the experiment**

Your payoff for the experiment, as well as that of the other player include two elements: (i) your cumulated payoff (the discounted sum of each period payoff) since the beginning of the experiment ($n = 0$) until the present period ($n = p$), and (ii) your "continuation payoff", which is your payoff if the experiment were to go on forever (from $n = p$ to period $n = \infty$) **with your extraction level and that of the other player** being fixed to the present period.

Your remuneration for this experiment is your payoff for the last period of the game. This payoff corresponds to your cumulated payoff over all the periods of the game, to which is added the payoff computed as if the game continued indefinitely with your extraction level and that of the other player of your pair fixed at that of the last period.

**How the experiment works**

Before the experiment starts you and the other player should each decide upon an initial extraction level, which will apply at the beginning of the experiment $(n = 0)$. Then, at each period, each of you have $10$ seconds to change this extracted amount by moving the slider on the window displayed on your screen. When you do not move the slider, the value that is considered at each period is the last one each of you set.

The decision screen includes four areas, in addition to the decision area with the slider. Three of these areas are graphic areas and the fourth is a text area. Figure below gives you a shot of the decision screen. Description of areas is as follows :

- ✓ graphic at the top left: your extraction level and the extraction level of your pair at each period
- ✓ graphic at the top right: the available resource at each period
- ✓ graphic at the bottom left: your payoff of the experiment, which is composed as explained previously of your cumulative payoff up to the present period, to which is added your payoff if your extraction and that of the other player of your pair is applied indefinitely
- ✓ text area at the bottom right: the same information as the curves but in the form of text, namely for each period, your extraction level, the total extraction level of your pair, the available resource, your discounted period $n$ payoff and your payoff of the experiment.

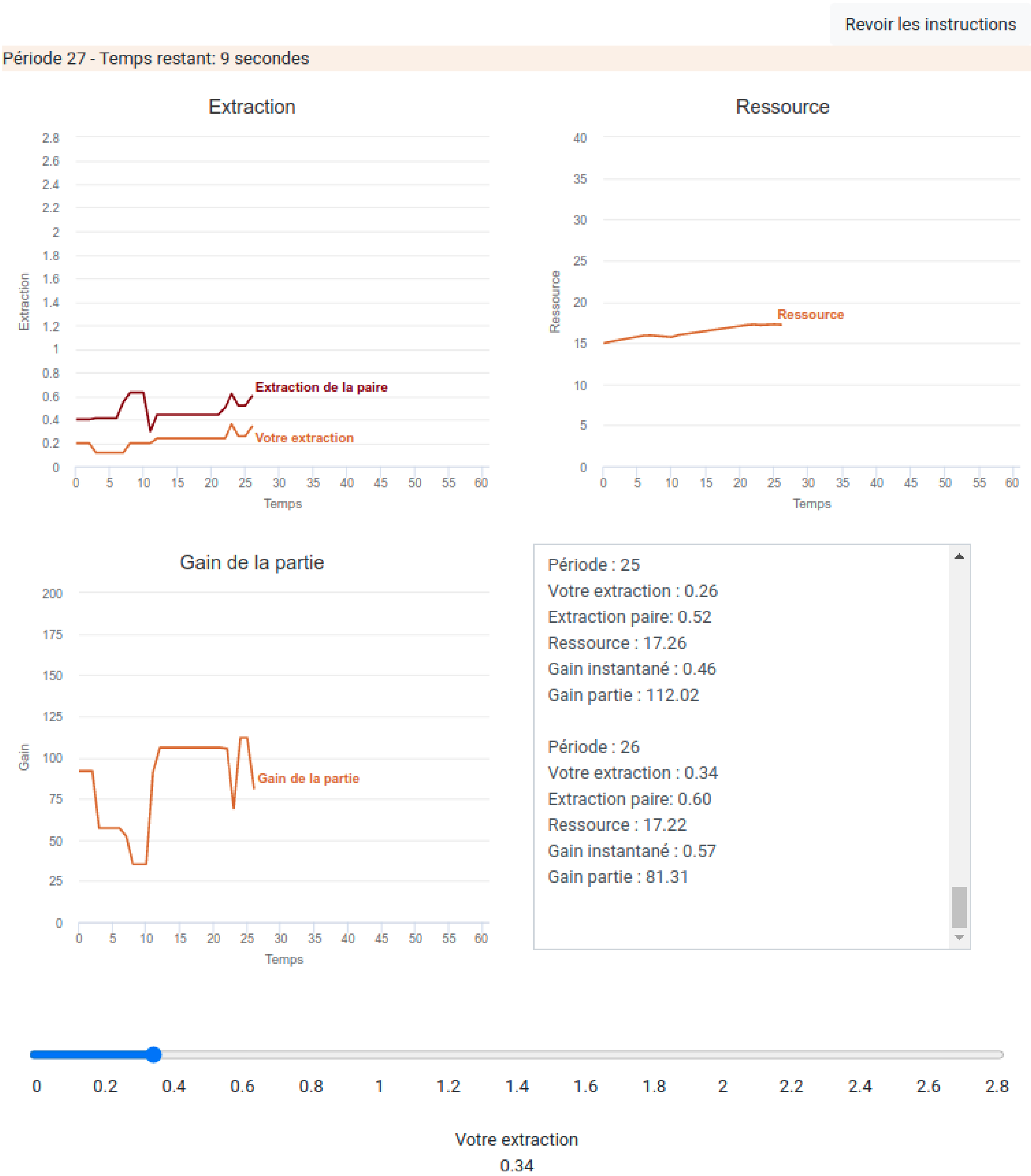



Figure S.14: The game screen shot

### Final details

This experiment includes a 60period training phase and a 60-period experimentation phase. It's your payoff for the experimentation that will be considered for your remuneration in euros. The exchange rate of ECUs to euros is as follows: 10 ECUs = 0.5€.