

Online supplementary materials to:

*Individual and strategic behaviors in a dynamic extraction problem: results
from a within-subject experiment in continuous time*

This document presents the experimental instructions (translated from French).

1 Instructions

Translated from French

1.1 Optimal control

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 aloud when all participants have finished their own reading. All of your decisions will be treated anonymously. 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.

This experiment includes two independent parts. Only the Part 1 instructions are included here; you will have those for Part 2 when Part 1 is over. Your payoff for the experiment will be the sum of your earnings over the two parts. Earnings in each part are in experimental currency units (ECU). The exchange rate of ECUs into euros is specified in the instructions for each part.

Part 1

This part includes two five-minutes training phases and a five-minute experimentation phase. The payoff for the experimentation is the one considered for your remuneration for this part.

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 your extraction rate as 0, 0.01, 0.02 ... 2.79, 2.8. You will move a slider similar to that depicted in Figure 1 to make your choice.

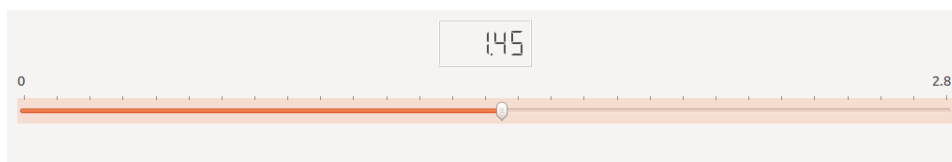


Figure 1: Slider for decision-making

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 earn revenue but also incur a cost. The cost depends on the amount of the available resource: the less of the 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 2 below shows the total revenue according to the extraction rate.

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,

- the cost increases when the available resource decreases
- the 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

Figure 3 shows the unitary cost according to the available resource.

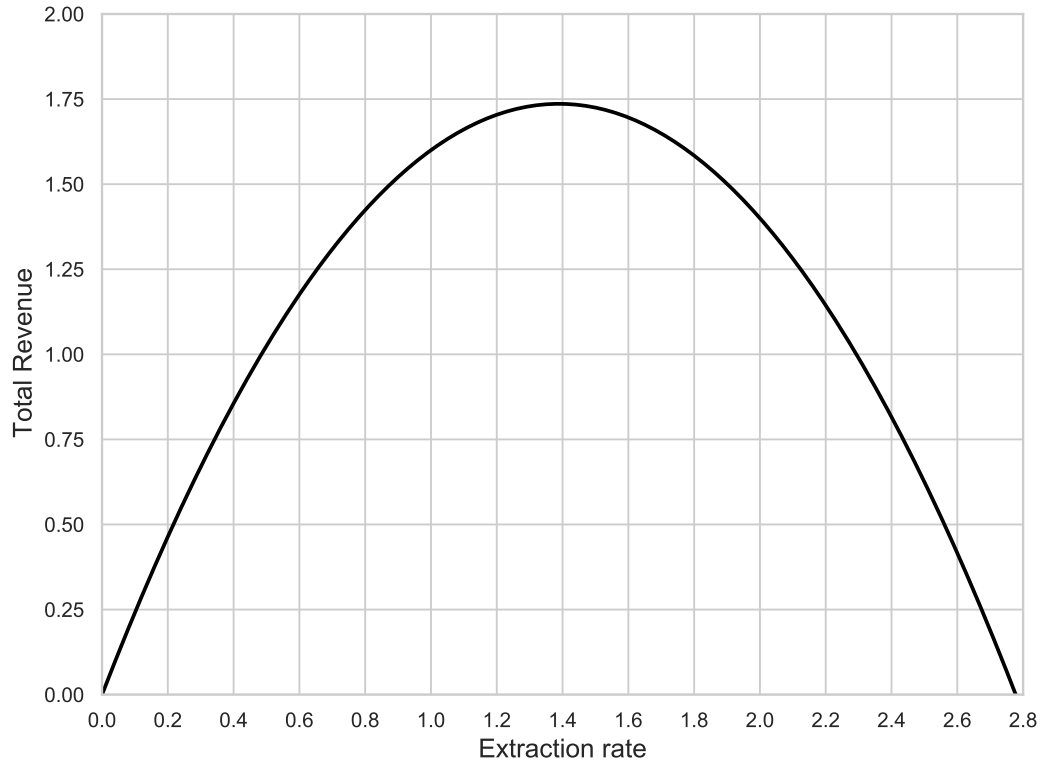


Figure 2: Total revenue from extraction

The total cost of extraction C_t , is equal to the extraction rate times the unitary cost, that is:

$$C_t = E_t \times c_t$$

Instant t payoff

At the instant t , payoff G_t equals the difference between benefit and cost, so that $G_t = REC_t - C_t$

Example

With $E_t = 1.4$ and $R_t = 20$, $REC_t = 1.736$ and $C_t = 0$, thus payoff is 1.736 ecus

With $E_t = 1.4$ and $R_t = 15$, $REC_t = 1.736$ and $C_t = 0.7$, thus payoff is 1.036 ecus

With $E_t = 1.4$ and $R_t = 10$, $REC_t = 1.736$ and $C_t = 1.4$, thus payoff is 0.336 ecus

With $E_t = 1.4$ and $R_t = 5$, $REC_t = 1.736$ and $C_t = 2.1$, thus payoff is -0.364 ecus

Discounted instantaneous payoff

Each instant, the instantaneous payoff (G_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, the same

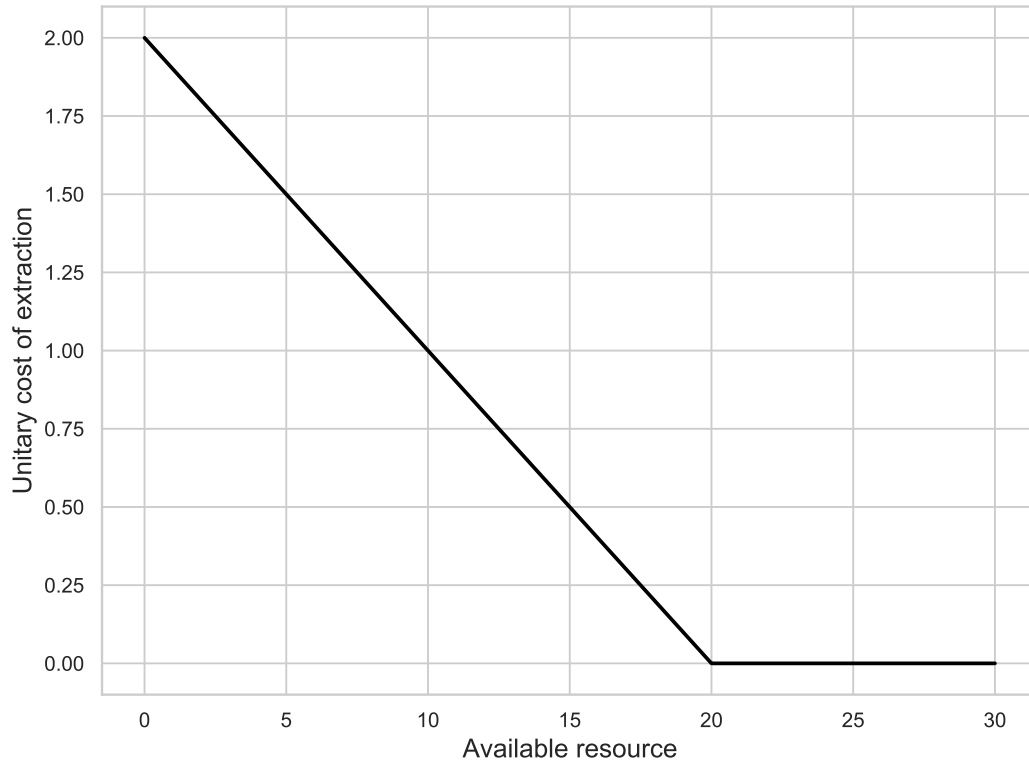


Figure 3: Unitary cost of extraction

instantaneous payoff has a different discounted value according to the instant.

Example

Let us take the 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 $t = 100$ the discounted payoff equals $0.5 \times e^{-0.005 \times 100} = 0.3033$

At instant $t = 300$ the discounted payoff equals $0.5 \times e^{-0.005 \times 60} = 0.1116$

What one should remember from this discounting principle is that the payoffs of the first instants have a 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 ($t = 300$). 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 part works

Before the part starts you should decide on an initial extraction rate that 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 also updated every second.

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 4 on page [vii](#) gives you a depiction of the decision screen. Description of the areas is as follows:

- graphic at the top left is your extraction rate
- graphic at the bottom left is the available resource
- graphic at the top right is your payoff for the experiment, which, as explained previously, comprises 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 contains 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: $10 \text{ ECUs} = 0.5\text{€}$.

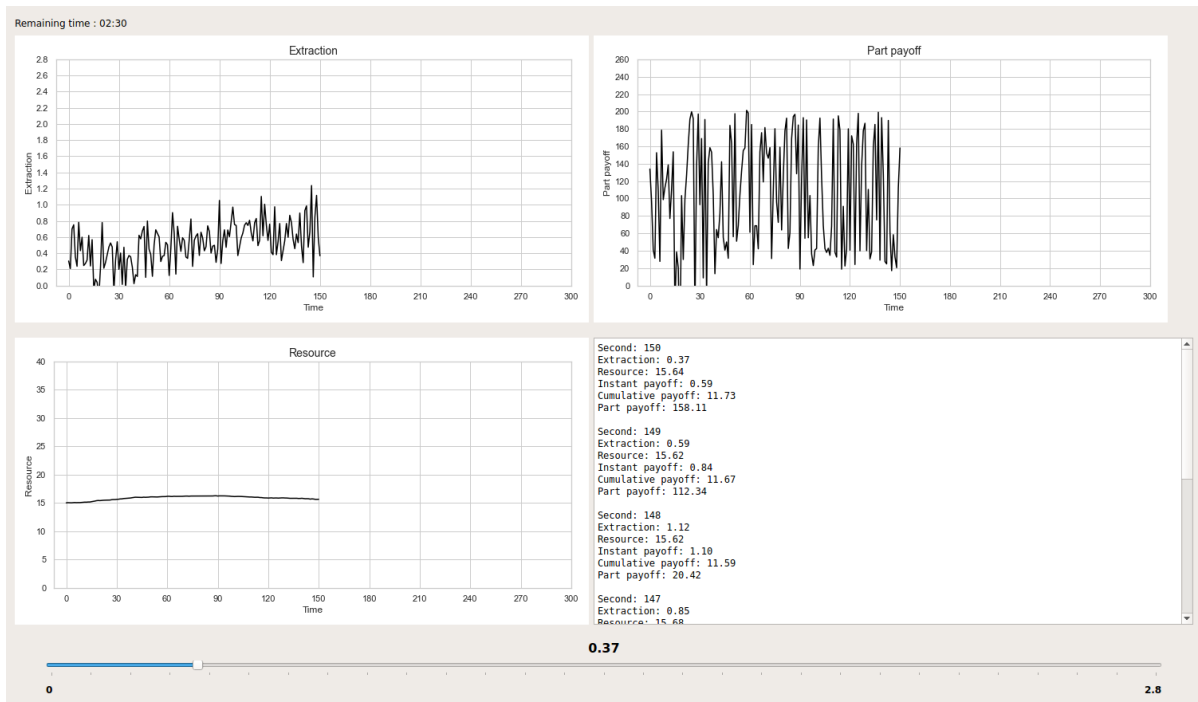


Figure 4: Decision-making screenshot. We follow a hypothetical subject who chooses his extraction rate at random

1.2 Game

Part 2

This part is identical to the previous one except that **from now on, you are two subjects who extract the same resource**. More precisely, at the beginning of the part, the central computer will randomly form pairs of 2 players. Each pair will initially have 15 units of resource, and each of the two players in the pair can at any moment extract an amount between 0 and 2.8 units.

Resource dynamics

The resource evolves continuously and this evolution depends on two elements : (i) **the total amount of resource extracted by your pair** at each instant t , and (ii) a fixed amount of 0.56 automatically added at each instant t .

If at the instant t the extraction of the pair exceeds the available resource, the extraction of each member of the pair for this instant is fixed to 0 by the computer.

Payoff

The calculation of the revenue for the extraction is identical to that in Part 1, namely $REC_t = 2.5E_t - 0.9E_t^2$, where E_t is your extraction. Thus, it does not depend on the extraction of the other player in the pair.

The calculation of the unitary cost is also identical, namely

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

Thus

- the cost increases when the amount of available resource decreases
- the cost is positive when the amount of available resource is strictly lower than 20 units and cost is null when the available resource is greater than or equal to 20 units
- **the cost depends indirectly on the total extraction of the pair from the available resource**

The total cost of extraction C_t , is equal to the extracted amount times the unitary cost, that is $E_t \times c_t$.

The instant t payoff is computed as previously by the difference between revenue and cost : $G_t = REC_t - C_t$. In the same way, the discounted instant t payoff is equal to the instant t payoff multiplied by the discount factor, that is $G_t \times e^{-0.005 \times t}$.

The payoff of this part is also computed as previously: the cumulated payoff from instantaneous discounted payoffs since the beginning of the part ($t = 0$) until the present instant ($t = p$) to which is added the "continuation payoff", which is the payoff if the game went on forever (from $t = p$ to $t = \infty$) **with your extraction and the extraction of the other player in the pair** being fixed to the present instant.

The payoff used for your remuneration for this part is your total discounted payoff at the last instant ($t = 300$).

How the part works

The progress of the part is identical to that of Part 1, that is, first the choice of an initial extraction, then as soon as the part is started, the possibility of changing this extraction at any moment by moving the slider on the decision window.

The decision screen includes the same four areas as previously. **Two supplementary curves appears in the top left graphic: the other player extraction in your pair and the total extraction of your pair.**

Last details

This part includes two five-minute training phases each and also a five minutes experimentation phase. It is your payoff for the experimentation that will be considered for your remuneration in this part.

The exchange rate of ECUs to euros is as follows : $10 \text{ ECUs} = 0.5\text{€}$

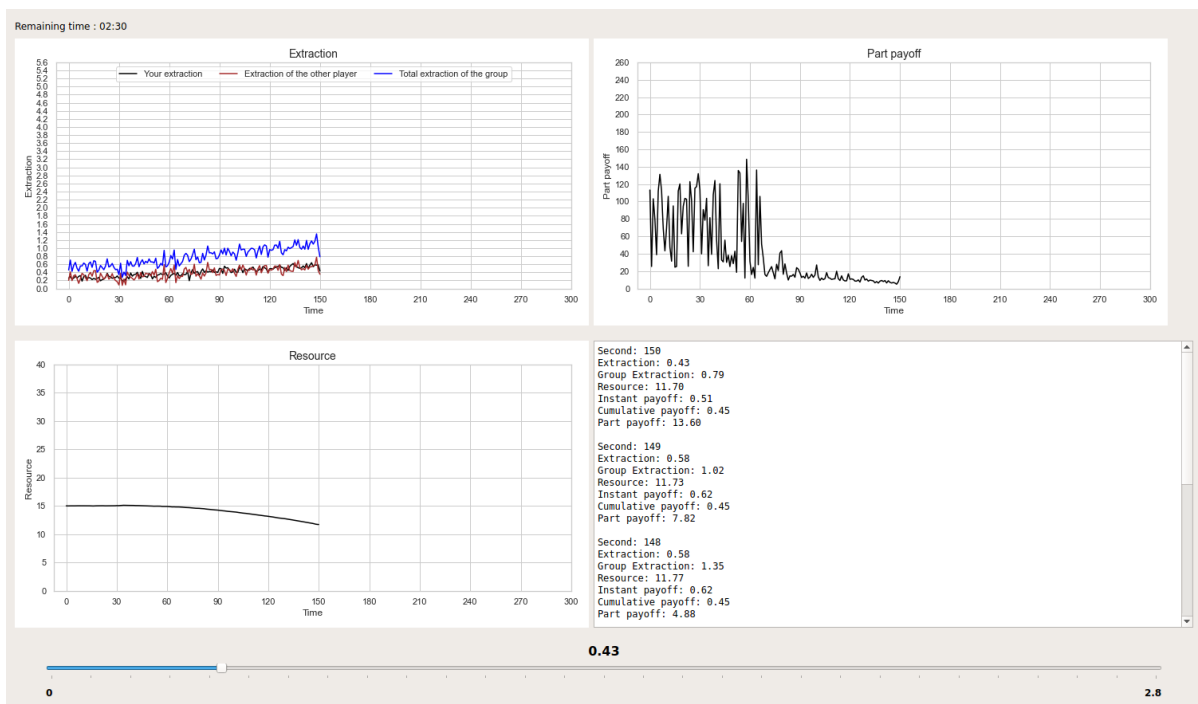


Figure 5: Decision-making screenshot. We follow two hypothetical subjects who choose their extraction rate at random