



Teacher guide for the quota controls game

Running it in the lab, theoretical background,
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 helps you prepare, run and debrief the **quota controls** game of the Behavioral and Experimental Economics Research Lab (BEER Lab), Department of Economics, Tecnológico de Monterrey. It is written for instructors of principles, intermediate microeconomics, international trade, industrial organization and economic policy, with or without prior experience in experimental economics. It is the quantity twin of the lab's *price controls* game. The game has two versions:

- **Basic version: a quota in a double auction.** The whole class trades in a continuous double auction, as in [Smith \(1962\)](#). After three free periods (the benchmark) the number of units that can trade is limited: either a market-wide quota filled first come, first served, or selling licences drawn at random among the sellers. Students see the price rise, the *quota rent* and who captures it, and the efficiency loss.
- **Extended version: quota auctions, buyers only.** Fixed groups of human buyers bid for units sold by automated sellers. After three free periods only a few units can be sold, and they are allocated by a uniform-price auction, a discriminatory (pay-as-bid) auction or a lottery. Students see who wins, what they pay, and who keeps the rent.

The **quick-start guide** gets a session running. Chapters 3 to 6 cover the basic version; Chapter 7, the extended one. Common rules are explained once; each treatment only describes what changes.

Author

This guide was prepared by Edgar O. Castro Méndez, research professor at the Department of Economics, Tecnológico de Monterrey, Monterrey campus. For questions or suggestions, contact the author at ecastrom@tec.mx.

For the instructor

This guide matches the English interface. A separate Spanish version exists. Screenshots in this guide were taken on a local instance of the game with **simulated decisions**; the numbers shown illustrate the interface and are *not* results from a real class. Project only aggregate results: never link participant codes to names, student IDs, seats or individual decisions.

Screenshots of the game's card on teaching-admin.beer-lab.org and teaching.beer-lab.org will be added in the next version of this guide; the steps are the same as for the lab's other games.

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Quick-start guide

1.1 Fact sheet

Purpose	Show what a quantity restriction (a quota) does to a competitive market: the price rises to what buyers are willing to pay for the last allowed unit, a <i>quota rent</i> appears, someone captures it, and surplus is lost, both from the lower quantity and from who gets to trade.
Participants	Basic: the whole class in one market, half buyers and half sellers (with an odd number, one more buyer); from 8 students. With 22 or more, the free equilibrium is always 11 units at 150 ECU and the quota is 8 units. Extended: fixed groups of 8 buyers.
Market	Basic: continuous double auction, 150 seconds per period; values 300, 285, 270, ...; costs 0, 15, 30, ... (one unit per person and period). Extended: one sealed bid per buyer per period against nine automated sellers.
Sequence	8 periods: the first 3 without restriction (benchmark); periods 4 to 8 with the quota, announced on a screen of its own.
Treatments	Basic: market-wide quota (first come, first served) or selling licences for some sellers. Extended: uniform-price auction, discriminatory auction or lottery of the quota units (or all three at once, one per group).
Duration	Basic: 25–30 minutes. Extended: 20–25 minutes. Not counting discussion.
Instructor (you)	teaching-admin.beer-lab.org → the game's card → Open panel (section 2.1).
Students	Room link https://quotacontrols.beer-lab.org/room/quota_controls_en , its QR code (section 2.5) or teaching.beer-lab.org .
Report	Free benchmark; the quota with its demand and supply prices, rent and deadweight loss; the session's supply and demand; the price of every trade in order; realized surplus of buyers and sellers by period (with licence holders marked); before and after with the rent captured by each side; in the extended version, bids and allocation of each group and period, bids against values, and who gets the rent and the units under each rule.

Note

There are two different pages. **teaching-admin.beer-lab.org** is yours: from there you open the game's panel and download this guide. **teaching.beer-lab.org** is your students': from there they can only *play*, not create sessions.

1.2 Minimal sequence

Before class

1. Request panel access at lab.economia@servicios.tec.mx, stating the game, course, number of students and date. You will receive the password for the **admin** user.
2. Open teaching-admin.beer-lab.org, find **Quota Controls** and click **Open panel**.
3. Rehearse in **Demo** (section 2.3) and choose the treatment (Chapter 6).

In class

4. Count the students present.
5. Under **Rooms**, open the [EN] **Quota Controls** room, choose the configuration, type the *exact* number of students under **Number of participants** and click **Create**.
6. Share the room link or project its QR code. Each student clicks **Start**.
7. Click **Monitor the session**. When done, open **Report**, click **Show results** and lead the discussion.

After class

8. In the room, click **Close this room**. The session's data stays under **Sessions**.

1.3 Checklist

- ☐ Panel password received and tested at quotacontrols.beer-lab.org/login.
- ☐ Rehearsal done in **Demo**.
- ☐ Treatment chosen: market-wide quota or licences (basic); auction rule (extended).
- ☐ Session's number of participants equal to the number of students present.
- ☐ Room link or QR at hand; tested from a phone.
- ☐ Students told that ECU are experimental units and there is no money payment.

Platform access

2.1 Your access: teaching-admin and the game's panel

The instructor page is teaching-admin.beer-lab.org. It is not in the beer-lab.org menu: type the address directly or bookmark it. It lists all of the lab's classroom games; you can search by title, topic or JEL code.

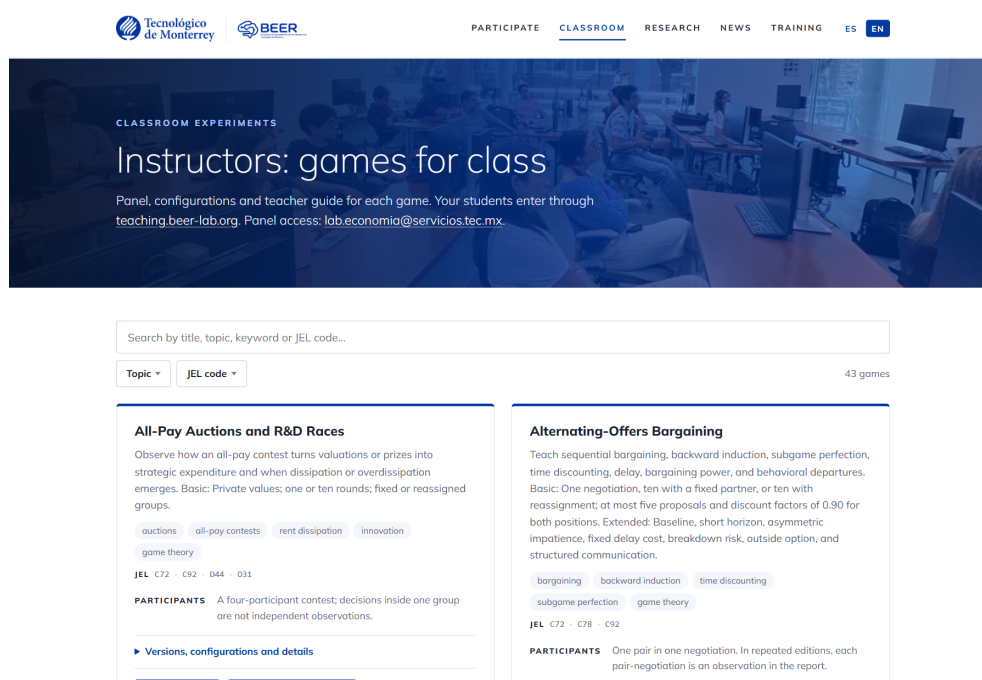


Figure 2.1: Instructor page: teaching-admin.beer-lab.org. Look for the **Quota Controls** card.

Each game has a card with its description and two buttons: **Open panel** and **Teacher guide (PDF)**. The game's panel (<https://quotacontrols.beer-lab.org>) is protected: **Open panel** shows the **Admin Login** screen, where you type **admin** and the password the lab gave you.

2.2 The panel: minimal vocabulary

Demo	Practice sessions with dummy participants that you play in several tabs. Never with students.
Rooms	Fixed class addresses: basic and extended, in Spanish and in English.
Create / Number of participants	Create the session in the room and declare how many people will play.
Monitor	Period and page of each participant. Shows no decisions.
Advance slowest participants	Moves forward whoever fell behind; also closes a trading period before time runs out.
Report	The instructor report for projecting aggregate results.
Data	CSV data download.
Close this room	Frees the room when you are done.

oTree Demo Sessions Rooms Data Server Check

Demo

[ES] Controles de cantidad — cuota total del mercado (8 periodos)
[ES] Controles de cantidad — licencias de venta sorteadas (8 periodos)
[EN] Quota controls — market-wide quota (8 periods)
[EN] Quota controls — selling licences drawn at random (8 periods)
[ES] Subastas de cuotas — 3 reglas por grupo (8 periodos)
[ES] Subastas de cuotas — precio uniforme (8 periodos)
[ES] Subastas de cuotas — cada quien paga su oferta (8 periodos)
[ES] Subastas de cuotas — sorteo de licencias (8 periodos)
[EN] Quota auctions — 3 rules by group (8 periods)
[EN] Quota auctions — uniform price (8 periods)
[EN] Quota auctions — pay as bid (8 periods)
[EN] Quota auctions — licence lottery (8 periods)

Juegos de mercados / Market games — BEER Lab

Controles de cantidad / Quota controls

To add to this list, create a new session config.

Figure 2.2: Demo: the game's 12 configurations (four basic and eight extended, in Spanish and English).

oTree Demo Sessions Rooms Data Server Check

Rooms

Current rooms:

[ES] Controles de cantidad
[EN] Quota Controls
[ES] Controles de cantidad — extendido (subastas de cuotas)
[EN] Quota Controls — extended (quota auctions)

Figure 2.3: Rooms: the game's four rooms.

2.3 Rehearse before class

In **Demo**, click a configuration: a practice session is created, with 10 participants in the basic version and 8 (or 24 in the mixed configuration) in the extended one. Open several **P1**, **P2**, ... links in separate tabs and play among them; advance the rest from the Monitor.

The screenshot shows the oTree web interface. At the top is a navigation bar with links: oTree, Demo, Sessions, Rooms, Data, and Server Check. Below this is a header for the session: "[EN] Quota controls — market-wide quota (8 periods): session 'ive5wuny'". A secondary navigation bar contains icons and labels for Edit, Links, Monitor, Data, Payments, Report, and Description. The main content area explains that users can use session-wide, persistent, or single-use links. It provides a session-wide link: <http://localhost:8033/join/javorapu>. It also mentions persistent links and provides a real session link: [a room](#). Finally, it lists single-use links for participants P1 through P7, each with a unique URL starting with <http://localhost:8033/initializeParticipant/> followed by a random string.

Participant	Link
P1	http://localhost:8033/initializeParticipant/rx9hrz6r
P2	http://localhost:8033/initializeParticipant/jraugaa
P3	http://localhost:8033/initializeParticipant/io84gwmo
P4	http://localhost:8033/initializeParticipant/snus8h13
P5	http://localhost:8033/initializeParticipant/1qvvy561
P6	http://localhost:8033/initializeParticipant/xzzxmojl
P7	http://localhost:8033/initializeParticipant/k0ed5wuy

Figure 2.4: Session links (local copy: addresses read `localhost`; on the server they read `quotacontrols.beer-lab.org`).

2.4 Create the session in class

Under **Rooms**, open the room for your language, choose the configuration, type the number of students present under **Number of participants** and click **Create**.

oTree Demo Sessions Rooms Data Server Check

Room: [EN] Quota Controls

Create a new session

English room. Only the configurations of this game, language and edition are shown below.

Session Config
 [EN] Quota controls — market-wide quota (8 periods) ▼

Number of participants

 Must be a multiple of 1

Create

[Configure session](#) ⚙️

App sequence

quota_controls (10 rounds) Quota controls: continuous double auction with induced values; free periods, then a market-wide quota (first come, first served) or licences for some sellers.

Figure 2.5: The basic English room's form.

Note

Declare the exact number. Roles (buyer or seller), values and costs are assigned when the session is created, and the quota (and, in the licence treatment, who holds a licence) is computed from them. If you declare more participants than actually join, the market waits for someone who never arrives. If a student disconnects, ask them to reopen the room in the same browser; if they cannot, use **Advance slowest participants**.

oTree Demo Sessions Rooms Data Server Check

[EN] Quota controls — market-wide quota (8 periods): session 'ive5wuny'

[Edit](#)
[Links](#)
[Monitor](#)
[Data](#)
[Payments](#)
[Report](#)
[Description](#)

ID	Code	Label	Progress	App	Round	PageName	Waiting	WaitsFor	Since
P1	rx9hrz6r		15/90	quota_controls	2	Trade			1m
P2	iraugaan		15/90	quota_controls	2	Trade			1m
P3	io84qwrno		15/90	quota_controls	2	Trade			1m
P4	snus8h13		15/90	quota_controls	2	Trade			1m
P5	1qvvy561		15/90	quota_controls	2	Trade			1m
P6	xzzxm0jl		15/90	quota_controls	2	Trade			1m
P7	y9sd5uyc		15/90	quota_controls	2	Trade			1m
P8	q3a62kr9		15/90	quota_controls	2	Trade			1m
P9	qd0i6y0d		15/90	quota_controls	2	Trade			1m
P10	h47933wx		15/90	quota_controls	2	Trade			1m
P11	...		15/90	quota_controls	2	Trade			1m

Figure 2.6: Monitor: period and page of each participant.

2.5 How your students join

Students need no account and nothing to install. They can join through the QR code (below and in Appendix A), the link https://quotacontrols.beer-lab.org/room/quota_controls_en, or

the catalogue at teaching.beer-lab.org.



English, basic

quotacontrols.beer-lab.org/room/quota_controls_en



English, extended

quotacontrols.beer-lab.org/room/quota_controls_extended



Spanish, basic

quotacontrols.beer-lab.org/room/quota_controls_es



Spanish, extended

quotacontrols.beer-lab.org/room/quota_controls_extendido

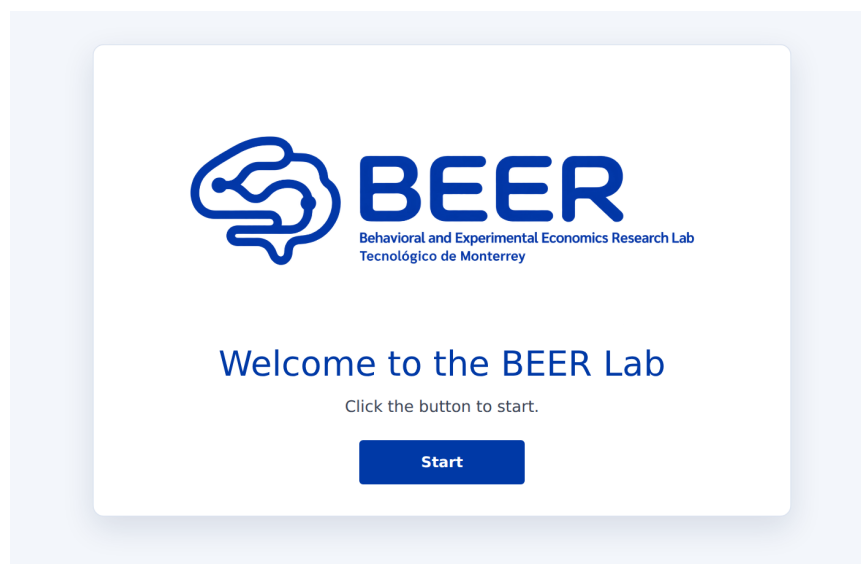


Figure 2.7: The room a student opens.

The screenshot shows the top navigation bar with logos for Tecnológico de Monterrey and BEER, and a menu with links: PARTICIPATE, CLASSROOM, RESEARCH, NEWS, TRAINING, ES, and EN. Below the navigation bar is a large banner image of a classroom with students at computers. Overlaid on the banner is the text: "INSTRUCTORS AND STUDENTS", "Classroom experiments", "Experimental economics games for classroom activities and discussion. Open the game your instructor tells you.", "Instructors: how to use these games in class or propose a new one → [instructor guide](#)", and "Lab research: [beer-lab.org/en/research](#)".

Below the banner is a search bar with the placeholder text "Search by title, topic, keyword or JEL code...". Below the search bar are two dropdown menus: "Topic" and "JEL code". To the right of the dropdowns is the text "43 games".

Below the search bar are two game cards. The first card is titled "All-Pay Auctions and R&D Races" and describes an experiment where participants observe how an all-pay contest turns valuations or prizes into strategic expenditure and when dissipation or overdispersion emerges. It lists basic rules (Private values; one or ten rounds; fixed or reassigned groups) and extended rules (Baseline, short horizon, asymmetric impatience, fixed delay cost, breakdown risk, outside option, and structured communication). It includes tags for "auctions", "all-pay contests", "rent dissipation", "innovation", and "game theory". The JEL code is C72 - C92 - D44 - O31. The address is [allpay.beer-lab.org](#). There are buttons for "Español" and "English".

The second card is titled "Alternating-Offers Bargaining" and describes a sequential bargaining experiment. It lists basic rules (One negotiation, ten with a fixed partner, or ten with reassignment; at most five proposals and discount factors of 0.90 for both positions) and extended rules (Baseline, short horizon, asymmetric impatience, fixed delay cost, breakdown risk, outside option, and structured communication). It includes tags for "bargaining", "backward induction", "time discounting", "subgame perfection", and "game theory". The JEL code is C72 - C78 - C92.

Figure 2.8: The [teaching.beer-lab.org](#) catalogue.

The basic game and its screens

3.1 Rules and incentives

The whole class forms a single market. When the session is created, half are assigned the buyer role and half the seller role; with an odd number there is one more buyer. Buyers are ordered at random and get values that step down by 15 from 300 ECU; sellers get costs that step up by 15 from 0 ECU. Role, value and cost stay the same in every period.

Each period lasts 150 seconds. Each person can buy or sell *one* unit per period. Buyers post bids and sellers post asks; everyone sees the best of each side. A new quote only enters if it improves the standing one (a higher bid, a lower ask), and anyone can accept the best quote on the other side: the trade closes immediately at that price. The software does not allow quoting or accepting at a loss.

$$\pi^{\text{buyer}} = v_i - p, \quad \pi^{\text{seller}} = p - c_j, \quad \text{and } 0 \text{ with no trade in the period.}$$

The first three periods have no restriction. Before period 4 a screen announces the new rule, valid until the end. The quota is $Q = q^* - 3$ units per period, where q^* is the competitive quantity of *your* class (at least one unit): with 22 or more students, $q^* = 11$ and $Q = 8$.

Treatment	Rule from period 4
Market-wide quota	At most Q trades per period in the whole market, counted in the order they close. Once Q have closed, nobody can quote or trade for the rest of the period; the screen shows how many trades are still available.
Licences	Q sellers, drawn at random when the session is created, hold a licence to sell one unit per period until the end. Sellers without a licence cannot quote or trade. Buyers trade as before.

For the instructor

The instructions only say that there *may* be a limit on the number of units in some periods and that it will be announced in advance. They never mention “quota rent”, “equilibrium” or “deadweight loss”. Before period 4 starts, ask: what do you think will happen to the price?

3.2 Welcome, instructions and comprehension





Welcome to the BEER Lab

The **Behavioral and Experimental Economics Research Lab** of the Department of Economics at Tecnológico de Monterrey is a space for learning about economic decisions through controlled activities.

Today you will take part in a market as a buyer or a seller. Your earnings depend on your decisions.

During the session

- Do not talk or communicate with other people, except through the means shown on screen.
- Make your decisions individually.
- Follow the on-screen instructions. Do not refresh or close this page.
- If you need help, raise your hand.

I have read and understood the lab rules.

☐ Yes ☐ No

[Start](#)

Powered by [oTree](#)

Figure 3.1: Welcome page and lab rules.

Instructions

Period 1 of 8

In this activity you are a buyer. Each period you want to buy one unit of a product.

Each period you have your own **value** for your unit: the highest price it is worth paying. If you buy at a lower price you earn the difference; if you buy at a higher price you lose. No one else knows your value.

Your earnings = your value – the price you buy at. If you do not buy, your earnings are 0.

Example: if your value is 150 and you buy at a price of 120, your earnings are $150 - 120 = 30$ ECU.

How trading works

- Each period lasts 150 seconds. Buyers propose a price to buy at (a bid) and sellers propose a price to sell at (an ask); everyone sees the two best current offers.
- A new bid is only accepted on screen if it is higher than the current best bid. A new ask is only accepted if it is lower than the current best ask.
- At any time you can accept the best offer from the other side: as a buyer, you can accept the best ask; as a seller, you can accept the best bid. Accepting closes the trade immediately at that price.
- The system will not let you propose or accept a price that would lose you money. You can buy or sell at most one unit per period; if you do not trade, your earnings for that period are 0.
- In some periods there may be a limit on the number of units that can be traded. If there is one, it will be announced before that period and shown on the trading screen.

- There will be 8 periods. Your role and your value or cost stay the same in every period. Your earnings from all periods are added up.
- Amounts are in ECU (experimental currency units). There is no cash payment.

[Continue](#)

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Figure 3.2: A buyer's instructions. The last rule warns that there may be a limit on the number of units.

Instructions

Period 1 of 8

In this activity you are a seller. Each period you want to sell one unit of a product.

Each period you have your own **cost** for your unit: the lowest price it is worth accepting. If you sell at a higher price you earn the difference; if you sell at a lower price you lose. No one else knows your cost.

Your earnings = the price you sell at – your cost. If you do not sell, your earnings are 0.

Example: if your cost is 80 and you sell at a price of 120, your earnings are $120 - 80 = 40$ ECU.

How trading works

- Each period lasts 150 seconds. Buyers propose a price to buy at (a bid) and sellers propose a price to sell at (an ask); everyone sees the two best current offers.
- A new bid is only accepted on screen if it is higher than the current best bid. A new ask is only accepted if it is lower than the current best ask.
- At any time you can accept the best offer from the other side: as a buyer, you can accept the best ask; as a seller, you can accept the best bid. Accepting closes the trade immediately at that price.
- The system will not let you propose or accept a price that would lose you money. You can buy or sell at most one unit per period; if you do not trade, your earnings for that period are 0.
- In some periods there may be a limit on the number of units that can be traded. If there is one, it will be announced before that period and shown on the trading screen.

- There will be 8 periods. Your role and your value or cost stay the same in every period. Your earnings from all periods are added up.
- Amounts are in ECU (experimental currency units). There is no cash payment.

Continue

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Figure 3.3: A seller's instructions.

The example uses a buyer with value 150, a seller with cost 80 and a price of 120: the buyer earns 30 and the seller 40. The comprehension check asks for those two numbers; after an error it explains the rule and lets the student retry.

Before you start

Period 1 of 8

Answer both questions based on the instructions (they apply to any buyer or seller).

A buyer has a value of 150 and buys at a price of 120. What are their earnings?

- ☐ -30 ECU
 ☐ 30 ECU
 ☐ 120 ECU
 ☐ 150 ECU

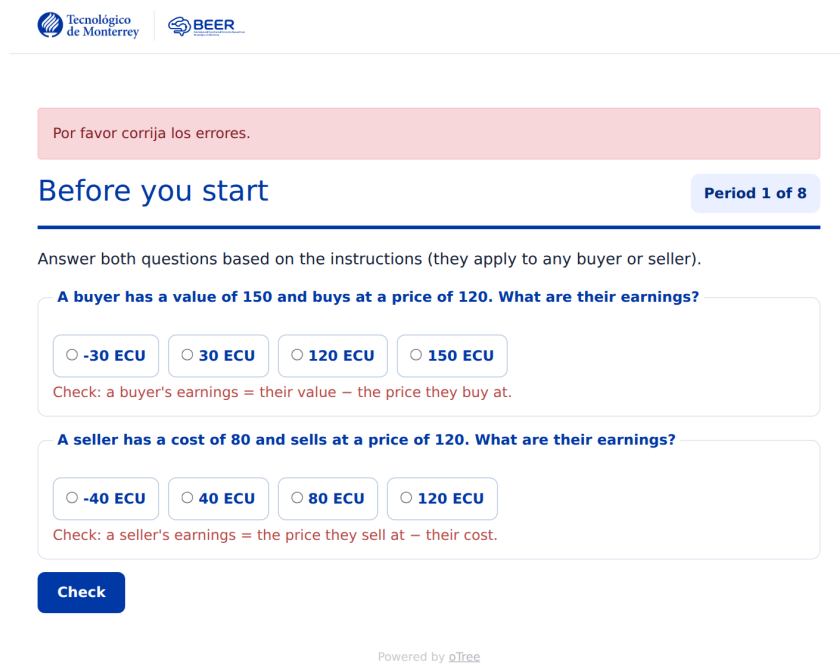
A seller has a cost of 80 and sells at a price of 120. What are their earnings?

- ☐ -40 ECU
 ☐ 40 ECU
 ☐ 80 ECU
 ☐ 120 ECU

Check

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Figure 3.4: Comprehension check.



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Por favor corrija los errores.

Before you start

Period 1 of 8

Answer both questions based on the instructions (they apply to any buyer or seller).

A buyer has a value of 150 and buys at a price of 120. What are their earnings?

☐ -30 ECU
 ☐ 30 ECU
 ☐ 120 ECU
 ☐ 150 ECU

Check: a buyer's earnings = their value – the price they buy at.

A seller has a cost of 80 and sells at a price of 120. What are their earnings?

☐ -40 ECU
 ☐ 40 ECU
 ☐ 80 ECU
 ☐ 120 ECU

Check: a seller's earnings = the price they sell at – their cost.

Check

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Figure 3.5: Wrong answer: the message restates the rule without giving the answer.

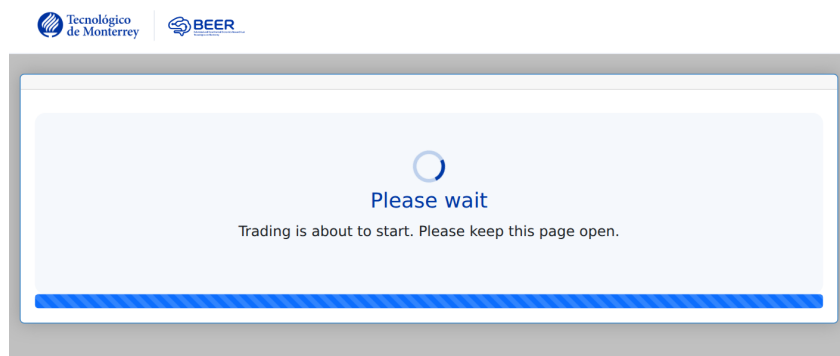


Figure 3.6: Waiting for the whole market to be ready.

What the participant sees

“Please wait” means other people are not ready yet. It is not an error. Participants should not close or reload the page.

3.3 Free periods (the benchmark)



Time left to complete this page: **2:25**

Trading

Period 2 of 8

You are a buyer.

Your value (the most it is worth paying)
180 ECU

Best bid
140

Best ask
165

Your bid

Offer to buy

Accept the best offer

Trades closed this period

#	Price
1	180
2	175
3	170
4	165
5	160
6	158

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Figure 3.7: A buyer's trading screen in a free period: their value, the best bid and ask, and the period's trades (simulated decisions).

3.4 Market-wide quota




New market rule

Period 4 of 8

From period 4 until the end, **at most 8 trades can be closed in each period in the whole market**. Trades are counted in the order they close: once 8 have closed, nobody can make offers or close trades for the rest of the period.

The system will not let you propose or accept a price that would lose you money. You can buy or sell at most one unit per period; if you do not trade, your earnings for that period are 0.

Continue

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Figure 3.8: Announcement before period 4 (market-wide quota, 22 participants: 8 trades per period).




Time left to complete this page: **2:27**

Trading

Period 4 of 8

In this period at most 8 trades can be closed in the whole market.

You are a buyer.

Your value (the most it is worth paying)

180 ECU

Best ask

—

Best bid

—

Trades that can still be closed this period

5

Your bid

Offer to buy

Accept the best offer

Trades closed this period

#	Price
1	160
2	165
3	170

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Figure 3.9: A period with the quota: the rule stays on screen and a counter shows how many trades can still close (simulated decisions).




Time left to complete this page: **2:24**

Trading

Period 4 of 8

In this period at most 8 trades can be closed in the whole market.

You are a buyer.

Your value (the most it is worth paying)
195 ECU

Best bid
—

Best ask
—

Trades that can still be closed this period
0

The 8 trades allowed this period have been closed: no more offers or trades are accepted.

Trades closed this period

#	Price
1	160
2	165
3	170
4	170
5	175
6	160
7	178
8	180

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Figure 3.10: The eighth trade has closed: the quota is filled and the buyer can no longer quote or trade (simulated decisions).

Period result

Period 4 of 8

Your role

buyer

Your value

180

Did you trade?

No

Price

—

Your earnings

0 ECU

Cumulative earnings

60 ECU

All trades this period

#	Price
1	160
2	165
3	170
4	170
5	175
6	160
7	178
8	180

Next periodPowered by [oTree](#)

Figure 3.11: Period result for a buyer who was left out when the quota filled (simulated decisions).

End of the activity

Period 8 of 8

Your total earnings

743 ECU

Period	Role	Value / cost	Traded	Price	Earnings
1	buyer	270	Yes	175	95
2	buyer	270	Yes	175	95
3	buyer	270	Yes	152	118
4	buyer	270	Yes	170	100
5	buyer	270	Yes	180	90
6	buyer	270	Yes	186	84
7	buyer	270	Yes	189	81
8	buyer	270	Yes	190	80

Thank you for participating. Please wait for your instructor.

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Figure 3.12: Closing screen: total earnings and history.

3.5 Licences

New market rule

Period 4 of 8

From period 4 until the end, **only 8 of the 11 sellers can sell**. They were drawn at random and each holds a licence to sell one unit per period. Sellers without a licence cannot make offers or close trades. Buyers trade as before.

You do not hold a licence: from now on you cannot make offers or sell. Your earnings in those periods are 0. You can watch the market.

The system will not let you propose or accept a price that would lose you money. You can buy or sell at most one unit per period; if you do not trade, your earnings for that period are 0.

Continue

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Figure 3.13: Announcement of the licences, as seen by a seller who did not get one.



Instructor report and debrief

4.1 When to reveal

Report opens with the results hidden and shows participants, buyers, sellers and completed periods. Click **Show results** after the last period (or after period 3, to ask for predictions before the quota).

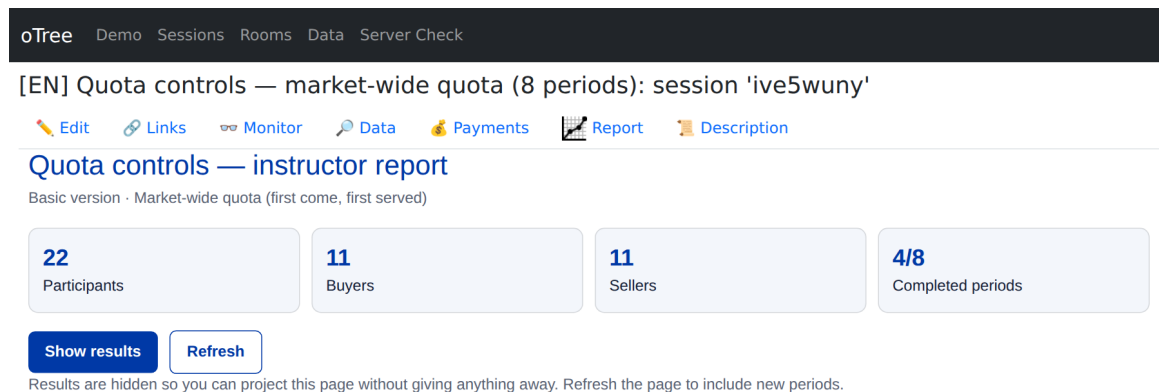


Figure 4.1: Report with results hidden.

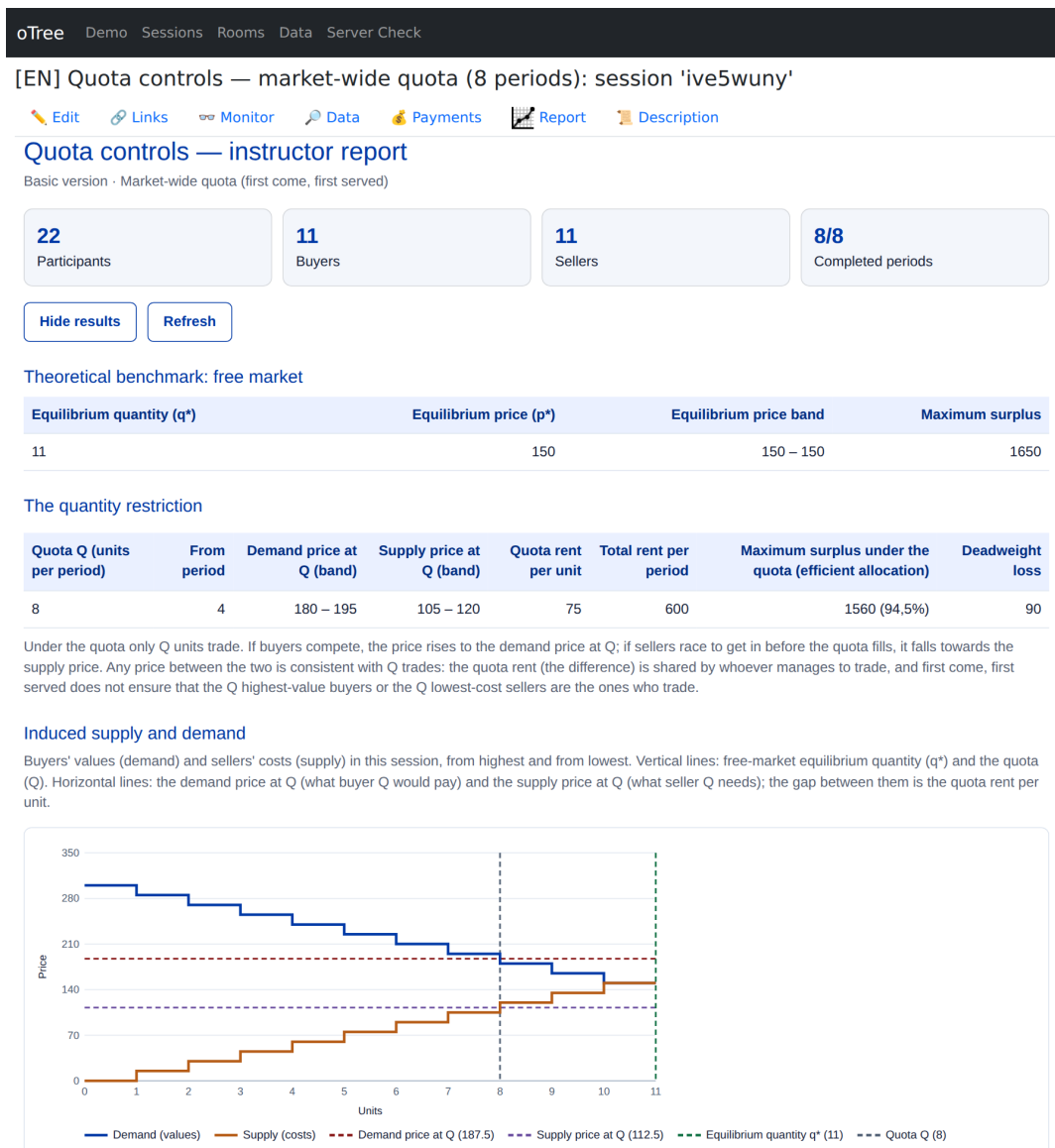
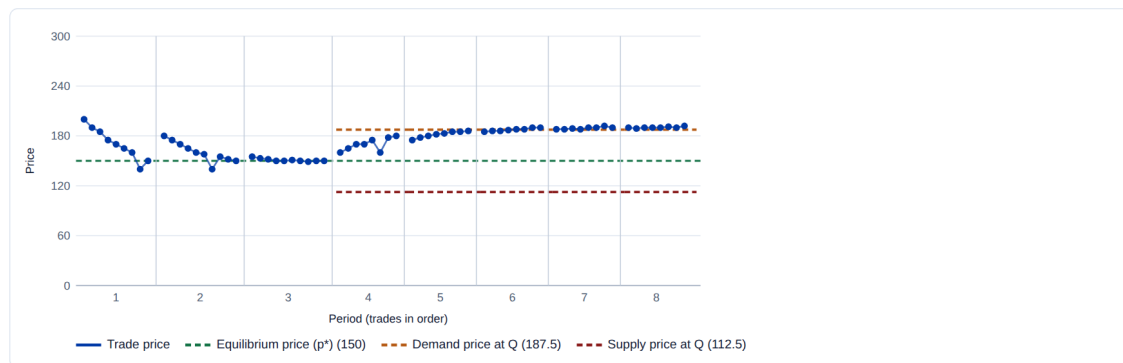


Figure 4.2: Report revealed: the free-market benchmark, the quota (demand and supply prices at the quota, rent and deadweight loss) and the session's induced supply and demand, with q^* , Q and the wedge between the two prices at Q (market-wide quota, 22 participants, simulated decisions).

Price of every trade, in order

Each dot is a trade, in the order it was closed; vertical lines separate periods (as in the charts of Smith, 1962). Dashed lines: the free-market equilibrium price and, in the periods with the quota, the demand and supply prices at Q . A price near the demand price leaves the rent to sellers; near the supply price, to buyers.



Realized surplus: buyers and sellers

Left, buyers: the steps are demand (values, highest first) and each blue bar is the gain of a buyer who bought (from the price up to the value). Right, sellers: the steps are supply (costs, lowest first) and each orange bar is the gain of a seller who sold (from the cost up to the price). In grey, each side's surplus in the free-market equilibrium: grey left visible is surplus not realized; bars outside the grey are gains of traders outside the efficient set or from prices better than equilibrium. Choose the period with the buttons.

Period 8 · With restriction · Trades: 8 · Consumer surplus: 458 (equilibrium: 825) · Producer surplus: 1102 (equilibrium: 825) · Efficiency: 94,5% · Rent to sellers: 600 · Rent to buyers: 0

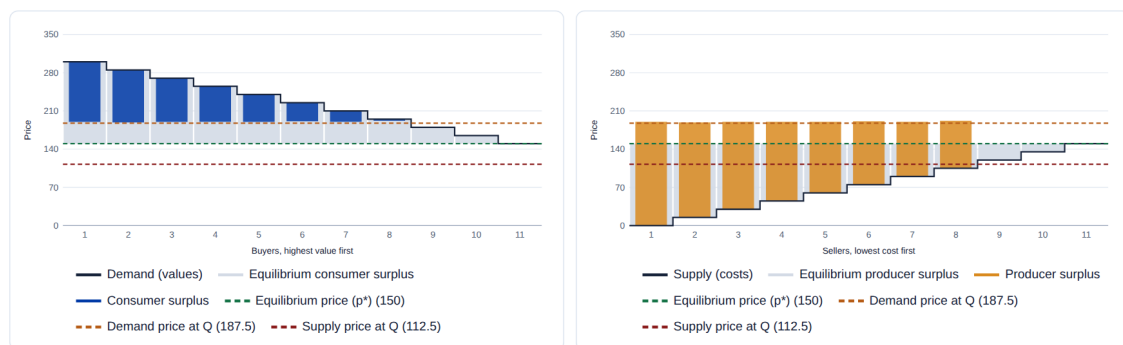


Figure 4.3: The two headline charts: the price of every trade in order, with p^* and, from period 4, the demand and supply prices at Q ; and the realized surplus of the chosen period, buyers on the left and sellers on the right (simulated decisions).

Before and after the restriction

Phase	Periods	Trades	Average price	Efficiency	Consumer surplus	Producer surplus	Rent to sellers	Rent to buyers	Smith's α	Outside the efficient set	Quota full at (s)
Free market	3	9,7	160,7	97,6%	690	920			10,0	0	
With restriction	5	8	183,7	93,4%	504,2	1037,8	561,2	38,8	22,7	0,8	7,1
Benchmark: free market		11	150	100%	825	825					
Benchmark: quota Q at the demand price		8	187,5	94,5%	480	1080	600	0			

Averages per period. Quota rent: in each trade under the quota, the part of the price above the supply price at Q goes to the seller and the part below the demand price at Q goes to the buyer; together they add up to trades $\times$ rent per unit. The two benchmark rows are theoretical: the free-market equilibrium, and the quota with the efficient allocation at the demand price at Q (the whole rent to sellers).

Average price by period

Average of the period's trade prices. Dashed lines: free-market equilibrium price and the demand and supply prices at Q .

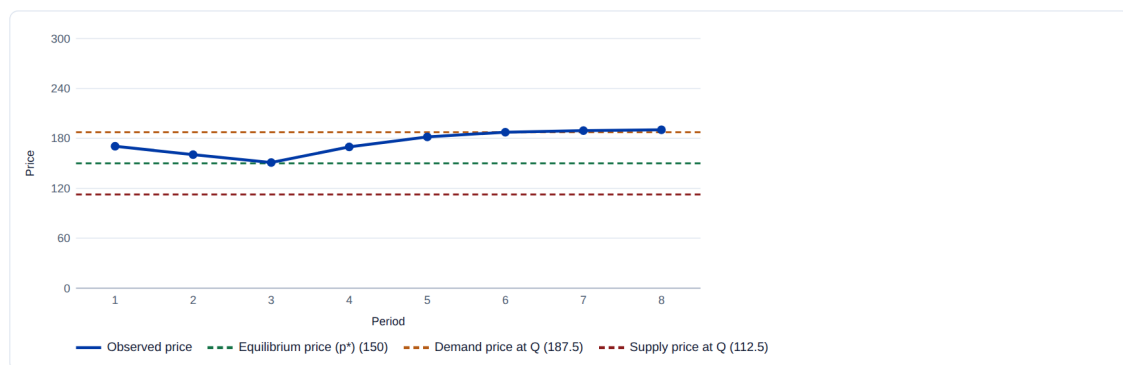


Figure 4.4: Before and after the quota, with the two benchmark rows and the rent captured by each side, and the average price by period (simulated decisions).

Results by period

Period	Phase	Trades	Average price	Efficiency	Consumer surplus	Producer surplus	Rent to sellers	Rent to buyers	Smith's α	Outside the efficient set	Quota full at (s)
1	Free market	9	170,6	94,5%	565	995			18,3	0	
2	Free market	10	160,5	98,2%	690	930			10,4	0	
3	Free market	10	151	100,0%	815	835			1,3	0	
4	With restriction	8	169,8	90,9%	592	908	458	142	14,0	2	7,7
5	With restriction	8	181,8	93,6%	526	1019	554	46	21,3	1	7,0
6	With restriction	8	187,5	94,5%	480	1080	594	6	25,0	0	7,0
7	With restriction	8	189,4	93,6%	465	1080	600	0	26,3	1	6,8
8	With restriction	8	190,2	94,5%	458	1102	600	0	26,8	0	6,9

Consumer and producer surplus: period totals. Smith's α : root mean squared deviation of prices from the free-market equilibrium price, as % of that price (0 = every price at p^* ; under the quota it rises as prices move away from p^*). Outside the efficient set: trades with a buyer or seller who is not among the q^* best on their side (the Q best under the restriction). Quota filled: seconds from the start of trading until trade Q closed (blank if it did not fill).

Individual data: Data → Custom export (quota_controls): one row per person and period (with the order, second and price of their trade) and, after a blank row, every bid and ask submitted, in order, with its status (ok, quota_full, uncensored, invalid = did not improve the standing offer or implied a loss).

Figure 4.5: Trades by period with q^* and Q , and the per-period table (simulated decisions).

The quantity restriction

Quota Q (units per period)	From period	Demand price at Q (band)	Supply price at Q (band)	Quota rent per unit	Total rent per period	Maximum surplus under the quota (efficient allocation)	Deadweight loss
8	4	180 – 195	105 – 120	75	600	1560 (94,5%)	90

With licences only licensed sellers can sell. Facing many buyers, they can ask up to the demand price at Q: the quota rent goes to the licence holders. If licences fall on high-cost sellers, the maximum surplus falls further (below).

The licences

Costs of the licensed sellers	The class's Q lowest costs	Licences held by sellers outside the Q lowest costs	Efficient trades with these licences	Price band with these licences	Maximum surplus with these licences
0 15 30 60 90 105 120 135	0 15 30 45 60 75 90 105	2	8	180 – 195	1425 (86,4%)

Induced supply and demand

Buyers' values (demand) and sellers' costs (supply) in this session, from highest and from lowest. Vertical lines: free-market equilibrium quantity (q^*) and the quota (Q). Horizontal lines: the demand price at Q (what buyer Q would pay) and the supply price at Q (what seller Q needs); the gap between them is the quota rent per unit. Dotted steps: supply when only licence holders can sell (their costs, lowest first).

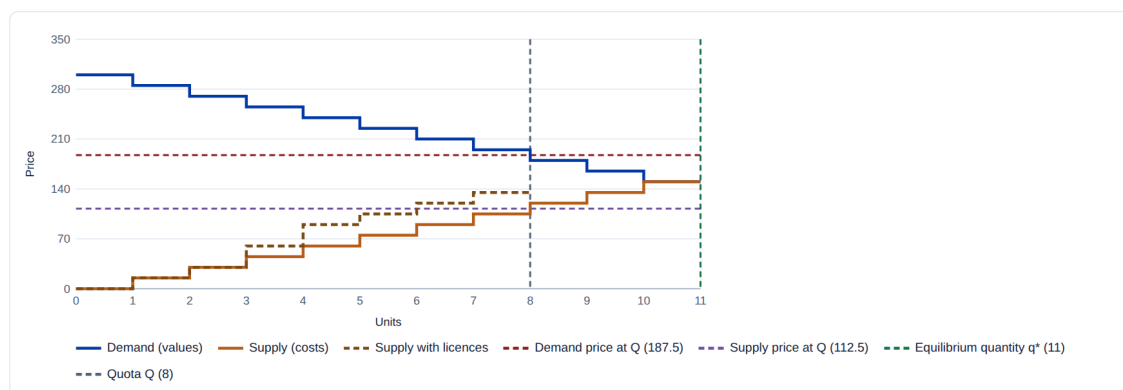


Figure 4.6: Licence treatment: the quota, the session's licences, and supply and demand with the licence holders' supply (dotted steps) (simulated decisions; the licences are the app's own draw).

Realized surplus: buyers and sellers

Left, buyers: the steps are demand (values, highest first) and each blue bar is the gain of a buyer who bought (from the price up to the value). Right, sellers: the steps are supply (costs, lowest first) and each orange bar is the gain of a seller who sold (from the cost up to the price). In grey, each side's surplus in the free-market equilibrium: grey left visible is surplus not realized; bars outside the grey are gains of traders outside the efficient set or from prices better than equilibrium. Choose the period with the buttons. Red diamonds: licensed sellers (from period 4). A diamond without a bar is an unused licence; a grey column without a diamond, a low-cost seller left out.

Period 1 Period 2 Period 3 Period 4 Period 5 Period 6 Period 7 Period 8

Period 8 · With restriction · Trades: 8 · Consumer surplus: 467 (equilibrium: 825) · Producer surplus: 958 (equilibrium: 825) · Efficiency: 86,4% · Rent to licence holders: 600 · Rent to buyers: 0

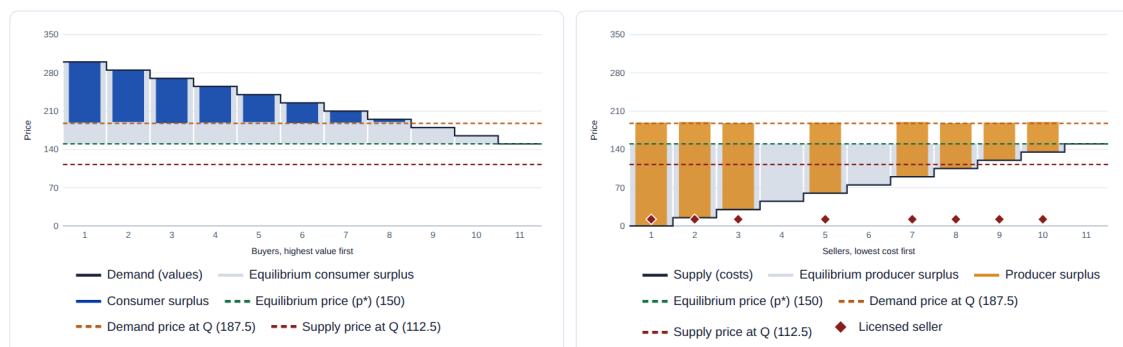


Figure 4.7: Licence treatment: realized surplus in a period under the quota; diamonds mark the licensed sellers (simulated decisions).

Before and after the restriction

Phase	Periods	Trades	Average price	Efficiency	Consumer surplus	Producer surplus	Rent to licence holders	Rent to buyers	Smith's α	Outside the efficient set
Free market	3	9	152	98,2%	792	828			2,5	0
With restriction	5	8	182,5	86,4%	519,8	905,2	556,4	43,6	21,7	2
Benchmark: free market		11	150	100%	825	825				
Benchmark: quota Q at the demand price		8	187,5	94,5%	480	1080	600	0		

Averages per period. Quota rent: in each trade under the quota, the part of the price above the supply price at Q goes to the seller and the part below the demand price at Q goes to the buyer; together they add up to trades $\times$ rent per unit. The two benchmark rows are theoretical: the free-market equilibrium, and the quota with the efficient allocation at the demand price at Q (the whole rent to sellers).

Figure 4.8: Licence treatment: before and after, with the rent captured by the licence holders (simulated decisions).

4.2 How to read the report

Every chart has a note under its title explaining how to read it; here is the essence, in the order of the report.

1. **Free-market benchmark:** how many units should trade, at what price, and the maximum surplus.
2. **The quantity restriction:** the quota Q and the two prices that matter at Q . The *demand price* is what buyers are willing to pay for the Q -th unit; the *supply price* is what the Q -th seller needs. Their gap is the **quota rent per unit**; times Q , the rent per period. The maximum surplus under the quota (if the Q best buyers trade with the Q best sellers) and the deadweight loss complete the picture.
3. **Licences** (licence treatment only): which costs hold a licence, compared with the Q lowest costs. Each licence in the hands of a high-cost seller lowers the maximum surplus further.
4. **Induced supply and demand:** your class's value and cost steps, with q^* and Q as vertical lines and the demand and supply prices at Q as horizontal lines: the vertical gap between them at Q is the rent per unit. With licences, the dotted steps are supply when only licence holders can sell.
5. **Price of every trade in order:** as in the charts of [Smith \(1962\)](#), every trade is a dot and vertical lines separate periods. From period 4 the demand and supply prices at Q appear: a price near the first leaves the rent to sellers; near the second, to buyers. You can also see whether early trades in a period are cheap and late ones expensive (or the other way round).
6. **Realized surplus:** choose the period with the buttons (it opens on the last one). On the left, demand and one blue bar per buyer who bought (from the price up to the value); on the right, supply and one orange bar per seller who sold (from the cost up to the price). In grey, the free-market equilibrium surplus: grey left visible is surplus lost. Under the quota, grey columns without a bar on the left are high-value buyers left without a unit; bars to the right of column Q (8 with 22 or more participants) are trades outside the efficient set. With licences, a diamond marks each licensed seller: a diamond without a bar is an unused licence; a grey column without a diamond, a low-cost seller left out.
7. **Before and after:** by phase, trades, price, efficiency, consumer and producer surplus, the **rent captured** by sellers (or licence holders) and by buyers, Smith's α (deviation of prices from p^* , in %), trades outside the efficient set and, with the market-wide quota, how many seconds it took to fill. Two benchmark rows: the free market and the quota at the demand

price at Q (efficient allocation, the whole rent to sellers). In each trade under the quota, the part of the price above the supply price at Q is the seller's rent and the part below the demand price at Q , the buyer's.

8. **Charts and table by period:** average price and trades by period, and the measures of the previous table period by period. From period 4 trades fall to Q and the price moves away from p^* towards the band between the supply and the demand price at Q ; with licences, towards the demand price.

Debrief script

First ask the buyers who did not trade after period 3: why not? Then ask the sellers without a licence how they feel about the licence holders. Reveal the price chart: why did the price rise if costs did not change? Then the quota table: the gap between what buyers pay and what the marginal seller needs is the rent. Who got it in our market? Close with policy: import quotas, taxi medallions, fishing quotas, production quotas in agriculture.

Theory and evidence

This chapter develops the theory of the basic version: the textbook analysis of a quota with the game's induced values and costs, its equivalence with a tax or a tariff, who captures the quota rent in each treatment, the difference between the textbook deadweight loss and the loss measured in the lab, and the lottery effect that appears when the right to trade is allocated by speed or by a draw. The theory of the extended version is in section 7.5. Unless stated otherwise, the numbers are for a class of 22 participants (11 buyers and 11 sellers); with more students the equilibrium and the quota are the same, but the random-allocation benchmarks change (section 5.8). The instructor report computes those of your class.

5.1 Notation and competitive equilibrium

There are n_B buyers and n_S sellers. The buyer of rank k (from highest value down) values one unit at v_k ; the seller of rank k (from lowest cost up) produces it at c_k . In the game

$$v_k = 300 - 15(k - 1), \quad c_k = 15(k - 1), \quad k = 1, 2, \dots$$

Demand and supply are step functions: how many people would buy or sell at each price,

$$Q^d(p) = \#\{k : v_k \geq p\}, \quad Q^s(p) = \#\{k : c_k \leq p\}.$$

The equilibrium quantity q^* is the largest k with $v_k \geq c_k$, and any price in the band $[\max(c_{q^*}, v_{q^*+1}), \min(v_{q^*}, c_{q^*+1})]$ clears the market. With 22 or more participants, $q^* = 11$ and the band shrinks to a point, $p^* = 150$. Maximum total surplus and its split at the equilibrium price are

$$W^* = \sum_{k=1}^{q^*} (v_k - c_k) = 1650, \quad CS^* = \sum_{k=1}^{q^*} (v_k - p^*) = 825, \quad PS^* = \sum_{k=1}^{q^*} (p^* - c_k) = 825.$$

A trade between buyer i and seller j at price p creates $v_i - c_j$ of surplus whatever p is: the price only splits it. A period's **efficiency** is $E = W/W^*$, where W is the sum of $v_i - c_j$ over the trades made. The report always divides by the free-market W^* , also in the periods with the quota.

Theoretical background

The textbook approximation. Drawing straight lines through the steps gives inverse demand $P^d(q) = 315 - 15q$ and inverse supply $P^s(q) = 15q - 15$. They cross at $q^* = 11$, $p^* = 150$, like the steps. The difference shows up away from equilibrium: the lines extrapolate traders who do not exist and triangles overstate the areas of the steps.

5.2 A binding quota: the textbook analysis

A quota $Q < q^*$ caps the number of units that can trade in a period. In the textbook diagram the supply curve becomes **vertical at Q** : up to Q units nothing changes; beyond Q nothing can be sold at any price. Two prices matter at Q :

- the **demand price** $P^d(Q)$, at which buyers want exactly Q units: any price in the band $[\max(v_{Q+1}, c_Q), v_Q]$;
- the **supply price** $P^s(Q)$, at which sellers would offer exactly Q units without the quota: any price in the band $[c_Q, \min(c_{Q+1}, v_Q)]$.

In the game $Q = q^* - 3 = 8$. The demand band is $[v_9, v_8] = [180, 195]$ and the supply band $[c_8, c_9] = [105, 120]$; the report uses their midpoints, $P^d(Q) = 187.5$ and $P^s(Q) = 112.5$. The vertical gap between the two is the **quota rent** per unit,

$$R = P^d(Q) - P^s(Q) = 187.5 - 112.5 = 75, \quad \text{total rent } Q \times R = 8 \times 75 = 600 \text{ ECU per period.}$$

With discrete steps the rent per unit is only pinned down between $180 - 120 = 60$ and $195 - 105 = 90$; 75 is the midpoint convention of the report. If the Q highest-value buyers trade with the Q lowest-cost sellers (*efficient allocation* under the quota), surplus and deadweight loss are

$$W_Q = \sum_{k=1}^Q (v_k - c_k) = 1560, \quad \text{DWL} = W^* - W_Q = \sum_{k=Q+1}^{q^*} (v_k - c_k) = 60 + 30 + 0 = 90,$$

5.5 % of W^* (94.5 % efficiency). The textbook lines give $P^d(8) = 195$ and $P^s(8) = 105$, a wedge of 90, a rent rectangle of $8 \times 90 = 720$ and a triangle of $\frac{1}{2} (q^* - Q) [P^d(Q) - P^s(Q)] = \frac{1}{2} \cdot 3 \cdot 90 = 135$: half as large again as the 90 of the steps, because unit 11 carries no surplus and the triangle adds the corners of the steps.

The split changes more than the total. At the demand price (the report's row "Benchmark: quota Q at the demand price", with all the rent going to sellers),

$$\text{CS}_Q = \sum_{k=1}^Q (v_k - P^d(Q)) = 1980 - 1500 = 480, \quad \text{PS}_Q = \sum_{k=1}^Q (P^d(Q) - c_k) = 1500 - 420 = 1080,$$

and the producers' 1080 is the sum of their surplus at the supply price, $8 \times 112.5 - 420 = 480$, and the rent, 600. The free-market 1650 is therefore split into

$$W^* = \underbrace{480}_{\text{CS at } P^d(Q)} + \underbrace{480}_{\text{PS at } P^s(Q)} + \underbrace{600}_{\text{quota rent}} + \underbrace{90}_{\text{DWL}}.$$

Buyers lose $825 - 480 = 345$: they pay 37.5 more on each of the 8 units they still buy (300) and lose the surplus of units 9 to 11 ($30 + 15 + 0 = 45$). Sellers gain $1080 - 825 = 255$: the same 300, minus the 45 they earned on units 9 to 11.

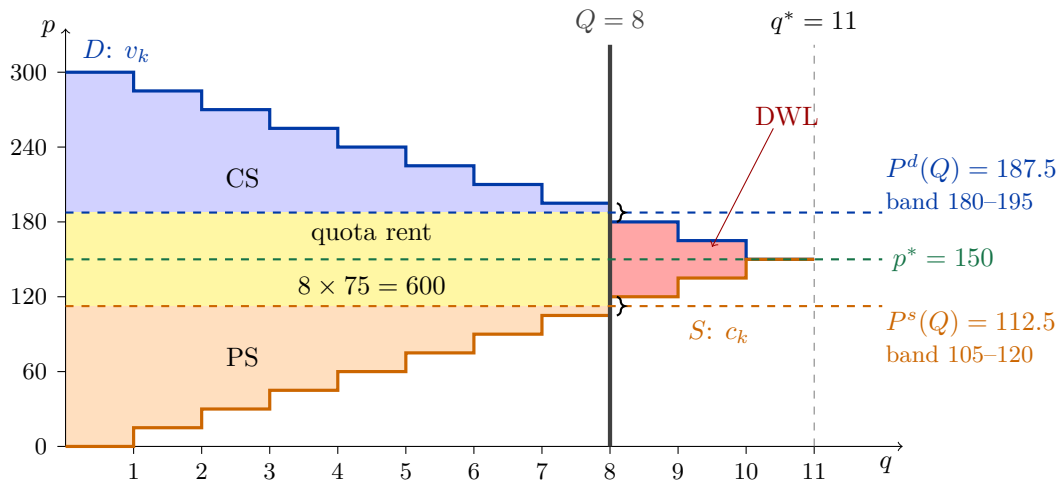


Figure 5.1: A quota of $Q = 8$ with 22 participants and efficient allocation. Supply becomes vertical at Q . Blue: consumer surplus (CS) at the demand price; yellow: quota rent, between the supply and the demand price at Q ; orange: producer surplus (PS) at the supply price; red: deadweight loss (DWL) of units 9 to 11, which are no longer traded (unit 11 carries no surplus). The vertical steps of demand and supply at Q are the two price bands.

5.3 The quota as a tax: Bhagwati's equivalence

Replace the quota by a tax of t ECU per unit: buyers pay p_b , sellers keep $p_s = p_b - t$. Exactly 8 units trade if buyers demand 8 at p_b and sellers supply 8 at p_s , that is, if $p_b \in [180, 195]$ and $p_s \in [105, 120]$: any tax with $60 < t \leq 90$ (with $t = 60$ unit 9 becomes a tie, $v_9 - t = c_9$). With $t = R = 75$, $p_b = 187.5$ and $p_s = 112.5$: the same quantity, the same prices and the same deadweight loss as the quota. The only difference is the rectangle of 600: with the tax it is *government revenue*; with the quota it is a *rent* for whoever holds the right to trade.

This is the **equivalence of tariffs and quotas** of Bhagwati (1965): under competition, an import quota and the tariff that leads to the same imports raise the domestic price by the same amount, and differ in who keeps the gap between the domestic and the world price: the treasury with the tariff, the holders of import licences with the quota (the government only gets it if it *auctions* the licences, which is what the extended version does). The equivalence breaks down when there is market power, for example a single domestic producer or a single holder of the quota (Bhagwati, 1965). It also breaks down when demand moves: a quota fixes the quantity and lets the price absorb the shock; a tariff fixes the wedge and lets the quantity absorb it.

A quota is also the quantity twin of the price ceiling in the lab's *price controls* game. The ceiling fixes the price and lets the quantity fall to the short side of the market (Isaac and Plott, 1981); the quota fixes the quantity and lets the price rise towards the demand price. In both cases a wedge opens between what buyers would pay for the last unit and what it costs, and someone captures it.

5.4 Who captures the rent

Under the quota, a trade at price p splits the rent of its unit between the two sides:

$$R = \underbrace{(p - P^s(Q))}_{\text{seller's share}} + \underbrace{(P^d(Q) - p)}_{\text{buyer's share}},$$

with p clipped to $[P^s(Q), P^d(Q)]$. This is exactly how the report computes the columns “Rent to sellers” (“Rent to licence holders”) and “Rent to buyers”: summed over a period’s trades, the two add up to trades $\times 75$.

- **Market-wide quota, first come, first served.** At any price between 105 and 195, $Q^d(p) \geq 8$ and $Q^s(p) \geq 8$: more buyers *and* more sellers want to trade than the quota allows. Theory pins down the quantity but not the price. If every trade closes at 187.5, sellers capture the whole 600; at 112.5, buyers do; at $p^* = 150$, each side gets 300. Who gets the rent depends on bargaining and on the race to close a trade before the quota fills.
- **Licences.** Only the Q licence holders can sell, and they face all the buyers. With 22 participants every possible draw of 8 licences leaves the licence holders with costs of at most 150, below $v_9 = 180$, so the competitive price of the licensed market lies in the demand band, 180–195, *whatever the draw*. The rent goes to the licence holders.

5.5 The lottery effect under the market-wide quota

The textbook picture assumes that the quota falls on the least valuable trades: the Q best buyers trade with the Q best sellers. A first-come quota does not guarantee it. At price p , all $Q^d(p)$ buyers with $v_k \geq p$ and all $Q^s(p)$ sellers with $c_k \leq p$ are willing to trade, and only Q of each succeed. If the Q places on each side go to people drawn *at random* among the willing ones (a lottery), expected surplus is

$$\mathbb{E}[W^{\text{lottery}}(p)] = Q [\bar{v}_D(p) - \bar{c}_S(p)], \quad \bar{v}_D(p) = \frac{1}{Q^d(p)} \sum_{k=1}^{Q^d(p)} v_k, \quad \bar{c}_S(p) = \frac{1}{Q^s(p)} \sum_{k=1}^{Q^s(p)} c_k,$$

and the total loss splits into the textbook DWL and a **misallocation loss** on each side:

$$W^* - \mathbb{E}[W^{\text{lottery}}] = \underbrace{\sum_{k=Q+1}^{q^*} (v_k - c_k)}_{\text{DWL: units not traded}} + \underbrace{\sum_{k=1}^Q v_k - Q \bar{v}_D(p)}_{\text{buyers' misallocation}} + \underbrace{Q \bar{c}_S(p) - \sum_{k=1}^Q c_k}_{\text{sellers' misallocation}}.$$

Quota $Q = 8$, 22 participants	$Q^d(p)$	$Q^s(p)$	Surplus	Efficiency	Loss	of which misallocation
Competitive equilibrium (no quota)			1650	100 %	0	
Efficient allocation (textbook)			1560	94.5 %	90	0
Lottery at $p = P^d(Q) = 187.5$	8	11	1380	83.6 %	270	180
Lottery at $p = p^* = 150$	11	11	1200	72.7 %	450	360
Lottery at $p = P^s(Q) = 112.5$	11	8	1380	83.6 %	270	180

The price does part of the rationing. At the demand price only the 8 highest-value buyers want to buy, so the demand side is efficient and luck only chooses the sellers ($\bar{c}_S = 75$ instead of $420/8 = 52.5$). At the supply price it is the other way round. A price in the middle leaves *both* sides to luck: the expected loss, 450, is five times the textbook DWL. With a lottery at $p^* = 150$, buyers and sellers each expect $8 \times 75 = 600$ of surplus (against 825 each in the free market) and split the rent 300–300.

The report counts a trade as *outside the efficient set* (column “Outside the efficient set”) when its buyer or its seller is not among the best Q of their side. With a lottery at 150, about $8 \times 3/11 \approx 2.2$ buyers and 2.2 sellers out of the 8 trades are outside, and about 3.8 trades per period are flagged if pairs form at random (2.2 at 112.5 or 187.5); with efficient allocation, none.

Theoretical background

Is there a lottery in the double auction? Nobody draws lots in the market-wide quota: the 8 places go to whoever closes a trade first. If speed has nothing to do with values and costs, the outcome resembles a lottery; if high-value buyers and low-cost sellers move first (they have more to gain and more room to accept the standing quotes), it approaches efficient allocation. Observed efficiency under the quota should therefore lie between about 73 % and 94.5 %, closer to the bottom the more the price stays near p^* and the faster the quota fills. The report's "Quota full at (s)" column, the second at which the 8th trade closed, measures that race. Outside the lab, competition for the right to trade under a quota is not free: [Krueger \(1974\)](#) shows how the rent from import licences is dissipated by the resources spent competing for them (rent seeking).

5.6 Random licences: a lottery on the supply side

In the licence treatment the app draws the Q licence holders at random among *all* n_S sellers, whatever their cost, when the session is created. The number M of licences outside the Q cheapest sellers is hypergeometric:

$$\Pr(M = m) = \frac{\binom{n_S - Q}{m} \binom{Q}{Q - m}}{\binom{n_S}{Q}}, \quad \mathbb{E}[M] = \frac{Q(n_S - Q)}{n_S}.$$

With $n_S = 11$ and $Q = 8$: $\Pr(M = 0) = 1/165 \approx 0.6\%$, $\Pr(M = 1) = 14.5\%$, $\Pr(M = 2) = 50.9\%$ and $\Pr(M = 3) = 33.9\%$; $\mathbb{E}[M] = 24/11 \approx 2.2$. A draw that gives the licences to the 8 cheapest sellers is very unlikely. Each licence draws a seller at random, so the expected cost of licensed supply is $Q\bar{c} = 8 \times 75 = 600$, against 420 for the 8 cheapest, and

$$\mathbb{E}[W_{\text{lic}}] = \sum_{k=1}^Q v_k - Q\bar{c} = 1980 - 600 = 1380 \quad (83.6\%), \quad W^* - \mathbb{E}[W_{\text{lic}}] = \underbrace{90}_{\text{DWL}} + \underbrace{180}_{\text{licence misallocation}}.$$

This is the same number as the lottery at the demand price: in both cases the price rationes the buyers and luck chooses the sellers. Each misallocated licence costs the difference in cost: a licence held by the seller with cost 150 instead of the one with cost 105 destroys 45 ECU of surplus every period. The report's licence table shows your session's draw, the misallocated licences and the maximum surplus with those licences; for instance, a draw of seller ranks $\{1, 2, 3, 4, 7, 8, 9, 10\}$ (costs 0, 15, 30, 45, 90, 105, 120, 135) has $M = 2$ and a maximum of 1440 (87.3 %).

Theoretical background

What if licences could be traded? The game does not allow it, which makes it a good discussion point. At a price near 187.5, a seller without a licence and with cost c_j would pay up to $187.5 - c_j$ for one; a licence holder with cost $c_i > c_j$ would sell it for anything above $187.5 - c_i$. Since $c_i > c_j$, there is a deal, and trading stops only when the licences are in the hands of the 8 cheapest sellers: surplus returns to $W_Q = 1560$ *whatever the initial draw*. The draw then decides only who gets the rent, not how much surplus is created. This is the logic of [Coase \(1960\)](#) and of [Montgomery \(1972\)](#), who showed that a market in pollution licences reaches a given cap at least cost: the basis of cap-and-trade, and of the lab's carbon market game. Transaction costs and market power in the licence market weaken the result.

5.7 From the textbook to the lab: measuring losses

The report's measures map onto the theory as follows.

1. **Efficiency** $E = W/W^*$ per period. Before the quota, the double auction usually exceeds 90 %. Under the quota, compare it with the benchmarks: 94.5 % (efficient allocation, the card “Highest possible under the quota”), 83.6 % (a lottery on one side, or random licences on average; with licences the licence table gives the exact maximum for your draw) and 72.7 % (a lottery on both sides at p^*).
2. **Loss decomposition.** With W_Q the efficient surplus under the quota,

$$W^* - W = \underbrace{(W^* - W_Q)}_{\text{DWL of the quota}} + \underbrace{(W_Q - W)}_{\text{misallocation and trades not made}}.$$

The first term (90) does not depend on what students do. With licences the second splits again, $W_Q - W = (W_Q - W_{\text{lic}}) + (W_{\text{lic}} - W)$: the first part comes from the draw, the second from trading. A trade by a buyer outside the best Q or a seller outside the best Q is an *extra-marginal* trade (Code and Sunder, 1993): the report's “Outside the efficient set” column. With licences the column cannot fall below the number of misallocated licences that are used (the licence table's “Licences held by sellers outside the Q lowest costs”).

3. **Rent to sellers (or licence holders) and to buyers.** The two columns add up the shares $p - P^s(Q)$ and $P^d(Q) - p$ of every trade under the quota. The benchmark row gives the whole 600 to sellers. With licences, expect most of it to go to the licence holders; with the market-wide quota, the split tells you who won the race.
4. **Licence diamonds.** In the realized-surplus chart, a diamond without a bar is an unused licence, and a grey column without a diamond is a low-cost seller left out: the grey area such sellers leave visible is the licence misallocation, $W_Q - W_{\text{lic}}$.
5. **Convergence:** the coefficient of Smith (1962),

$$\alpha = \frac{100}{p^*} \sqrt{\frac{1}{n} \sum_{t=1}^n (p_t - p^*)^2},$$

is computed against the free-market $p^* = 150$ in every period. Under the quota it stops measuring convergence: if every trade closes at the demand price, 187.5, $\alpha = 100 \cdot 37.5/150 = 25$ although the market is exactly where theory predicts; if every trade closes at 150, $\alpha = 0$ although the quota binds. Under the quota, read prices against the two lines at Q (the price-of-every-trade chart) instead.

5.8 How the benchmarks change with class size

The quota is always $Q = q^* - 3$. With fewer than 22 students q^* is smaller and three units are a larger share of the market; with more than 22, the equilibrium does not change, but more buyers and sellers are eligible at each price and the licences are drawn among more sellers, some with costs above the demand price (those licences go unused).

Students	Q	W^*	Efficient allocation	Lottery at p^*	Lottery at $P^d(Q)$	Random licences (misallocated)
10	2	1200	47.5 %	40.0 %	43.8 %	43.8 % (1.2)
14	4	1470	69.4 %	57.1 %	63.3 %	63.3 % (1.7)
18	6	1620	83.3 %	66.7 %	75.0 %	75.0 % (2.0)
20	7	1650	89.1 %	70.0 %	79.5 %	79.5 % (2.1)
22	8	1650	94.5 %	72.7 %	83.6 %	83.6 % (2.2)
26	8	1650	94.5 %	72.7 %	76.4 %	76.4 % (3.1)
30	8	1650	94.5 %	72.7 %	76.4 %	69.6 % (3.7)
40	8	1650	94.5 %	72.7 %	76.4 %	56.9 % (4.8)

Expected efficiency (% of W^*). p^* is the midpoint of the free band. Random licences: expectation over all possible draws, with the expected number of misallocated licences in parentheses; with 30 and 40 students, on average 0.5 and 1.8 licences are held by sellers whose cost is too high to sell.

5.9 Experimental evidence

The continuous double auction converges quickly to the competitive equilibrium even with few traders (Smith, 1962), which is why it is a good benchmark for what a restriction changes. Isaac and Plott (1981) bring price controls into that market; the lab's *price controls* game reproduces their design, and the two games can be played one after the other with the same class: a binding ceiling lowers the price and creates a shortage; a binding quota raises the price and creates a rent. Gode and Sunder (1993) show that the double auction's rules alone, with traders who quote at random but never at a loss, already achieve high allocative efficiency.

On the allocation of licences, Goeree et al. (2010) compare, in the lab, auctioning emission permits with giving them away to firms (*grandfathering*); in their experiments, giving the permits away did not lower product prices, and mainly transferred the value of the permits to the firms that received them. Holt (2019) discusses classroom versions of markets and multi-unit auctions. We do not know of a classic laboratory study of first-come-first-served quotas with the exact design of the basic version; read the class's results as a demonstration of the theory, not as a replication.

5.10 Regularities worth discussing

- From period 4 the number of trades falls to the quota and the average price rises above p^* , towards the band between the supply and the demand price at Q .
- With the market-wide quota, the price can stay anywhere in that band: early trades may be cheap (sellers rush to get in) or expensive (buyers rush). The rent-captured columns show who won the race.
- With licences, licence holders can charge close to the demand price and keep most of the 600 of rent, and about two of the eight licences sit with sellers outside the eight cheapest.
- Efficiency can fall by more than the 5.5 points of the textbook DWL: compare it with 94.5 %, 83.6 % and 72.7 %.

Note

A single class's results are descriptive: one market, whose periods are not independent observations. A difference between periods 1–3 and 4–8 mixes the effect of the quota with learning.

Basic configurations

The basic configurations have 8 periods of 150 seconds: 3 without restriction and 5 with it.

Configuration	What it is for
<code>quota_controls_en_total_quota</code>	A market-wide quota, first come, first served: the price rises, the rent is shared by whoever trades, and the race to trade can misallocate units. The most direct option for an introductory course.
<code>quota_controls_en_licences</code>	Licences for Q sellers drawn at random: the licence holders can capture the rent, and licences held by high-cost sellers add an efficiency loss. Ideal for trade policy (import licences) and regulation (medallions, fishing quotas).

The quota depends on the number of participants. With 22 or more it is always 8 units; with fewer students the report shows the exact values.

Students	q^*	Quota Q	Demand price at Q	Supply price at Q	Rent per unit	Deadweight loss
10	5	2	270–285	15–30	255	630
14	7	4	240–255	45–60	195	450
18	9	6	210–225	75–90	135	270
20	10	7	195–210	90–105	105	180
22 or more	11	8	180–195	105–120	75	90

For the instructor

If you have time for two sessions, play the market-wide quota first and then the licences with the same class: the contrast is who keeps the rent. Pairing the binding ceiling of the *price controls* game with the market-wide quota shows the two sides of the same coin: a ceiling fixes the price and rations quantity; a quota fixes quantity and lets the price rise.

Extended version: quota auctions

The extended version uses the [EN] **Quota Controls — extended (quota auctions)** room. Only the buyers are human: fixed groups of 8 buyers face 9 automated sellers, and each buyer submits one sealed bid per period.

7.1 Rules and incentives

Each automated seller sells one unit per period at any price at or above its cost: 20, 30, 40, $\dots$, 100 ECU. Each period, each buyer receives a value for one unit, $v_i \in \{195, 175, 155, 135, 115, 95, 75, 55\}$, reshuffled at random every period, and submits a bid between 0 and their value. Earnings are $v_i - p_i$ if they buy and 0 otherwise. Groups larger than 8 (leftover students join the first groups) repeat the value ladder.

Periods 1–3, free market. Bids are ranked from the highest down and costs from the lowest up; one unit is sold to each bid that covers the cost it is matched with. Everyone who buys pays the same price: the highest bid that did not buy or the cost of the last seller who sells, whichever is higher. With bids equal to values, 6 units are sold at 75.

Periods 4–8, quota. Only Q units can be sold, two fewer than the free-market quantity ($Q = 4$ in a group of 8). They are sold by the Q cheapest sellers, who receive S , the cost of the Q -th cheapest seller ($S = 50$). A bid below S cannot buy. The group's rule allocates the Q units:

Rule	Who buys and what they pay
Uniform price	The Q highest bids of at least S buy; all pay the highest losing bid, or S if that is higher.
Discriminatory	The Q highest bids of at least S buy; each pays their own bid (pay as bid).
Lottery	Q buyers are drawn at random among the bids of at least S ; they pay S .

What buyers pay above S is the revenue of the quota auction (the government's); in the lottery there is none. Ties are broken at random. Students only see the rule of their own group; a “period 4” screen announces it.

7.2 Configurations

Configuration	What it is for
quota_controls_extended_mixed	The three rules at the same time, one per group (group 1 uniform, 2 discriminatory, 3 lottery, 4 uniform...). With 24 or more students all three are seen.
quota_controls_extended_uniform	Uniform-price auction for every group.
quota_controls_extended_discriminatory	Pay-as-bid auction for every group: bid shading.
quota_controls_extended_lottery	Licence lottery for every group: the rent goes to the lucky buyers.

All have 8 periods (3 free, 5 with the quota) and take 20–25 minutes. With 8 to 15 students there is one group; with 16 to 23, two; with 24 or more, three or more.

7.3 Screens




Instructions Period 1 of 8

In this activity you are a buyer. You are part of a group of buyers that stays the same in every period. Each period you can buy at most one unit of a product.

Each period you have a **value** for the unit: the most it is worth paying. Your value changes from one period to the next and no one else knows it.

Your earnings = your value – the price you pay, if you buy. If you do not buy, your earnings are 0.

Example: with a value of 150, if you buy and pay 110, you earn $150 - 110 = 40$ ECU.

How units are sold

- Units are sold by 9 automated sellers, one unit each per period, at any price at or above their cost. Their costs are 20, 30, 40, 50, 60, 70, 80, 90, 100 ECU.
- Each period you enter a **bid**: the highest price you are willing to pay for one unit. It cannot exceed your value. Nobody sees the others' bids before the period closes.
- Bids are ranked from the highest down and costs from the lowest up. One unit is sold to each bid that covers the cost of the seller it is matched with in that order. Everyone who buys pays the same price: the highest bid that did not buy or the cost of the last seller who sells, whichever is higher. Ties are broken at random.
- In some periods the number of units sold in your group may be limited, with another rule to allocate them. If so, it will be announced before that period and the rule will be shown on the bid screen.

Example: with bids 150, 120, 90, 60 and costs 20, 50, 100, 130, 2 units are sold (the bid of 90 does not cover the cost of 100). The two buyers pay 90: the highest bid that did not buy (90) is higher than the cost of the last seller who sells (50).

- There will be 8 periods. Your earnings from all periods are added up.
- Amounts are in ECU (experimental currency units). There is no cash payment.

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Figure 7.1: Instructions: value, earnings, the free-market rule with a worked example, and the warning that the number of units may be limited.

The comprehension check asks for the earnings of a buyer with value 150 who pays 110 (40 ECU), and for the price with bids 140, 110, 80, 40 and costs 30, 60, 90, 120 (two units sell; the price is 80, the highest bid that did not buy).




Por favor corrija los errores.

Before you start

Period 1 of 8

Answer both questions based on the instructions.

A person with value 150 buys and pays 110. What are their earnings?

☐ 0 ECU
☐ 40 ECU
☐ 110 ECU
☐ 150 ECU

Check: earnings = value – price paid.

The bids are 140, 110, 80, 40 and the sellers' costs are 30, 60, 90, 120. What price do the buyers pay?

☐ 60 ECU
☐ 80 ECU
☐ 90 ECU
☐ 110 ECU

Check: count how many bids cover the cost they are matched with; the price is the highest bid that did not buy or the cost of the last seller who sells, whichever is higher.

Check

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Figure 7.2: Comprehension check after a wrong answer.




Your bid

Period 1 of 8

Your value this period

135 ECU

Rule for this period

Bids are ranked from the highest down and costs from the lowest up; one unit is sold to each bid that covers the cost of the seller it is matched with. Everyone who buys pays the same price: the highest bid that did not buy or the cost of the last seller who sells, whichever is higher. Ties are broken at random.

Sellers' costs: 20 30 40 50 60 70 80 90 100

Your bid (the most you are willing to pay)

135

A whole number between 0 and your value. A bid of 0 means you do not want to buy.

Submit bid

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Figure 7.3: Bid screen in a free period: value, rule and the sellers' costs (simulated decisions).

Period result

Period 1 of 8

Your value

135

Your bid

135

Did you buy?

Yes

Price you paid

75

Your earnings

60 ECU

Cumulative earnings

60 ECU

Units sold in your group

6

Market price

75

Your group's bids, highest first

Bid	Bought	Paid
190	Yes	75
165	Yes	75
155	Yes	75
135 (you)	Yes	75
105	Yes	75
90	Yes	75
75	No	—
45	No	—

Next period

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Figure 7.4: Result of a free period: the group's bids from highest to lowest, who bought and what they paid (simulated decisions).

New market rule

Period 4 of 8

From period 4 until the end, **only 4 units can be sold per period in your group**. Sellers receive 50 ECU per unit, so a bid below 50 cannot buy. The units are allocated with this rule:

Only 4 units are sold. The 4 highest bids of 50 or more buy. All pay the same price: the highest bid that did not buy, or 50 if that is higher. Ties are broken at random.

Continue

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Figure 7.5: Announcement of the quota in a group with the uniform-price rule.



Your bid

Period 4 of 8

Your value this period

155 ECU

Units that can be sold

4

What sellers receive per unit

50 ECU

Rule for this period

Only 4 units are sold. The 4 highest bids of 50 or more buy. Each buyer pays their own bid. Ties are broken at random.

Your bid (the most you are willing to pay)

125

A whole number between 0 and your value. A bid of 0 means you do not want to buy.

Submit bid

Previous periods

Period	Value	Bid	Bought	Price paid	Earnings
1	135	135	Yes	75	60
2	75	75	No	—	0
3	175	175	Yes	70	105

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Figure 7.6: Bid screen under the quota in a pay-as-bid group: units that can be sold and what sellers receive (simulated decisions).

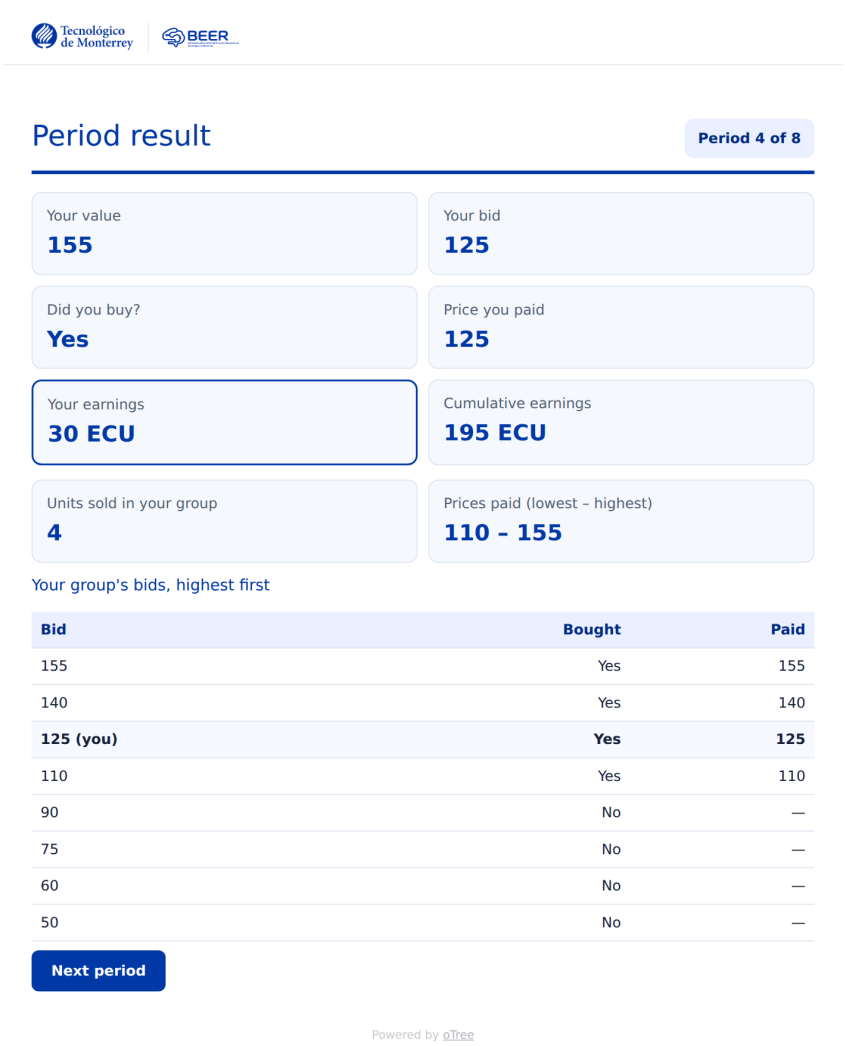


Figure 7.7: Result in a pay-as-bid group: each winner pays their own bid (simulated decisions).

Period result

Period 4 of 8

Your value

55

Your bid

55

Did you buy?

Yes

Price you paid

50

Your earnings

5 ECU

Cumulative earnings

200 ECU

Units sold in your group

4

Market price

50

Your group's bids, highest first

Bid	Bought	Paid
195	Yes	50
175	No	—
155	Yes	50
135	No	—
115	No	—
95	Yes	50
75	No	—
55 (you)	Yes	50

Next period

Powered by [oTree](#)

Figure 7.8: Result in a lottery group: the winners are drawn among the bids of at least S and pay S (simulated decisions).

7.4 Report

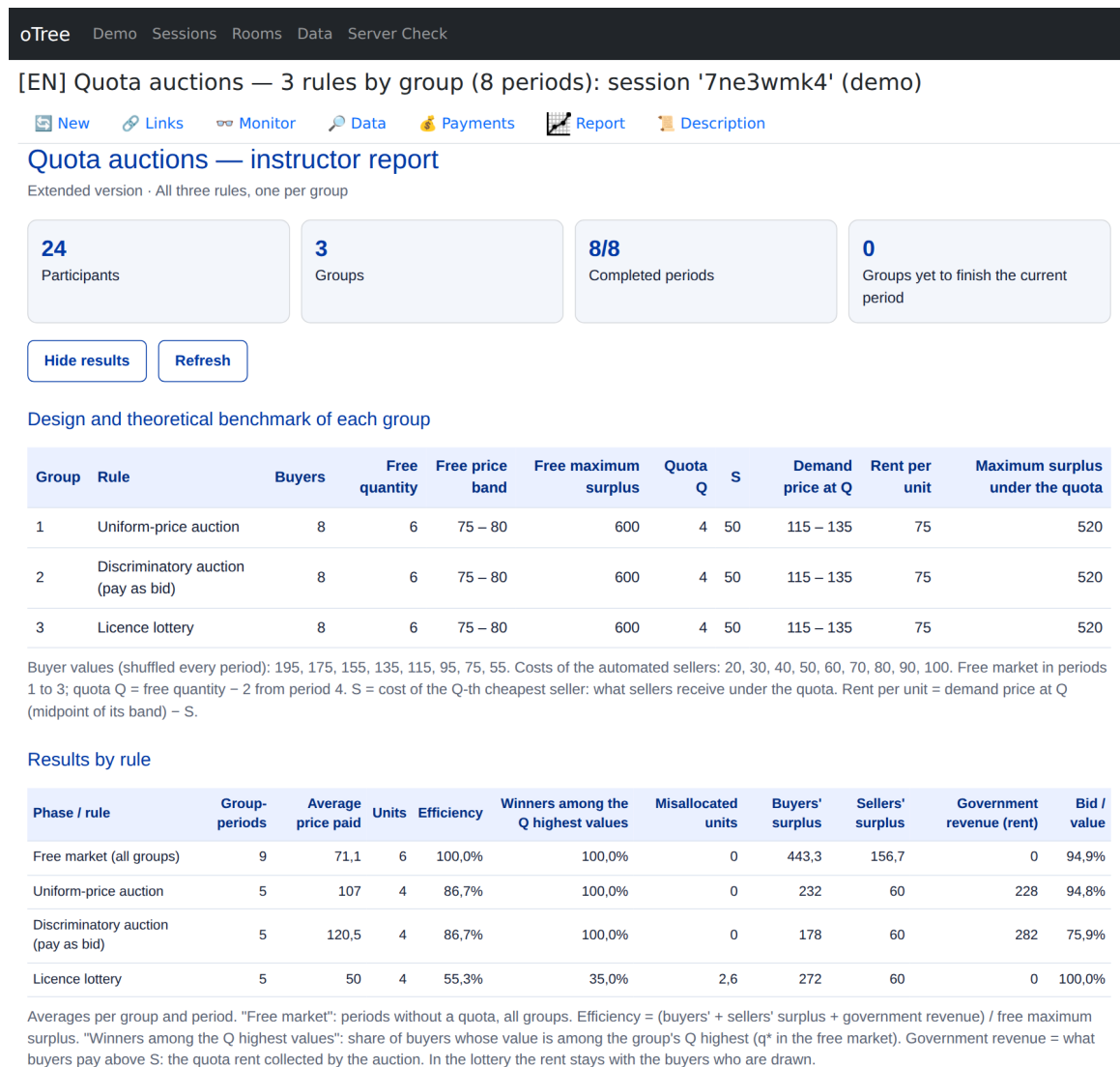


Figure 7.9: Extended report: design and benchmark of each group, and results by rule (simulated decisions).

Each period, group by group: bids, allocation and the split of surplus

Dark steps: the group's values, highest first (demand); orange steps: the automated sellers' costs (supply). Each dot is a buyer's bid, drawn in the column of their value: filled if they bought, a ring if not. For each unit sold, the stacked bar splits the surplus: dark grey, the seller's gain (from cost to what sellers receive); gold, what was paid above S (government revenue, the quota rent); blue, the buyer's gain (from the price paid to the value). Light grey: the maximum surplus with Q units (with the free quantity in the free market): grey left visible is surplus lost, and a blue bar to the right of the Q line is a unit won by someone with a lower value. Choose the group and the period with the buttons.

Group **1 · Uniform** 2 · Pay as bid 3 · Lottery
 Period 1 2 3 4 5 6 7 **8**

Group 1 · Uniform-price auction · Period 8 · With quota · Units: 4/4 · Prices paid: 105 · Sellers receive: 50 · Buyers' surplus: 240 · Sellers' surplus: 60 · Government revenue (rent): 220 · Efficiency: 86,7% · Misallocated units: 0



Figure 7.10: A period under the quota in the uniform-price group: values and costs, each buyer's bid (filled dot if they bought) and, for each unit sold, the seller's gain, what was paid above S and the buyer's gain (simulated decisions).

Group 1 · Uniform **2 · Pay as bid** 3 · Lottery
 Period 1 2 3 4 5 6 7 **8**

Group 2 · Discriminatory auction (pay as bid) · Period 8 · With quota · Units: 4/4 · Prices paid: 95 – 140 · Sellers receive: 50 · Buyers' surplus: 190 · Sellers' surplus: 60 · Government revenue (rent): 270 · Efficiency: 86,7% · Misallocated units: 0

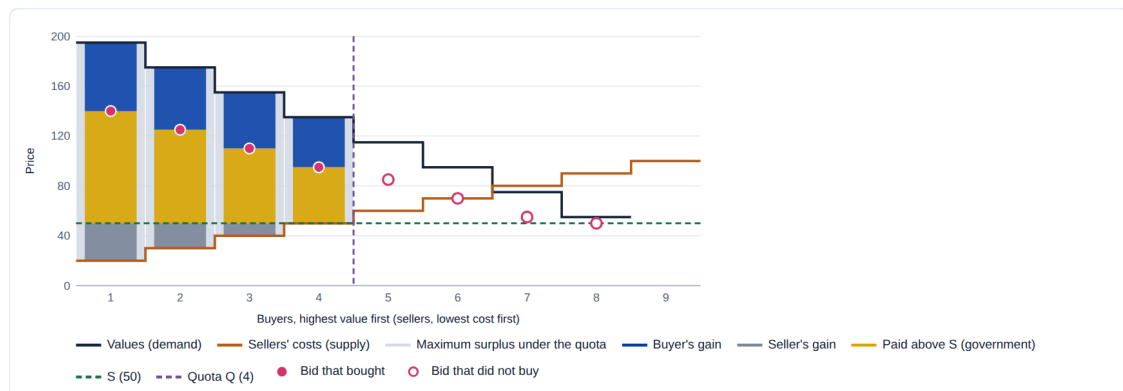


Figure 7.11: The same period in the pay-as-bid group: bids (and prices) fall below values (simulated decisions).



Figure 7.12: The same period in the lottery group: buyers pay S , there is no revenue and a unit can go to a low value (simulated decisions).

Bids against values

Each dot is a bid: horizontally, the bidder's value; vertically, the bid. Rings: free periods; coloured dots: periods with the quota. On the dashed diagonal the bid equals the value; below it, the bid is shaded. When everyone pays their own bid, it pays to bid below value (the dots drop); with a uniform price or a lottery, bidding one's value does not make a buyer pay more. Dashed horizontal line: S , the lowest bid that can buy under the quota.

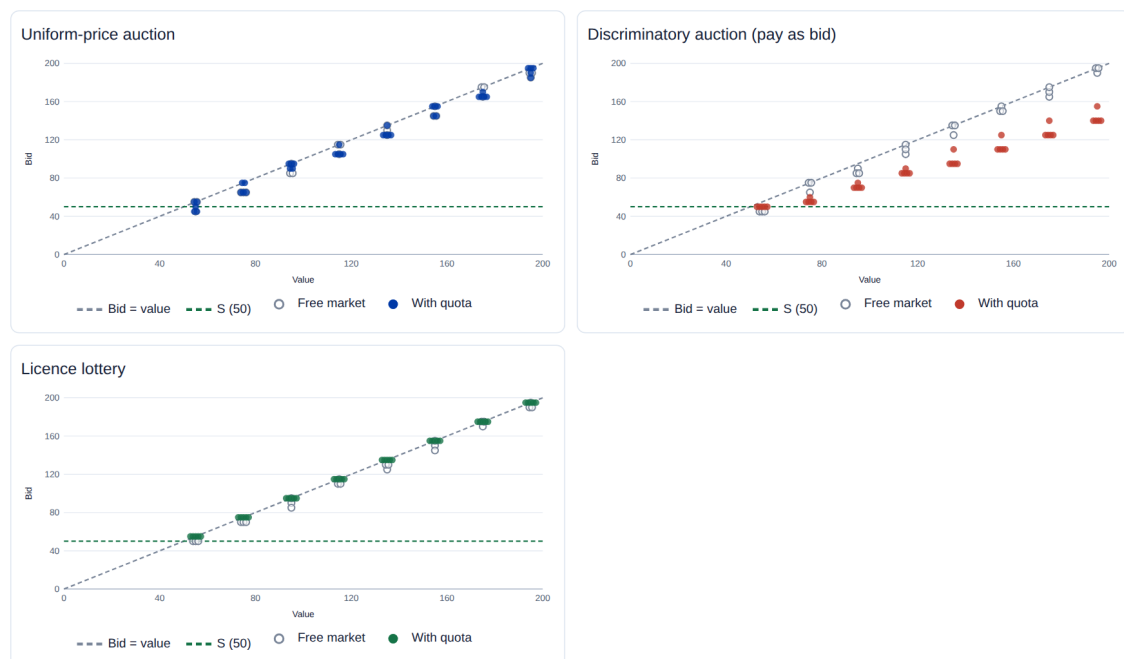
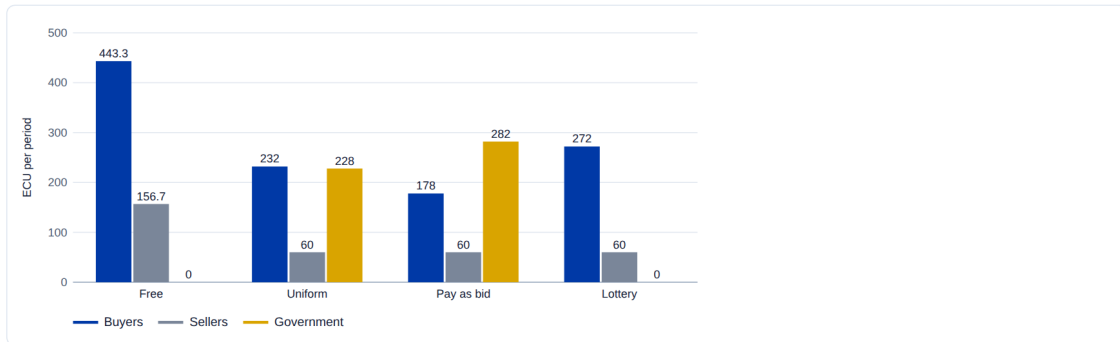


Figure 7.13: Bids against values, one chart per rule: rings in the free periods, coloured dots under the quota (simulated decisions).

Who gets the surplus?

Average per group and period. Under the quota, the rent (the gap between what buyers pay and what sellers receive) goes to the government in the auctions and to the buyers drawn in the lottery.



Who gets the units?

Average per group and period: the sum of the values of the buyers who bought against the sum of the group's Q highest values (those of the free quantity in the free market). The gap is value lost because someone with a lower value bought, or because fewer units were sold. The lottery does not reward whoever values the unit most.

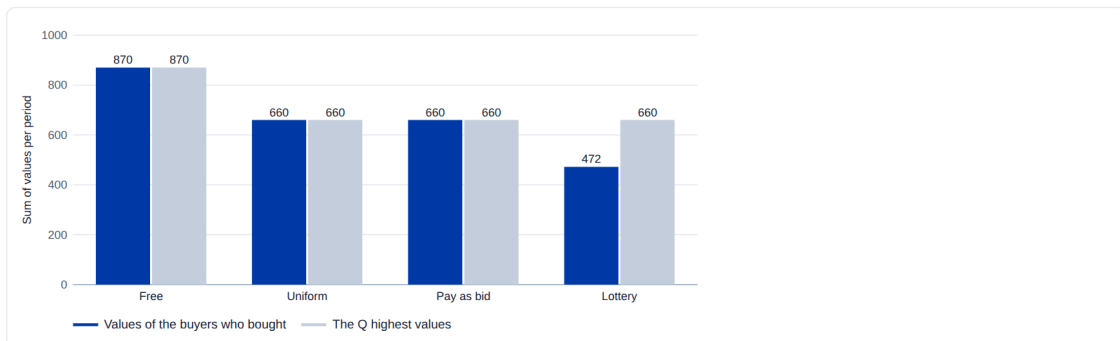


Figure 7.14: Who gets the surplus and who gets the units, by rule (simulated decisions).

Average price paid by period

One line per rule. Dashed lines (group of 8): midpoint of the free band, demand price at Q , and S .



Efficiency by period

Dashed line: the highest efficiency possible under the quota (group of 8).

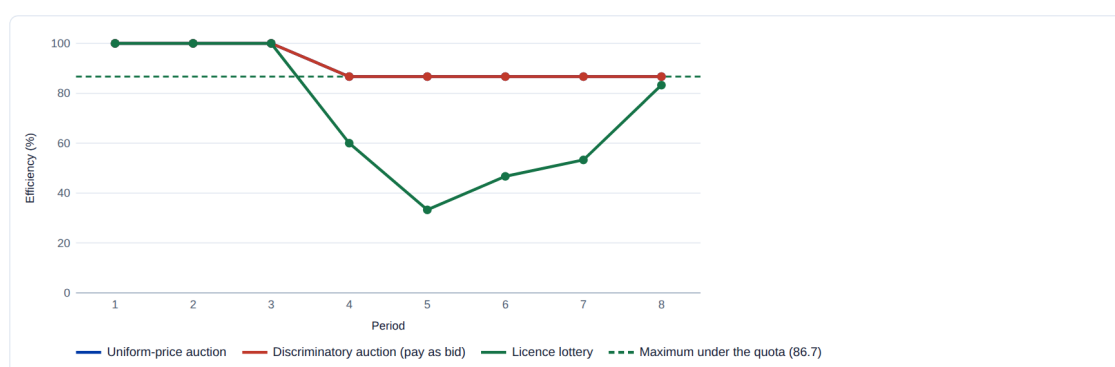


Figure 7.15: Average price paid and efficiency by period, one line per rule (simulated decisions).

1. **Design:** for each group, the free quantity and price band, the quota Q , what sellers receive (S), the demand price at Q and the rent per unit.
2. **Results by rule:** price paid, units, efficiency, the share of winners whose value is among the Q highest, misallocated units, and the split of the surplus between buyers, sellers and the government.
3. **Each period, group by group:** choose the group (in a mixed session, one per rule) and the period with the buttons. The dark steps are the group's values and the orange steps the automated sellers' costs; each bid is a dot in the column of its bidder's value. Each unit sold is a stacked bar: dark grey, the seller's gain; gold, what was paid above S (the rent collected by the government); blue, the buyer's gain. Light grey is the maximum surplus with Q units: if it is left visible, surplus was lost; a bar to the right of the Q line is a unit won by someone with a lower value. Compare the three groups in the same period: with a uniform price bids are close to values and the rent goes to the government; when everyone pays their bid, bids drop; with a lottery there is no gold and the allocation is random.
4. **Bids against values:** the classic chart of auction experiments. On the diagonal the bid equals the value; under pay-as-bid the dots fall below it (bid shading).
5. **Who gets the surplus and the units:** in the two auctions the rent shows up as government revenue; in the lottery it stays with the buyers drawn. Sellers get the same in all three. The second chart compares the values of the buyers who bought with the Q highest values: the gap is value lost to misallocation.
6. **Bids as a percentage of value, price and efficiency by period, and the per-group,**

per-period table: in the table, buyers + sellers + government = values of the buyers who bought – costs of the units sold.

7.5 Theory and evidence

7.5.1 Benchmarks of the extended market

In a group of 8 the values, from the highest down, are $v_k = 195, 175, \dots, 55$ ($v_k = 215 - 20k$) and the costs of the nine automated sellers, from the lowest up, $c_k = 20, 30, \dots, 100$ ($c_k = 10 + 10k$). With the notation of Chapter 5:

- **Free market.** $v_6 = 95 \geq c_6 = 70$ but $v_7 = 75 < c_7 = 80$, so $q^* = 6$, the clearing band is $[\max(c_6, v_7), \min(v_6, c_7)] = [75, 80]$ and $W^* = 175 + 145 + 115 + 85 + 55 + 25 = 600$. With bids equal to values the call market sells 6 units at $\max(c_6, v_7) = 75$: buyers earn $870 - 6 \times 75 = 420$ and sellers $6 \times 75 - 270 = 180$.
- **Quota.** $Q = q^* - 2 = 4$ units, sold by the four cheapest sellers at $S = c_4 = 50$. The demand price at Q is the band $[\max(v_5, c_4), v_4] = [115, 135]$, midpoint 125, so the report's rent per unit is $125 - S = 75$ (300 per period). With efficient allocation, $W_Q = \sum_{k \leq 4} (v_k - c_k) = 660 - 140 = 520$ (86.7% of W^*), and the DWL is $W^* - W_Q = (115 - 60) + (95 - 70) = 80$.

Groups with more than 8 buyers repeat the value ladder, so their benchmarks change (with 10 buyers, for instance, $q^* = 8$, $Q = 6$, $S = 70$, $W^* = 800$ and $W_Q = 760$); the design table of the report shows those of each group. The rest of this section uses a group of 8.

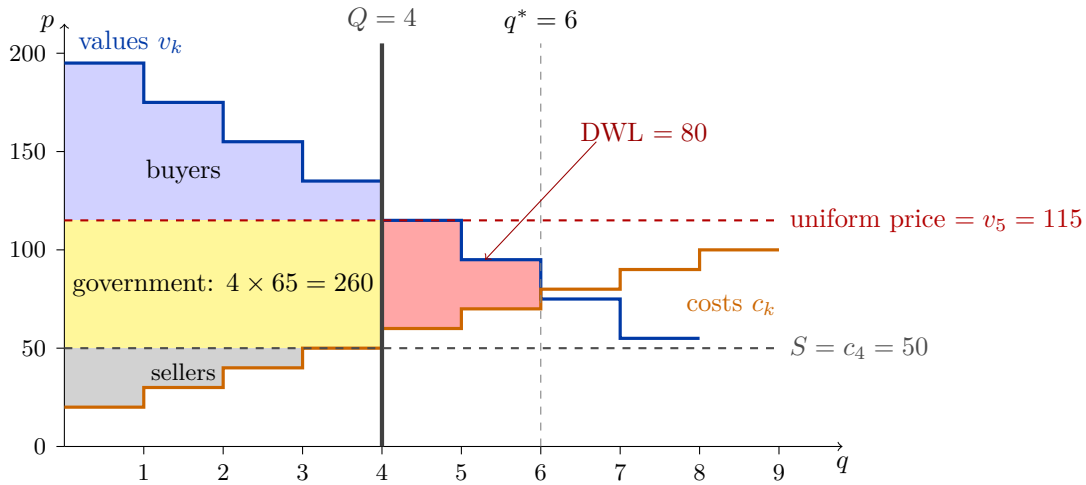


Figure 7.16: Extended version, a group of 8 under the quota with the uniform-price rule and bids equal to values. Blue: buyers' surplus (200); yellow: government revenue, what the four winners pay above S (260); grey: sellers' surplus (60); red: deadweight loss of units 5 and 6 (80).

7.5.2 Uniform price: bidding one's value is dominant

Consider a buyer with value v and let B be the Q -th highest bid among the *other* buyers. Under the uniform rule the buyer wins if her bid b is at least S and above B , and then pays

$$p = \max(S, B),$$

the highest losing bid or S : a price that does *not* depend on her own bid (Vickrey, 1961). Her bid only decides *whether* she wins at that price. If $v > \max(S, B)$, any winning bid earns the same

$v - p > 0$, and bidding below $\max(S, B)$ only throws that profit away; if $v < \max(S, B)$, winning would mean a loss, and bidding v avoids it. Bidding $b = v$ is therefore weakly dominant (the game does not allow bids above the value, so the overbidding often seen in second-price auctions is ruled out). The same argument applies to the free-market call market, where the price is the highest rejected bid or the marginal cost.¹

With bids equal to values, the four highest values win and pay $v_5 = 115$, the *bottom* of the demand band: the government collects $4 \times (115 - 50) = 260$, buyers keep $660 - 460 = 200$, sellers get $4 \times 50 - 140 = 60$, and the total, 520, is the maximum possible under the quota. Of the 300 of rent (measured at the midpoint 125), the auction transfers 260 to the government and leaves 40 with the winners.

7.5.3 Pay as bid: bid shading

When each winner pays her own bid, bidding one's value guarantees zero earnings. A buyer who bids b wins with some probability $\pi(b)$, increasing in b , and expects

$$U(b) = (v - b) \pi(b), \quad \text{so at the best bid} \quad (v - b^*) \pi'(b^*) = \pi(b^*).$$

Raising the bid by one ECU raises the chance of winning (worth $v - b$ each time it makes the difference) but costs one ECU in every case in which she would have won anyway: the optimal bid balances the two, and it is *below* the value. In the textbook model (values independent and drawn from the same distribution, risk-neutral bidders, one unit each, a symmetric equilibrium), the equilibrium bid is

$$\beta(v) = \mathbb{E}[\max(S, Y_Q) \mid Y_Q < v],$$

where Y_Q is the Q -th highest value among the other $n - 1$ buyers (Krishna, 2010). The highest values win in both auctions and each winner pays, on average, what she would pay in the uniform auction, $\max(S, Y_Q)$: this is **revenue equivalence**. It is a benchmark, not a prediction for the class: the theorem needs all of those assumptions.

The game departs from them in a way that helps intuition: the values are the same ladder reshuffled every period, so the highest value that does not win is always $v_5 = 115$. If those who cannot win bid their values, a buyer in the top four only needs to bid just above 115: with integer bids, each winner bids 116, the government collects $4 \times 66 = 264$, winners keep 196, and efficiency is still 86.7%, practically the uniform-price outcome. Students do not know the ladder at first, but the table of bids they see after each period lets them learn it. Two deviations matter in practice:

- **Uneven shading misallocates units.** If the buyer with 135 bids 100 and the one with 115 bids 110, the unit goes to the 115: each such swap destroys $135 - 115 = 20$ ECU of surplus. The uniform auction cannot produce this if bids equal values.
- **Risk aversion raises bids.** A risk-averse buyer shades less, because losing a unit hurts more than overpaying a little; then pay-as-bid revenue exceeds that of the uniform auction.

7.5.4 Lottery: the rent goes to the lucky

In the lottery every bid of at least S has the same chance and the winners pay S : bidding anything at or above S is weakly dominant for a buyer with $v \geq S$, and the size of the bid above S is irrelevant. In a group of 8 all values are at least 55, so all $n_E = 8$ buyers are eligible and the four

¹We checked both rules with the game's own clearing functions on thousands of random profiles of the other bids: no bid ever earned more than bidding one's value.

winners are random. With $\bar{v}_E$ the average eligible value,

$$\mathbb{E}[W^{\text{lottery}}] = Q \bar{v}_E - \sum_{k=1}^Q c_k = 4 \times 125 - 140 = 360 \quad (60\%),$$

$$W^* - \mathbb{E}[W^{\text{lottery}}] = \underbrace{W^* - W_Q}_{\text{DWL} = 80} + \underbrace{\sum_{k=1}^Q v_k - Q \bar{v}_E}_{\text{misallocation} = 660 - 500 = 160} = 240.$$

Buyers expect $Q(\bar{v}_E - S) = 300$, sellers 60 and the government nothing. On average $Q(n_E - Q)/n_E = 2$ of the 4 units go to buyers outside the four highest values, so only half of the winners are among the Q highest.

Rule (group of 8)	Price	Buyers	Sellers	Government	Efficiency	Misallocated units
Free market, bids = values	75	420	180	0	100 %	0
Uniform price, bids = values	115	200	60	260	86.7 %	0
Pay as bid, winners bid 116	116	196	60	264	86.7 %	0
Pay as bid, bids = values (bound)	135–195	0	60	460	86.7 %	0
Lottery (expected)	50	300	60	0	60.0 %	2

Efficiency as % of the free $W^* = 600$, as in the report. The row with bids equal to values under pay-as-bid is a bound: buyers would earn nothing.

7.5.5 Reading the extended report against the theory

- **Results by rule:** compare efficiency with 86.7 % (both auctions) and 60 % (lottery); “winners among the Q highest values” with 100 % and 50 %; misallocated units with 0 and 2 per group-period; government revenue with about 260 in the auctions and 0 in the lottery.
- **Each period, group by group:** the gold part of the bars is the rent the government collects (about 4×65 in the uniform group); blue bars to the right of the Q line are misallocated units, frequent in the lottery and, with uneven shading, possible in the pay-as-bid group.
- **Bids against values:** under the uniform rule, dots on or just below the diagonal; under pay-as-bid, dots well below it, and in theory a flat line near 116 for the four highest values (116 is 59 % of 195); in the lottery, any bid of at least 50 is as good as another, so the dots say little about values.
- **Who gets the surplus and the units:** sellers earn the same 60 under every rule (as long as the four units are sold); the rent moves between the government (auctions) and the lucky buyers (lottery). The values of the winners are 660 under efficient allocation and 500 on average with the lottery.

7.5.6 Experimental evidence

The comparison between discriminatory and uniform-price sealed-bid auctions was one of the first questions taken to the lab: [Smith \(1967\)](#) compared them, motivated by the debate on how the U.S. Treasury should sell its bills. In single-unit auctions with private values, [Kagel \(1995\)](#) surveys two robust regularities: in first-price (pay-as-bid) auctions bids are usually above the risk-neutral prediction, which is consistent with risk aversion, and in second-price auctions many bidders bid above their value instead of following the dominant strategy. In this game bids cannot exceed the value, so the second error is ruled out by design. [Goeree et al. \(2010\)](#) offer experimental evidence

on auctions as a way to allocate permits, and [Holt \(2019\)](#) discusses multi-unit auctions in the classroom.

Debrief script

Ask a winner from each group what they paid. Why did the pay-as-bid group bid below their values, and how far below? Then reveal the surplus split: where did the 75 ECU per unit of rent go in each group? Close with policy: should a government auction import licences, give them to firms, or draw them by lottery? Which option is equivalent to a tariff?

Lesson plan and reading the results

8.1 Suggested 50-minute session (basic version)

0–5 min	Create the session (market-wide quota or licences). Students join via QR or link.
5–12 min	Instructions and comprehension check.
12–22 min	Periods 1 to 3, no restriction. After period 3 you may reveal the report and ask for predictions.
22–37 min	Announcement and periods 4 to 8.
37–50 min	Reveal: price, trades and the rent; close with the policy discussion.

For the extended version, use the mixed configuration: 5 minutes to join, 7 for instructions, 15 for the 8 periods and 15 for discussion.

8.2 Questions to guide the discussion

- Why did the price rise if no cost changed?
- Who earned more with the quota than without it? Who lost?
- Under the market-wide quota, who managed to trade: the buyers with the highest values and the sellers with the lowest costs?
- With licences, would a seller without a licence pay to get one? How much?
- A tariff and a quota can give the same price; why might a government prefer one or the other?
- (Extended) Why bid below your value in the pay-as-bid auction? Who keeps the rent in the lottery?

8.3 Common misreadings

Misreading	Clarification
“A quota protects consumers.”	It raises the price buyers pay: some buyers are left out and those who buy pay more.
“The higher price means higher costs.”	Costs did not change; the gap between price and the marginal cost is the quota rent.
“Whoever gets a licence did something productive.”	The rent comes from the restriction, not from lower costs; with random licences, some holders have high costs.
“Auctioning licences raises the price.”	With the same quota the price buyers pay is about the same; the auction changes who keeps the rent.

Operations, privacy and troubleshooting

9.1 Privacy and conduct

Participant codes are anonymous: do not ask for or show names alongside individual decisions. Project aggregate results only.

9.2 Common issues

Situation	What to do
A student sees “The session is full”.	Close the room and create another session with the correct number.
The market keeps waiting.	Someone did not move on; ask them to reopen the room or use Advance slowest participants .
The quota filled early and many seconds remain.	Use Advance slowest participants in the Monitor to close the period.
A seller complains they cannot trade.	In the licence treatment, sellers without a licence cannot sell from period 4 on: that is the rule.
(Extended) A group keeps waiting for one bid.	Use Advance slowest participants : a missing bid counts as 0 (no purchase).

9.3 Data for later analysis

Data → **Custom export** downloads, in the basic version (**quota_controls**), one row per person and period: treatment, whether the quota applied and its size, role, rank, value or cost, licence, whether they traded, the order and second of their trade within the period, price, the counterpart’s value or cost, earnings and how many bids or asks they sent with each status; after a blank row, every bid and ask submitted, in order, with its status (**ok**; **quota_full**, refused because the quota was full; **unlicensed**, from a seller without a licence; **invalid**, did not improve the standing offer or implied a loss). In the extended version (**quota_auction**), one row per person and period: group, rule, quota, S , value and its rank in the group, bid, whether they bought, price paid, earnings, and the group’s units, price, what sellers receive, surpluses and government revenue. No personal identifiers are included.

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QR codes for each room

English, basic



quotacontrols.beer-lab.org/room/quota_controls_en

English, extended



quotacontrols.beer-lab.org/room/quota_controls_extended

Spanish, basic



quotacontrols.beer-lab.org/room/quota_controls_es

Spanish, extended



quotacontrols.beer-lab.org/room/quota_controls_extendido