



Instructor guide to the Stackelberg game

Laboratory implementation, theoretical foundations,
experimental evidence, and variants

Behavioral and Experimental Economics Research Lab
Department of Economics



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<https://beer-lab.org/>

How to use this guide

This guide supports preparation, implementation, and discussion of the Stackelberg game family at the Behavioral and Experimental Economics Research Lab (BEER Lab), Department of Economics, Tecnológico de Monterrey. It is written for instructors in principles of economics, intermediate microeconomics, industrial organization, game theory, business strategy, and experimental economics.

No previous experience with oTree or classroom experiments is required. The document offers three reading paths. The quick guide and lesson plans support a first session.

The operational chapters explain access, the participant experience, the private instructor report, and troubleshooting. The conceptual chapters develop quantity competition, backward induction, commitment, first-mover advantage, welfare, and experimental extensions. Basic and extended versions form one family: common elements appear once, while each variant describes only what changes.

Author

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For the instructor

For a first use, select the basic one-interaction version and derive the follower's best response before revealing results. Use ten rounds to study learning or role rotation. Project only the aggregate report and keep it hidden until decisions close. Do not show individual codes or connect choices with names, student IDs, or physical seats.

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Quick guide and learning outcomes

1.1 Access through the updated laboratory website

Start at <https://beer-lab.org/en/>. Select **CLASSROOM** in the top navigation menu; it opens <https://teaching.beer-lab.org/en/>. In the **Classroom experiments** catalog, use the search box to locate the activity by name. You can also filter by **Topic** or **JEL code**. Clear any filters left from an earlier search before looking for another game.

Each family's card distinguishes **Español** and **English** access links. The **Show extended version** checkbox selects that edition before following a link. Catalog language and session language are separate choices: verify both. Students use the room specified by the instructor; the instructor prepares and monitors the session through this family's own administrative pages.



Figure 1.1: Current institutional website. Select CLASSROOM in the top navigation menu to open the teaching experiments. Captured on October 7, 2026.



Figure 1.2: Current catalog: search by title, topic, or JEL code. Then locate this family's card and select language and edition. Captured on October 7, 2026.

Checking resources, comprehension, and participant requirements

Before opening the room, check the selected configuration and the number of students present. The session-creation form states the group size and minimum required by that configuration. An individual activity accepts any positive participant count; an interactive activity must satisfy its stated requirement: complete groups when size is fixed, or a minimum participant count when size is flexible. Requirements may change across treatments, for example when adding a third party or changing an institution's size. If you edit a grouping parameter, check the requirement for the edited configuration, rather than relying only on the demo's suggested count.

In the instructions, ensure that students can identify what each role receives, what they can decide, and how the outcome is calculated. An initial account, a distributable budget, and final earnings need not be the same amount. Refer to the resources panel and the example for the selected treatment. Do not carry the basic edition's endowment into a treatment that changes accounts or introduces additional positions.

ECU stands for *Experimental Currency Units*: the activity's unit of account. An outcome of 100 ECU does not automatically equal 100 pesos or 100 dollars. Conversion depends on the session configuration. Before announcing a payment, confirm with the laboratory whether money is paid, the conversion rate, and which decisions count for payment. In hypothetical modules, describe amounts as outcomes in the stated situation.

When a comprehension check is included, an incorrect response receives an explanation beside that question, identifying the submitted answer and the correct answer. Other answers remain in the form. Ask the student to return to the example, locate the relevant rule, and redo the calculation before correcting the response. Avoid revealing answers to the entire class for an individual error, and do not interpret a comprehension mistake as an economic choice in the game.

— una interacción	Duopolio de Stackelberg / Stackelberg Duopoly — BEER Lab Seleccione una variante de este juego. Select a version of this game.
— 10 rondas, pareja fija	
— 10 rondas, parejas reasignadas	
— one interaction	
— 10 rounds, fixed partner	
— 10 rounds, reassigned partners	
extendido — referencia, una interacción	
extendido — referencia, pareja fija	
extendido — referencia, parejas reasignadas	
extendido — Cournot simultáneo	
extendido — liderazgo alternado	
extendido — momento de decisión endógeno	
extendido — observación imperfecta	
extendido — costos asimétricos	
extendido — capacidad limitada de la líder	
ackelberg — baseline, one interaction	
ackelberg — baseline, fixed partner	
ackelberg — baseline, reassigned partners	
ackelberg — simultaneous Cournot	
ackelberg — alternating leadership	
ackelberg — endogenous timing	
ackelberg — imperfect observation	
ackelberg — asymmetric costs	
ackelberg — leader capacity constraint	

Figure 1.3: Demo contains only the configurations of this game family, in both languages and editions.

Rooms

Current rooms:

[ES] Duopolio de Stackelberg
[EN] Stackelberg Duopoly
[ES] Duopolio de Stackelberg: extendido
[EN] Stackelberg Duopoly: extended

Figure 1.4: Rooms contains the four rooms for this family: basic and extended editions in Spanish and English.

Room: [EN] Stackelberg Duopoly

Create a new session

Session Config

[EN] Stackelberg — one interaction

Number of participants

Complete groups of 2 participants. Use a multiple of 2; minimum 2.

Create

[Configure session](#) 

App sequence

stackelberg_game (10 rounds)

Bilingual Stackelberg quantity-competition teaching game.

Figure 1.5: Session-creation form for the basic English room. Check the selected configuration and participant requirement before creating the session.

Downloading a session with several rounds

For the instructor

Open **Data** within the relevant session and use that session's CSV or CSV-for-Excel download link. The general export has one row per participant and columns for the different rounds. Ten rounds do not necessarily mean ten rows per person. When the family provides its own long-format export, observations may instead be organized by participant and round or another unit defined by the design.

Save the original file together with the configuration name, session code, and active-round count. Check that columns for the last active round are present and that the data belong to the selected session. Empty cells can represent inactive rounds, a pending decision, or a field that does not apply to a role; do not automatically recode them as zeros. To compare learning, preserve round and group identifiers alongside participant identifiers. Share only anonymous aggregates in class, and record session incidents before constructing derived tables.

Attention

The public route for this family is proposed for laboratory deployment. The validated local instance uses port 8039. Demo must display exactly 24 configurations and Rooms exactly four rooms. If another game family appears, do not start the session; verify `GAME_FAMILY=stackelberg`.

Purpose	Understand how an observable output commitment changes best responses, price, profits, and welfare in a duopoly.
Experimental unit	A pair of firms; under repetition, independence depends on the matching rule.
Basic edition	One interaction, ten rounds with the same partner, and ten rounds with reassignment.
Extended edition	Simultaneous Cournot, alternating leadership, endogenous timing, imperfect observation, asymmetric costs, and constrained capacity.
Decision	Integer output from 0 to 100; the leader is capped at 35 in the capacity treatment.
Outcome	Total output, price, margin, operating profit, and credited ECU.
Students	https://stackelberg.beer-lab.org/room/stackelberg_en
Instructor	https://stackelberg.beer-lab.org/demo
Local test	http://localhost:8039/demo , with <code>GAME_FAMILY=stackelberg</code> .
Topics	oligopoly; Stackelberg; commitment; Cournot; game theory.
JEL	C72; C92; D43; L13.

By the end, students should be able to construct a best response; solve a sequential game by backward induction; distinguish Nash equilibrium from subgame-perfect equilibrium; explain why an irreversible action may have strategic value; compare Stackelberg with Cournot and monopoly; calculate price and profit from quantities; distinguish information from commitment; analyze asymmetric costs and capacity constraints; and interpret classroom evidence without mistaking a group mean for every pair's behavior.

The activity also develops empirical literacy. The report separates leader and follower through colors, histograms, and role-specific profits. A distribution identifies convergence, multimodality, and extreme responses hidden by a mean. Round evolution documents descriptive learning. Absolute best-response error shows whether followers respond to the relevant quantity, but it does not by itself prove rationality or identify preferences. Define the independent unit before comparing treatments.

Checkpoint

Before opening a room, an instructor should solve four numbers without the guide: $q_L = 50$, $q_F = 25$, $P = 45$, and profits 1, 250/625. The instructor should also explain why credited ECU add 2,000 to operating profit: the balance prevents negative displayed earnings, but it does not change marginal incentives.

Economic model and predictions

Two firms produce a homogeneous good. Inverse demand is

$$P(Q) = \max\{0, 120 - Q\}, \quad Q = q_1 + q_2.$$

Each unit costs 20 ECU in the benchmark. Firm i earns operating profit

$$\pi_i = (P - 20)q_i = (100 - q_i - q_j)q_i$$

as long as total output does not exceed 120. The interface credits $2,000 + \pi_i$ ECU. The 2,000 balance is a constant: it changes the displayed level, not the profit-maximizing output. This distinction matters because some students try to recover the balance even though it is neither a sunk cost nor an endowment to allocate.

2.1 The follower's response

The leader selects q_L and the follower observes it. For a given quantity, the follower maximizes $(100 - q_L - q_F)q_F$. The first-order condition is $100 - q_L - 2q_F = 0$, so

$$BR_F(q_L) = \max\left\{0, \frac{100 - q_L}{2}\right\}.$$

The negative slope reflects strategic substitutes: a larger commitment by the leader makes a smaller follower quantity profitable. A one-unit reduction in leader output raises the best response by one half. The follower is not trying to complete a fixed total of 100; it balances the margin on all its units against the price effect of an additional unit.

2.2 The leader's choice

Backward induction substitutes the response into leader profit:

$$\pi_L(q_L) = \left[100 - q_L - \frac{100 - q_L}{2}\right] q_L = \frac{(100 - q_L)q_L}{2}.$$

The derivative is $50 - q_L$, so $q_L^* = 50$. The follower responds with $q_F^* = 25$. Total output is 75, price is 45, and operating profits are $25 \times 50 = 1,250$ for the leader and $25 \times 25 = 625$ for the follower. The equilibrium is subgame perfect because the response is optimal after every feasible leader output, not only along the predicted path.

Theoretical foundation

Moving first has value because output is observable and committed. If the leader could revise its choice after the response, producing 50 would not constrain later conduct and the logic would change. Timing, observation, and irreversibility jointly define the Stackelberg institution.

2.3 Cournot, monopoly, and competition

In Cournot, firms choose simultaneously. Symmetric best responses intersect at $q_1 = q_2 = 100/3 \simeq 33.33$. Total output is 66.67, price is 53.33, and each firm earns 1,111.11 ECU. Stackelberg increases total output to 75 and lowers price to 45. The leader earns more than a Cournot firm, while the follower earns less. Industry profit falls from about 2,222.22 to 1,875 as consumer surplus rises.

A monopolist controlling both plants would choose total output 50 and price 70, earning 2,500. The competitive benchmark produces 100 at price 20. Therefore,

$$Q^M = 50 < Q^C = 66.67 < Q^S = 75 < Q^{PC} = 100.$$

This ordering connects industrial organization and welfare. Rivalry raises output, and the leader's aggressive commitment intensifies rivalry. Higher total output, however, does not imply higher joint firm profit.

2.4 Welfare and surplus

With linear demand and marginal cost 20, consumer surplus is $CS = (120 - P)Q/2 = Q^2/2$ when price lies on demand. Total surplus is $CS + \pi_1 + \pi_2$. Under Stackelberg, consumer surplus is 2,812.5 and industry profit is 1,875, totaling 4,687.5. Under Cournot, consumer surplus and industry profit are each about 2,222.22, totaling 4,444.44. The efficient allocation yields 5,000. Commitment can benefit consumers and raise efficiency while reducing producer rent.

Feedback script

Build four columns on the board: monopoly, Cournot, Stackelberg, and competition. First ask students to rank quantities without calculation. Then complete price, industry profit, consumer surplus, and total surplus. End by asking who benefits from leader commitment and why the answer depends on whether “who” means leader, follower, industry, or consumers.

Access, rooms, and technical preparation

The institutional path starts at <https://beer-lab.org/>. The teaching section opens <https://teaching.beer-lab.org/>, where the Stackelberg card should lead to the family domain. Instructors use <https://stackelberg.beer-lab.org/demo>; students never need this administrative page. For the validated local laboratory, replace the domain with <http://localhost:8039>.

The domain is designed as an isolated instance. Demo lists 24 configurations: six basic and eighteen extended across Spanish and English. Rooms displays four rooms: `stackelberg_es`, `stackelberg_en`, `stackelberg_extendido`, and `stackelberg_extended`. Sessions and Data also remain within this family when deployment uses a separate database.

3.1 Selecting a configuration

For a 25–35 minute introduction, choose the basic one-interaction configuration. For a 60–80 minute class on learning, use ten rounds with fixed partners. To discuss reputation and independence, compare fixed partners with reassignment. Extended configurations require the instructor to announce the institutional change and students to understand the sequential benchmark first.

Participant count must be even because each market contains two firms. If one extra person arrives, do not invent a participant identity. Assign an observation task, allow a two-person team on one computer if the protocol permits, or create a separate plan. Both positions must complete an interaction; leaving a computer strands the partner on a waiting page.

For the instructor

Open the session before students enter, copy the participant link, and test it in a private window. Confirm language, edition, treatment, rounds, and matching in the header. Keep the report tab open. Do not reuse a participant code from an earlier session: after a database recreation, it may produce a message that the user no longer exists.

3.2 Pre-class checklist

Check connectivity, browser zoom, logo visibility, absence of debug information, and at least two test computers. Make sure the projector displays only the instructor screen. Decide whether ECU are illustrative points or use an announced conversion; state the rule before play. Prepare demand on a slide or board and keep predictions hidden if you want to elicit intuition.

Random reassignment requires at least four participants and works better with more pairs. With one pair, random and fixed matching generate the same effective encounter. Repeated designs require enough time for each leader decision, follower response, outcome, and transition. A tight schedule is not a reason to rush participants who are calculating.

Checkpoint

The minimum test has six steps: open Demo, count 24 configurations, open Rooms, count four rooms, enter the basic English room and confirm its first option is basic, and run a four-participant session through the revealed report. If any step fails, use the validated local instance or contact the administrator before class.

Participant experience

The first page welcomes students to the BEER Lab, states the academic purpose, and gives common rules: work silently, do not converse, do not view neighboring screens, and follow instructions. Students mark acceptance to continue. This page is part of the protocol and should not be replaced by improvised oral language.



Welcome

The **Behavioral and Experimental Economics Research Lab** in the Department of Economics at Tecnológico de Monterrey is a space designed to learn about economic decision-making through controlled activities.

Figure 4.1: Institutional welcome and general laboratory rules. Continuation 1/2.

In this activity, you will manage a firm in a market with two producers. Your decisions and another person's decisions will determine price and profit.

Instructions present demand, cost, timing, operating balance, a worked example, the number of rounds, and the matching rule. The text distinguishes operating profit from credited ECU. A one-shot session says "1 round" and repeated sessions use the correct plural. Allow individual reading before explaining, and answer questions publicly so everyone receives the same information.

General laboratory rules

- Remain silent throughout the activity.
- Do not converse with neighbors.
- Do not look at neighboring screens.
- Do not refresh, close, or leave the page.
- If you have a problem, raise your hand and wait for private assistance.

The comprehension check asks who observes before choosing, the best response to 50, a simple profit, and the session's number of rounds. Correct responses are follower, 25, 1,600, and the configured number. Incorrect answers produce a review message and another attempt. The purpose is internal validity rather than grading.

☐ I have read and agree to follow these rules.

Welcome

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In this activity, you will manage a firm in a market with two producers. Your decisions and another person's decisions will determine price and profit.

General laboratory rules

- Remain silent throughout the activity.
- Do not talk or communicate with other participants.
- Make your decisions individually and privately.
- Follow the instructions shown on screen.
- Do not refresh, close, or leave the page.
- If you have a problem, raise your hand and wait for private assistance.

☐ I have read and agree to follow these rules.

Start

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Figure 4.2: Institutional welcome and general laboratory rules. Continuation 2/2.



Instructions

Resources and unit of account

Each participant's starting account per round: 2000 ECU. The round's profit or loss is added to that account.

ECU stands for Experimental Currency Units. It is the unit of account for this activity.

This session does not convert ECU into real money.

Stackelberg with perfect observation



The market

Two firms produce a homogeneous good. Price depends on the total quantity produced.

Costs and profits

Each unit costs 20 ECU unless the treatment

edition's initial resources, decision rules, and experimental units. Continuation 1/2.

Order of decisions

The leader chooses first. The follower observes the quantity and responds.

Each round starts with a 2,000 ECU operating balance. The credited result is 2,000 plus operating profit, so one

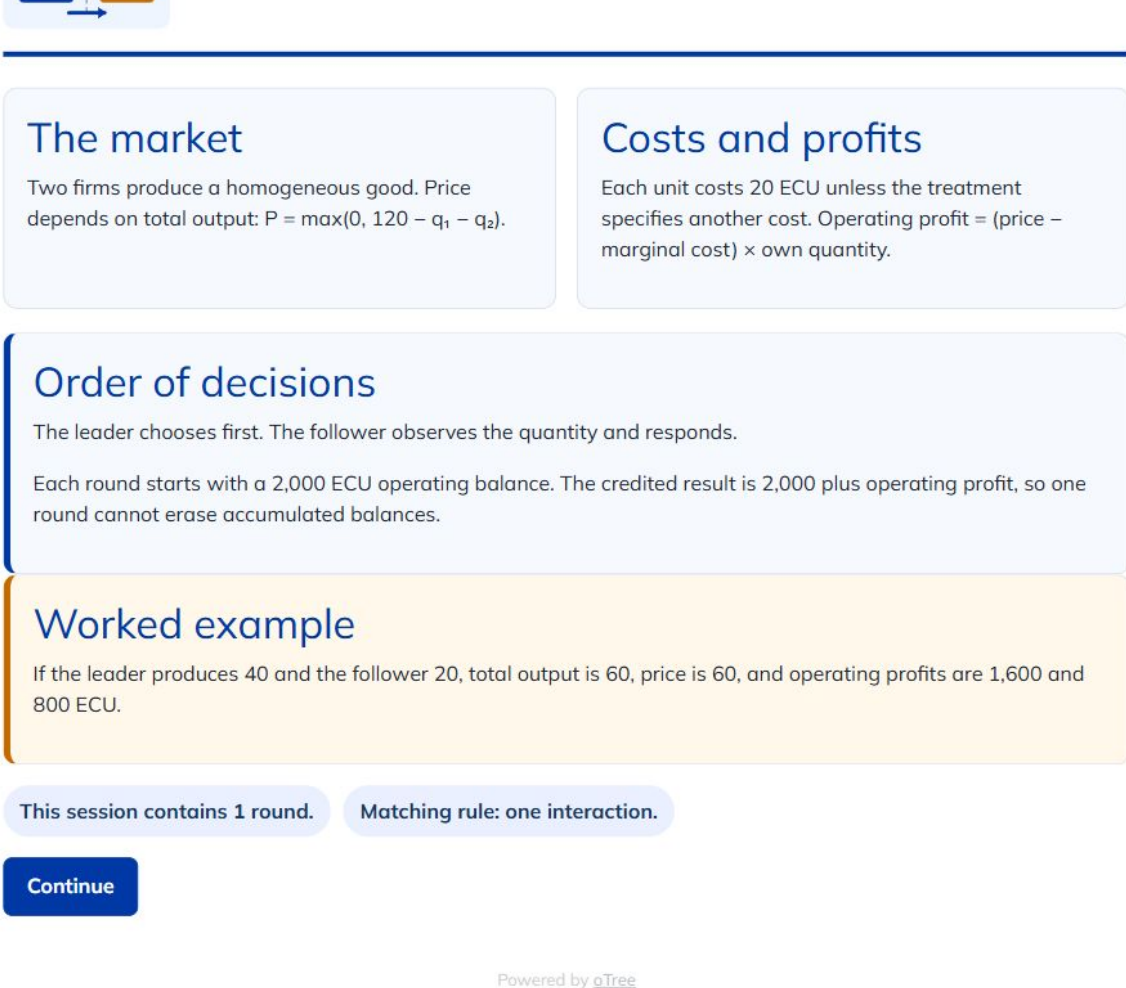


Figure 4.4: Current instructions for the basic edition: initial resources, decision rules, and experimental units. Continuation 2/2.

4.1 Role-specific screens

The leader receives a blue card stating that it moves first and its output is committed. It sees the feasible range and confirms an integer. The follower receives an orange card, observes leader output or the relevant signal, and chooses a response. This color contrast continues in outcomes and the report; it carries meaning rather than decoration.

A waiting page prevents one participant from moving alone. The result page then reports quantities, total output, price, role-specific profits, own credited outcome, and the theoretical benchmark. Treat the benchmark as a comparison rather than a correct answer that invalidates choices. In the last round, the button reaches an explicit final summary; participants never end at the generic “No more pages left” message.

What participants will see

Participants should always know four things: their position, the information they observe, the output they can choose, and how their outcome is calculated. Oral commentary that reveals other pairs’ conduct or interim aggregate results changes the game. Answer technical questions, but refer strategic advice back to the written instructions.

4.2 Common comprehension errors

Some students add the 2,000 balance to the objective and believe it changes the first-order condition. Others subtract quantity as cost while forgetting the factor 20. It is also common to treat 120 as a



Review the marked questions. Each shows your answer and an explanation; your other answers are retained.

Comprehension check

Resources and unit of account

ECU stands for Experimental Currency Units. It is the unit of account for this activity.
This session does not convert ECU into real money.

Stackelberg with perfect observation

In the sequential design, who observes a quantity before choosing?

- ☐ The follower firm
- ☒ The leader firm
- ☐ Both choose after observing each other

Your answer: The leader firm. The correct answer is The follower firm. Review the order, best-response function, profit formula, and number of rounds.

Figure 4.5: Current comprehension check with an incorrect answer, its specific explanation, and retained responses. Continuation 1/2.

With cost 20, if the leader produces 50, what is the follower's best response?

25 ECU

If a firm produces 40, price is 60, and marginal cost is 20, what is operating profit?

1600 ECU

How many rounds are in this session?

- ☒ 1
- ☐ 10

Comprehension check

Resources and unit of account

ECU stands for Experimental Currency Units. It is the unit of account for this activity.
This session does not convert ECU into real money.

Stackelberg with perfect observation

In the sequential design, who observes a quantity before choosing?

- ☐ The follower firm
- ☒ The leader firm
- ☐ Both choose after observing each other

Your answer: The leader firm. The correct answer is The follower firm. Review the order, best-response function, profit formula, and number of rounds.

With cost 20, if the leader produces 50, what is the follower's best response?

25 ECU

If a firm produces 40, price is 60, and marginal cost is 20, what is operating profit?

1600 ECU

How many rounds are in this session?

- ☒ 1
- ☐ 10

Check answers

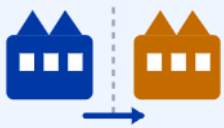
Powered by [oTree](#)

Figure 4.6: Current comprehension check with an incorrect answer, its specific explanation, and retained responses. Continuation 2/2.

Production decision

Round 1 / 1

Stackelberg with perfect observation



YOUR POSITION
Leader firm
You choose first and your quantity will be committed.

Quantity to produce

Enter an integer from 0 to 100.

Confirm quantity

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Figure 4.7: Positions are distinguished by wording and color. Leader output choice.

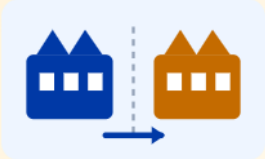
fixed price, confuse own with total output, or assume the follower wants total output to equal 100. Reconstruct $P = 120 - q_L - q_F$ and multiply the margin $(P - 20)$ by own quantity.

Another error is to think the leader chooses the follower's output. The leader commits only its own production; the follower still chooses. Under imperfect observation, the highlighted number is a signal rather than true output. Under alternating roles, color and position can change across rounds. Ask students to read their role card before calculating.

Production decision

Round 1 / 1

Stackelberg with perfect observation



YOUR POSITION

Follower firm

You choose after receiving information about the leader's quantity.

Leader's chosen quantity: 50

Quantity to produce

Enter an integer from 0 to 100.

Confirm quantity

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Figure 4.8: Follower response.



Round result

Round 1 / 1

Stackelberg with perfect observation

Your quantity 50	Other firm's quantity 25	Total output 75	Price 45 ECU
Operating profit 1250 ECU	ECU credited 3250 ECU		

Leader firm
q = 50
1250 ECU

Follower firm
q = 25
625 ECU

Theoretical benchmark

With continuous quantities, the subgame-perfect benchmark is $q_L=50$, $q_F=25$, $P=45$; profits are 1,250 and 625 ECU.

[View final summary](#)

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Figure 4.9: Result and ending in the participant path. Interaction outcome.



Activity completed

You have completed all decisions. Please wait quietly for the instructor's directions.

ECU accumulated in the activity

3250 ECU

Rounds as leader

1

Rounds as follower

0

Finish

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Figure 4.10: Explicit completion page.

Variants and teaching comparisons

All variants belong to one family. They share the demand equation, ECU presentation, institutional welcome, comprehension check, explicit ending, and aggregate report. Change one dimension at a time and announce it before play. Each treatment profile below separates mechanism, prediction, report interpretation, and discussion prompts so the common protocol is not repeated.

5.1 Sequential benchmark with perfect observation

A leader firm commits to output first. The follower observes that quantity without error and responds. The one-interaction version introduces backward induction; the ten-round versions support learning comparisons under fixed or reassigned partners.

Theoretical foundation

The follower's best response is $q_F = (100 - q_L)/2$. Anticipating it, the leader maximizes $q_L(100 - q_L - q_F)$ and chooses 50. The follower chooses 25, price is 45, and operating profits are 1,250 and 625 ECU.

For the instructor

Compare each role with its benchmark and then examine the pair. A leader below 50 may be sustaining a higher price or sharing profit more evenly; a leader above 50 may be exploiting the residual response. Do not label every deviation as an error without examining the other firm's action.

Keep demand and decision language constant in a comparison. Before revealing, request predictions for leader quantity, response, price, and the profit distribution. Afterwards ask the class to distinguish incomplete understanding, strategically rational beliefs about the partner, and social objectives beyond monetary profit. This classification requires more than one metric and discourages treating all heterogeneity as noise.

Feedback script

Does moving first create power because the action is committed or merely because it occurs earlier? What must the leader believe about the follower to choose 50? Why does the better-informed follower earn less in the benchmark?

5.2 Simultaneous Cournot

Both firms choose output without observing the other's current decision. The treatment removes sequential commitment while preserving demand, costs, choice bounds, and profit calculations. It isolates the consequence of timing against a familiar duopoly benchmark.

Theoretical foundation

With symmetric costs, each best response is $q_i = (100 - q_j)/2$. Their intersection yields $q_1 = q_2 = 100/3$, total output $200/3$, price $160/3$, and profit $10,000/9$ ECU for each firm.

For the instructor

Place total output, price, and role-specific profits side by side. In Cournot, leader and follower labels are administrative only and must not be interpreted as a sequence. The main comparison is that Stackelberg predicts more total output, a lower price, and a less equal distribution of profit.

Keep demand and decision language constant in a comparison. Before revealing, request predictions for leader quantity, response, price, and the profit distribution. Afterwards ask the class to distinguish incomplete understanding, strategically rational beliefs about the partner, and social objectives beyond monetary profit. This classification requires more than one metric and discourages treating all heterogeneity as noise.

Feedback script

Why does commitment increase the first mover's quantity? Which outcome do consumers prefer? Do joint industry profits move in the same direction as consumer welfare?

5.3 Alternating leadership

The pair remains fixed while the leader position switches across rounds. Every participant experiences both sides and can compare the commitment advantage, the task of responding, and possible intertemporal reciprocity.

Theoretical foundation

The benchmark remains 50 for the current leader and 25 for the follower. The identity earning 1,250 ECU changes. If participants use the same role-contingent strategies, an even number of rounds distributes the institutional advantage across both people.

For the instructor

Separate observations by role rather than reporting only person-level averages. An individual mean of 37.5 may conceal exact benchmark behavior: 50 as leader and 25 as follower. Also examine whether receiving an aggressive quantity predicts punitive conduct after roles reverse.

Keep demand and decision language constant in a comparison. Before revealing, request predictions for leader quantity, response, price, and the profit distribution. Afterwards ask the class to distinguish incomplete understanding, strategically rational beliefs about the partner, and social objectives beyond monetary profit. This classification requires more than one metric and discourages

treating all heterogeneity as noise.

Feedback script

Does experience as a follower change later leadership? Does role rotation reduce inequality or only distribute it over time? Which patterns suggest reciprocity, and which are consistent with strategic learning?

5.4 Endogenous timing

Before choosing output, each firm decides whether to commit early or wait. If one commits and the other waits, play becomes sequential. If both select the same time, they choose simultaneously. The institution asks whether participants actually seek the first position.

Theoretical foundation

Analysis must consider the subgames created by timing choices. A first-mover advantage in an imposed Stackelberg game does not ensure that firms spontaneously coordinate on leader and follower roles. If both rush or both wait, the quantity stage is simultaneous and Cournot incentives return.

For the instructor

The report separates early–late, early–early, and late–late. Do not interpret these counts as preferences without the associated quantities. Relate each timing pattern to output, price, and profit. The frequency of orderly sequencing is an empirical outcome, not an assumption.

Keep demand and decision language constant in a comparison. Before revealing, request predictions for leader quantity, response, price, and the profit distribution. Afterwards ask the class to distinguish incomplete understanding, strategically rational beliefs about the partner, and social objectives beyond monetary profit. This classification requires more than one metric and discourages treating all heterogeneity as noise.

Feedback script

Why might two firms that value commitment still move simultaneously? Does waiting always soften competition? How would a small cost of early commitment change the timing game?

5.5 Imperfect observation

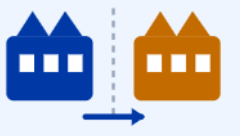
The leader moves first, but the follower receives a signal that may differ from actual leader output by ten units. The leader knows observation is imperfect. The design preserves timing while weakening the informational channel that makes commitment effective.

Theoretical foundation

There is no single elementary prediction identical to 50–25 without specifying beliefs about noise. A mechanical response to signal s is $(100 - s)/2$. A Bayesian follower combines the signal with beliefs about the leader's strategy and the error distribution.

Timing choice

Round 1 / 10



Choose whether to commit your quantity early or wait. If one firm chooses early and the other waits, the latter observes the early quantity. If both choose the same time, they decide simultaneously.

☐ Choose early
☐ Wait

Confirm timing

Powered by [oTree](#)

Figure 5.1: Endogenous choice of commitment timing.

For the instructor

Compare the signal, true output, and response. Calculate deviation from the best response to the signal and, separately, to the realized quantity, while stating which information was available. Never judge an action using information that the participant could not observe.

Keep demand and decision language constant in a comparison. Before revealing, request predictions for leader quantity, response, price, and the profit distribution. Afterwards ask the class to distinguish incomplete understanding, strategically rational beliefs about the partner, and social objectives beyond monetary profit. This classification requires more than one metric and discourages treating all heterogeneity as noise.

Feedback script

Does imperfect observability reduce commitment value? Must a leader produce more to make its intent visible? When can a response to a noisy signal be rational even if it looks poor ex post?

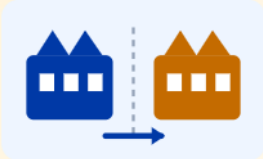
5.6 Asymmetric costs

The leader keeps marginal cost 20 while the follower has marginal cost 10. The treatment breaks technological symmetry and shows that timing alone does not determine which firm earns more.

Production decision

Round 1 / 10

Imperfect observation



YOUR POSITION

Follower firm

You choose after receiving information about the leader's quantity.

Observed signal about the leader's quantity: 40

The signal can differ from the actual quantity.

Quantity to produce

Enter an integer from 0 to 100.

Confirm quantity

Powered by [oTree](#)

Figure 5.2: Follower information under imperfect observation.

Theoretical foundation

The follower's response is $q_F = (110 - q_L)/2$. The leader anticipates it and chooses 45; the follower responds with 32.5 and price is 42.5. Continuous benchmark profits are 1,012.5 for the leader and 1,056.25 ECU for the follower. Integer choices create small differences.

For the instructor

Show cost, quantity, and margin by role. The follower can outperform the leader because its cost advantage offsets its timing disadvantage. The teaching point is that first-mover advantage depends on the environment; it is not a universal property of moving first.

Keep demand and decision language constant in a comparison. Before revealing, request predictions for leader quantity, response, price, and the profit distribution. Afterwards ask the class to distinguish incomplete understanding, strategically rational beliefs about the partner, and social objectives beyond monetary profit. This classification requires more than one metric and discourages treating all heterogeneity as noise.

Feedback script

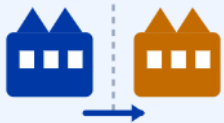
Which advantage is stronger here: commitment or productive efficiency? What changes if the low-cost firm leads? What information would a regulator need to interpret different market shares?



Production decision

Round 1 / 10

Asymmetric costs



YOUR POSITION

Leader firm

You choose first and your quantity will be committed.

Quantity to produce

Enter an integer from 0 to 100.

Confirm quantity

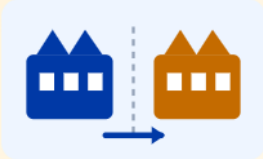
Powered by [oTree](#)

Figure 5.3: The treatment states costs and roles explicitly. Leader decision with asymmetric costs.

Production decision

Round 1 / 10

Asymmetric costs



YOUR POSITION

Follower firm

You choose after receiving information about the leader's quantity.

Leader's chosen quantity: 45

Quantity to produce

Enter an integer from 0 to 100.

Confirm quantity

Powered by [oTree](#)

Figure 5.4: Lower-cost follower decision.

5.7 Leader capacity constraint

The leader can choose no more than 35 units while the follower retains the 0–100 range. The constraint blocks the unconstrained Stackelberg output and makes capacity part of strategy.

Theoretical foundation

Because the unconstrained optimum is 50, the constraint binds. The leader chooses 35 and the follower's continuous best response is 32.5. Price is 52.5; profits are 1,137.5 and 1,056.25 ECU. Lower capacity can raise price and narrow the output gap.

For the instructor

Do not present the limit as advice. Compare the constrained outcome with the unavailable benchmark and explain that 50 cannot be chosen. A mass at 35 suggests participants recognize that leader profit rises throughout the feasible interval.

Keep demand and decision language constant in a comparison. Before revealing, request predictions for leader quantity, response, price, and the profit distribution. Afterwards ask the class to distinguish incomplete understanding, strategically rational beliefs about the partner, and social objectives beyond monetary profit. This classification requires more than one metric and discourages treating all heterogeneity as noise.

Feedback script

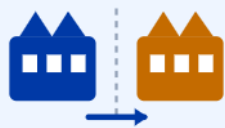
Does a capacity constraint always hurt the constrained firm? Can it credibly commit the firm to lower output? How does consumer and producer welfare compare with unrestricted Stackelberg?



Production decision

Round 1 / 10

Leader capacity constraint



YOUR POSITION

Leader firm

You choose first and your quantity will be committed.

Quantity to produce

Enter an integer from 0 to 35.

Confirm quantity

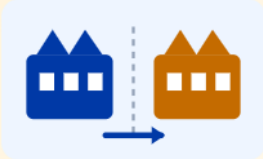
Powered by [oTree](#)

Figure 5.5: Capacity and response in the extended treatment. Visible constraint for the leader.

Production decision

Round 1 / 10

Leader capacity constraint



YOUR POSITION

Follower firm

You choose after receiving information about the leader's quantity.

Leader's chosen quantity: 35

Quantity to produce

Enter an integer from 0 to 100.

Confirm quantity

Powered by [oTree](#)

Figure 5.6: Follower response.

Instructor report and interpretation

The report is private and aggregate. Before all expected decisions are complete, it displays participants, completed decisions, pending decisions, and interactions with a disabled button. After completion, *Reveal results* shows the content; the instructor can hide it again. This prevents accidental projection while other pairs still choose.

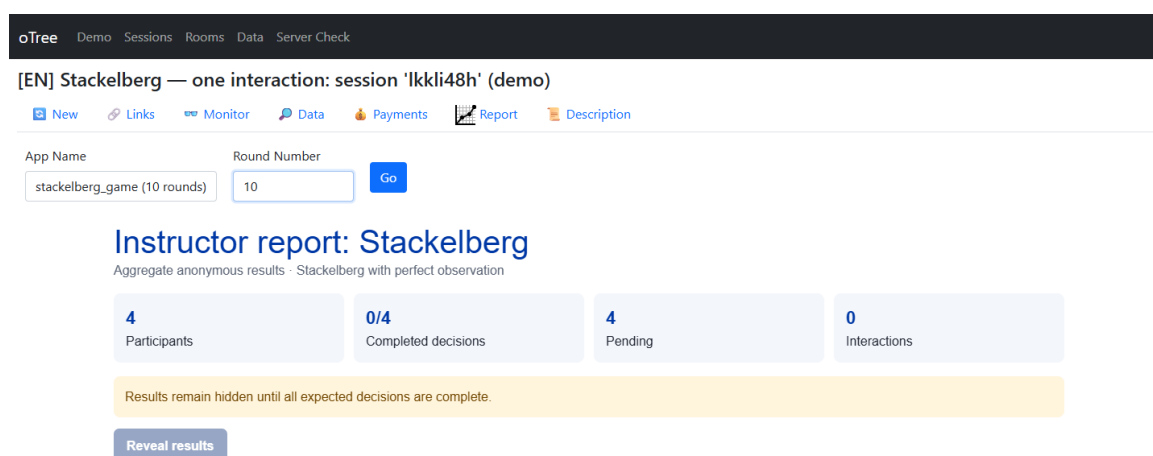


Figure 6.1: Reveal control separates implementation and debrief. Results protected before reveal.

The first row summarizes mean leader and follower quantities, output, price, profits, and leader advantage. Best-response error is mean $|q_F - (100 - q_L)/2|$ for sequential interactions. A small number shows proximity to the best response conditional on received quantity. It does not establish that the leader anticipated correctly, that learning occurred without help, or that the participant values only ECU.

Read histograms separately. A leader mean of 50 can mean everyone chose 50 or half chose 30 and half 70. The first distribution supports coordination on the benchmark; the second reveals heterogeneity. Compare shapes, not only tallest bars, because each bar reports a count and the height scales to the most common bin. Use the same ten-unit bins across roles.

Round evolution reports means for leader output, follower output, total output, and price, plus completed interactions. Convergence is descriptive. Consecutive rounds for a fixed pair are not independent, and reassignment still repeats each individual. The graph is appropriate for classroom feedback; formal inference requires clustering or aggregation that reflects dependence.

Timing patterns appear only in the endogenous treatment, eliminating irrelevant zero cards elsewhere. Treatment comparison is useful when a session contains variants, although causal interpretation requires comparable recruitment, instructions, and order. Do not combine courses without documenting differences.

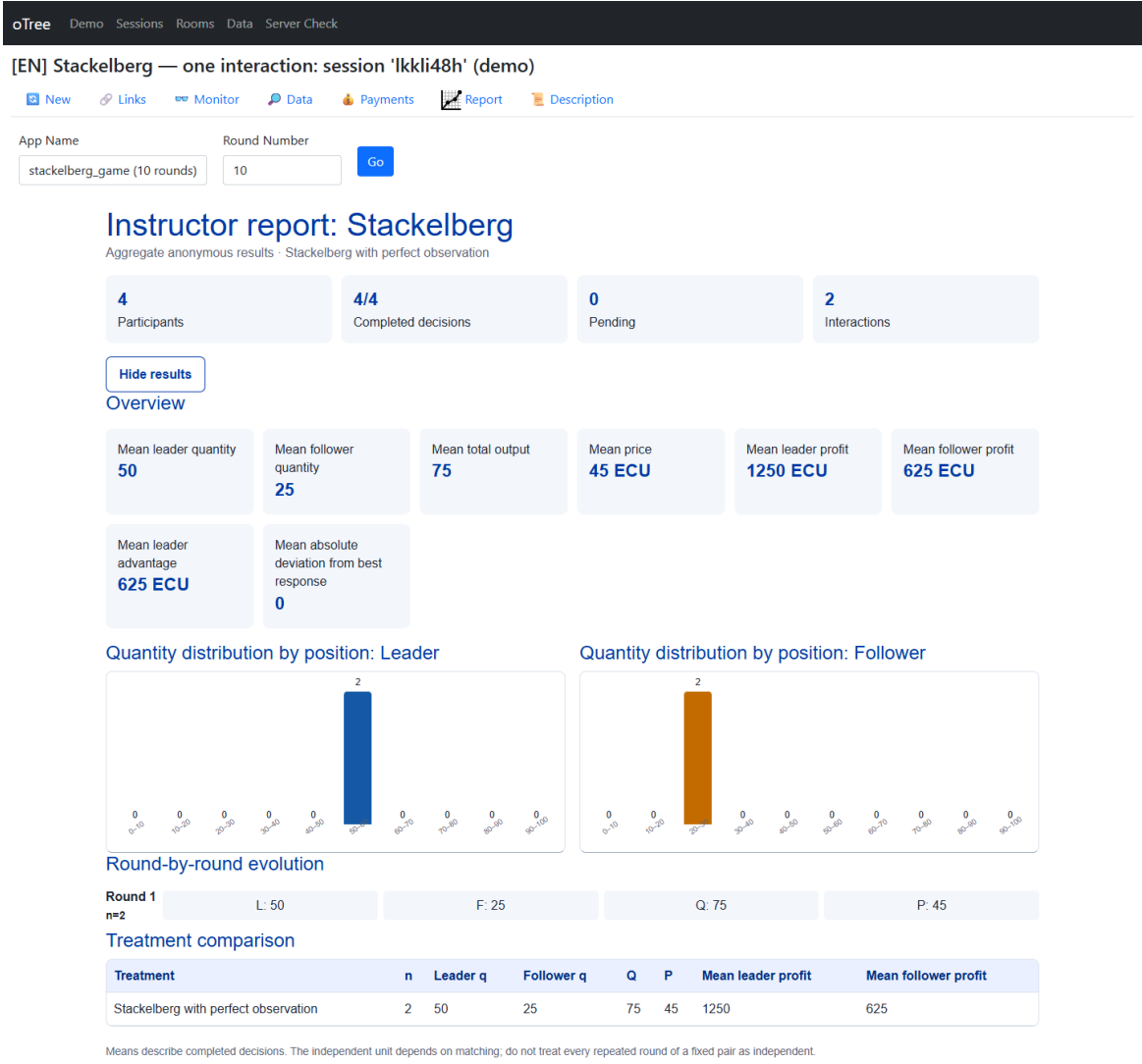


Figure 6.2: Aggregate report after reveal.

For the instructor

Reveal in this order: leader distribution, follower distribution, best-response relation, then price and profits. Ask for a prediction before each block. The sequence follows backward induction and prevents the number 50 from dominating interpretation too early.

6.1 Pattern diagnosis

If leaders cluster near 50 and followers near 25, the benchmark organizes behavior. If followers best respond while leaders produce less, investigate profit sharing, tacit accommodation, or reciprocity beliefs. If leaders choose 50 and responses disperse, emphasize the second step of backward induction and check arithmetic. If both quantities are high, price and profits can collapse; relate the pattern to excessive competition. If both are low, price rises and joint profit may approach monopoly, although its division depends on quantities.

Suppose a leader chooses 40 expecting response 30. Price is 50, and profits are 1,200 and 900. Relative to the benchmark, the leader sacrifices 50 and the follower gains 275; joint profit rises from 1,875 to 2,100. This can reflect softer competition or distributional concern. If the follower chooses 25 instead, price is 55 and profits are 1,400 and 875, benefiting the leader. Do not infer intent from leader output without the response.

Feedback script

Use three levels of claims. Description: “median leader output was 45.” Theoretical comparison: “it is five units below the benchmark.” Cautious interpretation: “it is consistent with less aggressive conduct, reciprocity beliefs, or incomplete calculation.” Reserve causal language for assigned comparisons and keep behavior separate from psychological motive.

Lesson plans and teaching sequences

7.1 A 50-minute introduction

Use five minutes to present two firms and collect intuitive predictions. Give ten minutes for reading and comprehension, five for one interaction, eight for students to derive the follower response before reveal, twelve for the report and backward induction, and ten for comparing Cournot, Stackelberg, and monopoly plus an exit question.

An exit question may ask: “In three sentences, explain why the leader produces more than a Cournot firm and who benefits.” A complete response mentions observable commitment, displacement of the rival response, more total output, lower price, higher leader profit, and lower follower profit. Do not require welfare and profit to move together.

7.2 An 80-minute learning session

Use ten rounds with fixed partners and do not reveal the aggregate report between rounds. Ask students to privately record their predicted response before each outcome. At the end compare the first three and last three rounds and graph best-response error. Discuss whether convergence reflects calculation, learning about one partner, or relationship formation. Use reassignment in a later class to separate bilateral reputation from general learning.

Fixed matching permits dynamic strategies, punishment, and accommodation. A finitely repeated benchmark does not automatically describe behavior when social preferences, type uncertainty, or limited reasoning matter. Present backward induction as a reference and use trajectories to consider other mechanisms. Do not announce that repetition must eliminate accommodation.

7.3 A 90-minute comparison

Randomly assign half the class to Stackelberg and half to Cournot while holding language, rounds, and parameters constant. Before play, collect signed hypotheses about total output, price, and profit differences. Run the sessions, reveal reports separately, and construct a common table. Assignment strengthens interpretation, although a single class has low power and pair dependence.

Then show the theoretical output ordering and ask whether the data preserve signs even if levels differ. This separates qualitative from point predictions: a model may correctly predict that Stackelberg raises total output even when exact quantities differ. Request intervals and distributions rather than only means.

7.4 An advanced institutions class

Use endogenous timing, imperfect observation, or capacity after solving the reference. For timing, draw a tree containing the timing stage and quantity subgames. For noise, distinguish the information available at choice from ex post evaluation. For capacity, solve a constrained problem and discuss investment as commitment. Each extension should answer one question; running all of them in one meeting sacrifices depth.

Checkpoint

A complete plan states objective, treatment, prediction, duration, minimum class size, primary metric, reveal order, and closing question. Without a metric, the report becomes a collection of charts without an argument. Without a pre-play prediction, the benchmark can become a retrospective explanation for any pattern.

Solved exercises and discussion questions

8.1 Basic calculation

Suppose the leader chooses 60. The best response is $(100 - 60)/2 = 20$. Total output is 80, price is 40, leader profit is $(40 - 20)60 = 1,200$, and follower profit is $(40 - 20)20 = 400$. Credited ECU are 3,200 and 2,400. Although the leader produces more than the benchmark, it earns 50 less because price falls enough.

If the follower instead chooses 10 after 60, price is 50. The leader earns 1,800 and the follower 300. This does not maximize the follower's monetary profit but strongly benefits the leader. Use the example to distinguish optimal response, joint outcome, and intention. Ask what additional evidence would support reciprocity or confusion.

8.2 Cournot derivation

Each firm solves $\max_{q_i} (100 - q_i - q_j)q_i$. The first-order condition gives $q_i = (100 - q_j)/2$. Under symmetry, $q_i = q_j = q$, so $q = (100 - q)/2$ and $3q = 100$. The solution is 33.33. Directly setting both outputs to 50 is wrong: 50 is monopoly total output or Stackelberg leader output, depending on context, not each Cournot firm's output.

8.3 Welfare comparison

Under Stackelberg, $Q = 75$, $P = 45$, and consumer surplus is $(120 - 45)75/2 = 2,812.5$. Industry profit is 1,875. Total surplus is 4,687.5 and deadweight loss relative to 5,000 is 312.5. Under Cournot, $Q = 66.67$ and deadweight loss is about 555.56. Leader commitment reduces deadweight loss even though the leader did not choose it for social purposes.

8.4 Asymmetric costs

With follower cost 10, its margin is $110 - q_L - q_F$ and its response is $(110 - q_L)/2$. The leader with cost 20 maximizes $(100 - q_L - q_F)q_L$ after substitution. The expression becomes $(45 - q_L/2)q_L$, with derivative $45 - q_L$. Thus the leader chooses 45 and the follower 32.5. A cost advantage can overturn the leader's profit advantage.

8.5 Capacity

Unconstrained leader profit rises until 50. If the feasible set ends at 35, the optimum is the boundary 35. No new interior condition is needed: the derivative $50 - q_L$ is positive at 35. The follower chooses 32.5. This elementary constrained problem links the game to real production limits and investment commitments.

Feedback script

After each exercise, ask which object is a choice and which is a consequence. Quantities are decisions; price comes from demand; profit combines price, cost, and quantity; credited ECU add a constant. This classification removes many errors and prepares students for models with prices, capacities, or richer information.

8.6 Open questions

Can low leader output invite accommodation? How can one distinguish accommodation from calculation error? What commitment is credible if production occurs after observing the rival? Does public capacity affect conduct even when it does not bind? Should the efficient firm lead? Which policy raises welfare without known costs? How does inequality aversion affect follower responses? Which observation separates reciprocity from altruism? These questions allow multiple answers, but each argument must name the relevant information, incentives, and evidence.

Experimental evidence and literature

Stackelberg experiments bring an institution with observed or anticipated commitment into the laboratory. Qualitative predictions about output and position are often informative, while matching, repetition, inequality, and endogenous timing influence behavior. Use the evidence to form hypotheses rather than promise exact replication in one class.

Huck, Müller, and Normann (2001) compare experimental Cournot and Stackelberg markets under fixed and random matching. A central teaching result is that Stackelberg can raise output and efficiency relative to Cournot, while fixed matching softens competition. They also discuss deviations associated with inequality. The teaching activity preserves the conceptual structure with transparent demand and costs; it does not reproduce their exact parameters or monetary incentives.

Huck, Müller, and Normann (2002) make timing endogenous. A Stackelberg outcome is less common when roles must emerge than when the sequence is imposed. This motivates the early–late treatment. Rebelein and Turkay (2016) show how a classroom experiment teaches when first movers have an advantage. Morgan and Várdy (2004) study commitment when observation is costly, helping distinguish the value of moving first from the value of being observed.

Theoretical foundation

The classroom adaptation preserves output, observation, commitment, and response. It simplifies demand, uses integer choices, and adds an operating balance. Signal, cost, and capacity treatments compare strategic statics in a class. They are not exact replications; the guide states where the mechanism is preserved and where implementation changes.

Oligopoly experiments often find attempts to increase joint profit through quantities below noncooperative predictions. Fixed partners can sustain such conduct through reciprocity or learning about types. Reassignment weakens bilateral reputation, although learning and norms remain. Matching is therefore part of interpretation and belongs in every result table.

Inequality aversion is especially relevant because Stackelberg predicts a large profit gap. A leader may reduce output to leave space for the follower; a follower may respond aggressively to a leader that captures much of the market. Both depart from individual monetary maximization but imply different mechanisms. Distinguishing them requires role comparisons, trajectories, and, for research, additional treatments.

9.1 Validity and limits of comparison

Laboratory clarity supports internal validity while simplifying reality. Firms know demand and cost, the product is homogeneous, macroeconomic uncertainty is absent, and output is entered

through a numerical control. A real firm may choose capacity, quality, inventory, and prices on different horizons. The class should identify which abstraction isolates commitment and which elements would be needed for another question. Transparent simplification is a strength when interpreted within scope.

Integer output is another adaptation. Asymmetric-cost and capacity benchmarks contain 32.5, which cannot be selected exactly. Neighboring integers may yield nearly identical profit. The report therefore shows a continuous benchmark rather than declaring one correct response. For a precision analysis, calculate profit loss relative to the best feasible integer as well as quantity distance. A one-unit gap may have little economic significance even if it appears as an arithmetic deviation.

Incentives matter as well. Illustrative ECU can generate attention and discussion, but they are not automatically equivalent to salient cash payment. If a course converts results to points or prizes, announce the rule in advance and follow institutional policy. Comparing an incentivized session with a non-incentivized one changes both strategic treatment and payment mechanism. Document conversion, anonymity, and team decisions.

A classroom sample does not necessarily represent firms or a broader population. Results support confrontation of predictions, visualization of distributions, and hypothesis generation. External claims require replication, sampling design, and further evidence. This caution does not diminish the activity. It teaches that an experiment identifies consequences under a defined institution and that generalization is a separate analytical step.

Data, ethics, troubleshooting, and closure

The export contains anonymous code, round, language, edition, treatment, matching, mode, role, timing choice, leader output, observed signal, error, follower output, own output, cost, total output, price, profit, and credited ECU. The code links rounds within a session; do not combine it with names or IDs in projections or shared classroom files.

For descriptive analysis, retain a data dictionary, identify sessions, and document exclusions. A disconnect before completion is not zero output. Incomplete pairs remain pending rather than receiving invented outcomes. Under fixed matching, aggregate by pair or use inference recognizing dependence. Reassignment creates a network of encounters and repeated individuals. Report means support teaching feedback, not a full statistical design.

10.1 Common problems

If a participant sees “Please wait,” inspect the partner’s computer; the sequence needs the other decision. If the user does not exist, return to current session links. If Demo shows unrelated families, stop: the family variable or deployment is wrong. If a basic room selects an extended configuration, inspect prefix filtering and the `_extendido/_extended` exclusion. If styling is absent, refresh without cache and verify static assets.

If the report stays hidden, inspect pending decisions. Revealing before closure can contaminate choices. If a browser closes, reopen that participant’s exact link rather than assigning someone else’s. Restart the local instance after code changes because the production server does not auto-reload. Never use `resetdb` on production to repair a page.

Attention

Public domains require DNS, proxy, process, and database setup by the laboratory. The code proposes routes and isolation through `GAME_FAMILY=stackelberg`; live validation in this delivery is at <http://localhost:8039>. Before sharing a public QR code, the administrator must check Demo, Rooms, Sessions, and Data on production.

10.2 Pedagogical closure

A strong debrief returns to mechanism. The leader gains not because it is more intelligent, but because observable output constrains the subsequent response. The follower is not passive; it optimizes in the residual market. Higher output lowers price and may help consumers while reducing

joint profits. Cost, capacity, and information can alter or reverse the advantage. Classroom data show how strongly this reasoning organizes behavior.

Ask each student for an explanation containing sequence, best response, commitment, and one report statistic. Listing 50 and 25 alone does not show understanding. Describing a graph alone does not connect evidence to theory. The goal is to integrate institution, prediction, and observation with careful language.

10.3 Responsible facilitation and archiving

During play, the instructor manages procedure rather than giving strategic advice. It is appropriate to show where output is entered, repeat the written formula, or repair a connection. It is inappropriate to suggest that 50 is “better,” announce that other pairs produce a lot, or praise a strategy before closure. A small intervention can change beliefs and coordinate choices. Record meaningful interruptions in a session log.

After the debrief, download data under a name containing family, date, course, treatment, and session. Store implementation notes separately without participant names. When sharing with the class, use aggregate figures and remove codes. If data will be used outside teaching or for research, follow applicable consent and institutional review processes; classroom participation alone is not permission for every later use.

Preserve the configuration and guide version. Code can evolve, and sessions with the same display name can use different parameters if the commit is not recorded. For cumulative comparisons, note Git hash, domain, rounds, matching, ECU conversion, and verbal changes. This traceability explains differences without relying on informal memory.

Close the session explicitly. Confirm every screen says activity completed, address pending participants, and only then reveal. A person waiting for a partner should not be abandoned while the rest of the class discusses results. Technical and pedagogical closure form one sequence: complete, verify, reveal, interpret, and archive.

Integrative cases and assessment

11.1 Capacity and investment case

Consider two airlines choosing seats on a route. An incumbent announces a fleet expansion first, and an entrant chooses capacity after observing it. The analogy with Stackelberg does not require every seat to be identical. It requires greater supply to lower the rival's marginal revenue and the initial investment to be difficult to reverse. Ask students what makes the commitment observable, which period contains the response, and which costs belong in the model.

A superficial answer says the first airline always wins. A strong answer conditions the claim. If the incumbent has high marginal cost, expansion is not credible, the entrant has a large cost advantage, or future demand is uncertain, the advantage may shrink or reverse. The asymmetric-cost treatment gives a numerical counterexample: the efficient follower earns more despite choosing later. The case teaches transfer by mechanism rather than industry label.

Now impose a teaching-scale capacity limit of 35. Students should recognize that the incumbent would commit to 50 but cannot. The optimum is the feasible boundary because the objective still increases at 35. Ask them to compare price, profit, and welfare with the unrestricted benchmark. The conclusion is not that every constraint benefits a firm. Here the limit changes competitive intensity, and the effect depends on demand, cost, and response.

11.2 Information and observation case

A platform announces an investment, but its competitor observes only a noisy news report. The report can overstate or understate actual capacity. Give groups a signal of 40, 50, or 60 and ask them to respond using $(100 - s)/2$. Then reveal that true output differs by ten units. Each group evaluates its decision using information available at the time and calculates the perfect-information counterfactual.

This exercise disciplines ex ante evaluation. A rational decision can earn little ex post because the signal was unfavorable. Grading it using true output confuses decision quality with informational luck. Connect the problem to Bayesian inference: if aggressive announcements are common, the same signal can produce a different belief than when leaders are usually moderate. The game does not elicit beliefs directly, so the report describes responses and errors without assigning a probability judgment.

Ask groups to propose disclosure policy. Accurate reporting may improve market response while also strengthening the leader's strategic commitment. Consumer effects do not follow from a general claim that transparency is good. Students must trace the channel: information changes response, response changes total output, and output determines price and surplus. The causal

chain matters more than a broad opinion about disclosure.

11.3 Comparative assignment with class data

Provide the anonymous export and request a two-page memo with one table and two figures. The table reports pairs, role-specific mean and median output, total output, price, and profit. The first figure compares role distributions with identical bins. The second shows round evolution or plots follower response against leader output together with the best-response line. Every figure needs a title, units, denominator, and one interpretive sentence.

Separate description, comparison, and explanation in the instructions. First, students report what happened. Second, they calculate distance from the benchmark. Third, they offer at least two compatible mechanisms and a comparison capable of distinguishing them. Leader outputs below 50, for example, may reflect joint-profit accommodation or calculation error. Subsequent responses and matching help evaluate the first account, while comprehension and convergence help evaluate the second.

For an advanced assignment, compare fixed and reassigned partners. A plot may use rounds as observations, but inference cannot treat every row as independent. Students may aggregate by pair under fixed matching and by individual or session under reassignment, stating limitations. The lesson is that a large data file does not necessarily contain many independent observations.

11.4 Assessment rubric

A one-hundred-point rubric can assign twenty points each to institutional mechanism, derivation, data interpretation, comparison of variants, and clarity with caution. Mechanism requires timing, observation, and irreversibility. Derivation requires the best response and substitution. Data interpretation requires distribution and denominator. Variants require the changed dimension. Clarity requires separating observation, prediction, and interpretation.

Do not award full credit to an answer that memorizes 50 and 25 without explaining them. Nor should an answer identify a deviation and immediately conclude irrationality. Excellent work recognizes that theory is conditional on monetary maximization, information, and commitment; uses aggregate evidence without revealing identities; and proposes testable explanations. The rubric evaluates reasoning rather than obedience to the benchmark.

A short oral assessment can randomly assign one of four tasks: solve as follower, solve as leader, compare Cournot, or interpret a histogram. Rotating tasks prevents students from learning only one stage. For fairness, provide demand and cost functions in advance but not the solution. Arithmetic supports the argument and should not displace institutional understanding.

Checkpoint

Before grading, confirm that each question is answerable with supplied information. Under noisy signals, do not require true output at the moment of choice. Under alternating leadership, identify round and role. For treatment comparisons, state matching and sample size. A precise rubric protects the same informational discipline the game teaches.

11.5 Adapting by course level

In principles, focus on timing, price, and profit, and provide the best-response function. In intermediate microeconomics, derive first-order conditions and surplus. In game theory, require complete strategies after every leader output and discuss subgame perfection. In industrial organization, compare institutions, entry, investment, and regulation. In experimental methods, emphasize assignment, independent units, matching, attrition, and preregistered metrics.

The interface can remain constant while questions change. This reuse is pedagogically valuable: students in different courses observe a common object while instructors adjust analytical depth. There is no need to activate every variant to demonstrate breadth. A small, purposeful selection followed by a strong debrief often teaches more than a rapid tour of treatments.

End with transfer to a new case such as inventory, advertising, digital infrastructure, or research and development. Students must justify whether actions are strategic substitutes, commitment is observable, and a sequential response exists. If one element is absent, Stackelberg may not be the right model. Knowing when not to apply a model is part of the learning objective.

Configurations and reference routes

The basic edition has three configurations per language: one interaction, ten fixed-partner rounds, and ten reassigned rounds. The extended edition has nine per language: the three reference forms and six mechanisms. Room `stackelberg_es` filters Spanish basic configurations; `stackelberg_en`, English basic; `stackelberg_extendido`, Spanish extended; and `stackelberg_extended`, English extended.

Edition	Configurations per language	Recommended use
Basic	3	Sequential benchmark: one interaction, fixed repetition, and reassignment.
Extended	9	Three references plus Cournot, rotation, timing, signal, cost, and capacity.
Family total	24	Twelve Spanish and twelve English configurations.

For deployment diagnosis, Demo must count 24 and Rooms four. A higher count means the instance failed to filter the family. A lower count usually indicates an omitted configuration or missing family key. The basic room must exclude extended suffixes and initially select a basic configuration in the room's language.

Proposed routes appear separately to preserve legibility:

- https://stackelberg.beer-lab.org/room/stackelberg_es
- https://stackelberg.beer-lab.org/room/stackelberg_en
- https://stackelberg.beer-lab.org/room/stackelberg_extendido
- https://stackelberg.beer-lab.org/room/stackelberg_extended

Instructors use <https://stackelberg.beer-lab.org/demo>. The same routes are validated locally by replacing the host with <http://localhost:8039>.

Instructor glossary

Commitment: an observable action that cannot be revised after the rival responds. **Best response:** the action maximizing profit against a given rival action. **Backward induction:** solving the last decision first and substituting its optimal behavior into earlier stages. **Subgame-perfect equilibrium:** a strategy profile optimal after every history beginning a subgame. **Strategic substitutes:** choices whose best response falls when the rival action rises. **First-mover advantage:** value generated by committing a relevant action; it is not equivalent to acting early in every environment.

Fixed matching: the same pair remains together across rounds. **Reassignment:** partners change, weakening persistent bilateral relationships. **Imperfect observation:** the responder receives a signal that may differ from the true action. **Capacity:** an upper bound on feasible production. **ECU:** experimental currency unit. **Aggregate report:** a private interface summarizing the class without identifying individuals.

Operating profit: revenue less variable cost in a round. **Operating balance:** the constant 2,000 ECU added to keep credited values nonnegative. **Total output:** the two firms' combined production. **Residual market:** demand left to the follower after leader commitment. **Cost advantage:** a technological difference changing margins and best responses. **Treatment:** an institutional rule changing one dimension while holding others constant.

Theoretical benchmark: a conditional comparison, not a required answer. **Best-response error:** absolute distance between follower output and the ECU-maximizing response to the relevant quantity. **Independent unit:** the level providing separate information under interaction rules. **Controlled reveal:** the instructor action showing the report after decisions close. **Internal validity:** credibility that an observed difference comes from institutional change. **External validity:** the reach of generalization to other participants, settings, or markets.

Bibliography

- Huck, S., Müller, W., and Normann, H.-T. (2001). Stackelberg beats Cournot—On collusion and efficiency in experimental markets. *The Economic Journal*, 111, 749–765. <https://doi.org/10.1111/1468-0297.00658>.
- Huck, S., Müller, W., and Normann, H.-T. (2002). To commit or not to commit: Endogenous timing in experimental duopoly markets. *Games and Economic Behavior*, 38(2), 240–264. <https://doi.org/10.1006/game.2001.0889>.
- Morgan, J., and Várdy, F. (2004). An experimental study of commitment in Stackelberg games with observation costs. *Games and Economic Behavior*, 49(2), 401–423. <https://doi.org/10.1016/j.geb.2004.04.005>.
- Rebelein, R., and Turkay, E. (2016). When do first-movers have an advantage? A Stackelberg classroom experiment. *Journal of Economic Education*, 47(3), 226–240. <https://doi.org/10.1080/00220485.2016.1179144>.
- von Stackelberg, H. (1934). *Marktform und Gleichgewicht*. Vienna: Julius Springer.