



Instructor guide to economic growth and capital accumulation

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 the preparation, implementation, and classroom discussion of the Economic Growth and Capital Accumulation family at the Behavioral and Experimental Economics Research Lab (BEER Lab), Department of Economics, Tecnológico de Monterrey.

It assumes no previous experience with oTree, growth experiments, or laboratory teaching. Common procedures are explained once.

Treatment profiles then identify only what changes. The English and Spanish configurations use one application and the same economic parameters, so language does not alter the design.

Author

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For the instructor

The guide follows the English interface. Spanish configurations reproduce the same mechanics. Project only aggregate results; never connect participant codes to names, student numbers, seats, or public comments.

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Quick implementation guide

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.

económico — una decisión	Crecimiento económico y acumulación de capital / Economic Growth and Capital Accumulation — BEER Lab Seleccione una variante de este juego. Select a version of this game.
económico — 10 periodos, capital inicial bajo	
económico — 10 periodos, capital inicial alto	
rowth — one decision	
rowth — 10 periods, low initial capital	
rowth — 10 periods, high initial capital	
económico extendido — referencia	
económico extendido — alta depreciación	
económico extendido — crecimiento poblacional	
económico extendido — salto de productividad	
económico extendido — destrucción de capital	
económico extendido — trampa de bajo capital	
económico extendido — tecnología AK	
económico extendido — información de regla de oro	
conomic Growth — benchmark	
conomic Growth — high depreciation	
conomic Growth — population growth	
conomic Growth — productivity takeoff	
conomic Growth — capital destruction	
conomic Growth — low-capital trap	
conomic Growth — AK technology	
conomic Growth — golden-rule information	

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

Rooms

Current rooms:

[ES] Crecimiento económico y acumulación de capital
[EN] Economic Growth and Capital Accumulation
[ES] Crecimiento económico y acumulación: extendido
[EN] Economic Growth and Capital Accumulation: extended

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

Room: [EN] Economic Growth and Capital Accumulation

Create a new session

Session Config

[EN] Economic Growth — one decision

Number of participants

Individual decisions: any positive participant count is allowed.

Create

[Configure session](#) 

App sequence

economic_growth_game (10 rounds)

Participants choose saving rates and observe consumption, investment, capital accumulation, and long-run benchmarks.

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.

1.2 Basic facts

Purpose	Understand how saving turns current output into investment, how investment changes future capital, and why an economy faces a tradeoff between current and sustainable consumption.
Experimental unit	One participant manages one independent economy. The descriptive unit is the economy-period; repeated decisions by one person are not independent replications.
Basic edition	One decision; ten periods with low initial capital; or ten periods with high initial capital.

Extended edition	Benchmark, high depreciation, population growth, productivity takeoff, capital destruction, low-capital trap, AK technology, and golden-rule information.
Decision	Choose a saving rate between 0 and 80 percent of output in every period.
Outcome	Consumption, investment, next-period capital, capital growth, sustainable consumption, and a pedagogical score in ECU.
Topics	economic growth; capital accumulation; saving; steady state; productivity.
JEL	A22; C91; E22; O41.
Suggested duration	20–30 minutes for one decision; 45–65 minutes for ten periods; 80–100 minutes for a treatment comparison.
Participants	Any positive number; each participant manages one independent economy.

1.3 Routes and timing

The institutional route begins at beer-lab.org, continues through teaching.beer-lab.org, and opens the family at economicgrowth.beer-lab.org. Students using the basic English version enter https://economicgrowth.beer-lab.org/room/economic_growth_en; the extended room is https://economicgrowth.beer-lab.org/room/economic_growth_extended. Instructors use <https://economicgrowth.beer-lab.org/demo>.

One decision takes about 20–30 minutes when prediction, instructions, choice, and feedback are included. Ten periods require 45–65 minutes. A comparison between two treatments can fill an 80–100 minute class or two meetings. The task is individual, so attendance need not be a multiple of two or four. Participants create independent economies under common rules, and nobody waits for a partner before receiving a period result.

1.4 Decisions before class

Begin with the learning question. Use one decision to introduce the output–saving–investment–capital flow. Use ten low-capital periods to study convergence from below. Compare low and high initial capital to examine movement from opposite sides of a steady state. Extended treatments isolate depreciation, population dilution, productivity, shocks, non-convexities, endogenous growth, and information about a long-run benchmark.

Choose when theory will be revealed. An inductive sequence collects a saving choice before naming the steady state and uses class trajectories to construct the model. A deductive sequence derives the equations and uses the laboratory as a dynamic application. Both can work. Announcing the golden-rule rate before a benchmark changes the information environment and can turn the choice into compliance with an instructor cue.

Specify the comparison before seeing results. Under high depreciation, a given saving rate supports less capital. Population growth raises the replacement requirement for capital per worker. A productivity takeoff raises output and investable resources beginning in period six. A disaster destroys capital discretely and initiates reconstruction. Written predictions protect the discussion from explanations invented after figures are revealed.

For the instructor

A reliable sequence for a new class is: private saving prediction; one decision; reconstruction of the flow; ten low-capital periods; report kept hidden; vote on the trajectory; reveal; derivation of the steady state; and one high-depreciation or productivity treatment. Do not announce a “correct” saving rate before play.

1.5 Minimum operating sequence

1. Confirm the dedicated host, language, edition, and treatment.
2. Open the selected room from **Rooms**; do not search among other game families.
3. Select the exact configuration and create a session for the students present.
4. Keep **Monitor** and **Report** in separate tabs. Share only the stable room route.
5. Ask participants to read the rules and answer comprehension without talking.
6. During choices, explain units and controls but do not recommend a saving rate.
7. At completion, collect predictions about consumption, terminal capital, and convergence before revealing the report.
8. Read distributions and trajectories first; connect them to equations second.
9. Export data if sections will be compared. Record date, course, configuration, attendance, and incidents.

Checkpoint

Before starting: correct server; four rooms; configuration recorded; participant count correct; room link tested; report hidden; projector free of identifiers; feedback time reserved; backup exercise available; and no obsolete active session in the room.

Access, rooms, and family architecture

2.1 A dedicated instance

The `/demo` page must display exactly 22 economic-growth configurations: six basic and sixteen extended. The `/rooms` page must display four rooms: basic and extended in English and Spanish. Separation prevents a user entering Economic Growth from opening Dictator, Trust, Monetary Policy, or another family. Isolation reduces operational errors, preserves stable routes, and allows production deployments to keep family data in its own database.

English and Spanish configurations run one application. Equations, treatment parameters, and exported variables are identical. Language changes instructions, validation, waiting messages, results, and the instructor report. A shared application makes an economic correction available to both languages at once. Basic and extended rooms remain separate so an introductory instructor does not have to navigate advanced treatments.

Attention

If the host shows other game families, do not create a session by manually searching a large list. The instance was not launched with `GAME_FAMILY=economicgrowth`. Report the deployment problem. Participants must never receive the administrative route or password.

2.2 Basic and extended configurations

The basic room offers three modes. `economic_growth_en_one_decision` isolates the static tradeoff. The low-capital ten-period mode starts at 60; the high-capital mode starts at 260. All use productivity 10, depreciation 10 percent, constant population, and Cobb–Douglas output with exponent 0.35.

The extended room offers eight ten-period treatments. The benchmark reproduces the low-capital basic design. Each remaining treatment changes one mechanism. Do not switch treatments inside a session. If the same students play two versions, the second combines treatment with learning and experience. That sequence can teach comparative dynamics, but it is not a clean treatment comparison without an order discussion.

2.3 Creating, monitoring, and recovering a session

After configuration selection, oTree creates individual participant links and administrative access to Monitor, Data, and Report. The stable room route sends students to the active session. Individual

links support demonstrations and controlled recovery of a closed tab; they should not be projected with names or student numbers. Monitor identifies whether an anonymous participant remains at welcome, instructions, comprehension, decision, result, or completion.

oTree Demo Sessions Rooms Data Server Check Logout

[EN] Economic Growth — 10 periods, low initial capital: session 'hqzqzocx' (demo)

New Links Monitor Data Payments Report Description

Below are temporary links for testing and demonstration. To launch a real study, either create persistent links by setting up a [room](#), or create a session through the [sessions page](#).

Choose one of the following options to play the session:

Combined views

Split-screen view Launch

Grid view Launch

Session-wide testing link

Open the below link in up to 6 browser tabs.

<http://127.0.0.1:8060/join/finomini>

Single-use links

Open each link in its own browser tab.

P1	http://127.0.0.1:8060/initializeParticipant/9ev44ou1
P2	http://127.0.0.1:8060/initializeParticipant/rxa2b6ev
P3	http://127.0.0.1:8060/initializeParticipant/bxtccih1
P4	http://127.0.0.1:8060/initializeParticipant/m8nik6qv
P5	http://127.0.0.1:8060/initializeParticipant/pvwo2dqp
P6	http://127.0.0.1:8060/initializeParticipant/iuy9f9tx

Figure 2.1: Links and administrative tools for a growth session.

Because the activity is individual, a slow participant does not block others. The aggregate report remains hidden until the expected economy-period observations are complete. When somebody leaves, the instructor can wait, restore the link, or interpret a report whose completion count is visible. Never reset the database during class. An old link after a reset can report that a user does not exist; create a new session and distribute the current room route.

Participant journey

3.1 Welcome and laboratory rules

The first screen identifies the BEER Lab in the Department of Economics at Tecnológico de Monterrey. It explains that controlled decisions support learning about economic behavior. Every participant accepts silence, independent choice, careful reading, ECU as the experimental unit, and the hand-raising protocol for questions. These rules limit unintended communication and



BEER LAB

Economy and accumulation

You will manage an experimental economy and decide how to divide its output between consumption and investment.

Purpose of the laboratory

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. Decisions will be analyzed anonymously and in aggregate.

General rules

- Remain silent and do not communicate with other participants.
- Make decisions individually and do not show your screen.
- Read every screen carefully; amounts are expressed in ECU.
- Do not refresh, close, or leave the page during the activity.
- Raise your hand and wait for the instructor if you have a technical problem.

☐ I have read and accept the laboratory rules.

Start

Figure 3.1: Institutional cover and acceptance of laboratory rules.

Silence does not remove discussion from the class. It separates the choice stage from the interpretation stage. During play, a comment about a saving rate can become a common recommendation and suppress the heterogeneity the report is designed to reveal. During feedback, heterogeneity

becomes evidence for discussion.

3.2 Instructions and visible relationships

Instructions assign each participant the management of one economy. The screen presents a sequence: available capital produces output; part is consumed; part is saved and invested; some capital depreciates; and investment plus undepreciated capital determines next-period capital. It also displays the three equations used by the program and the scoring rule.

The participant chooses a percentage of output rather than investment units. The same rate therefore creates different amounts when output changes. Investment does not disappear; it enters next-period capital. Depreciation is not a penalty for saving; it removes a fraction of the existing stock independently of the chosen rate. The comprehension page tests these distinctions.

The score gives 65 percent weight to current consumption and 35 percent to sustainable consumption capacity associated with next-period capital. This is a transparent teaching device. It is not part of Solow's original model and is not a social-welfare function. It keeps both the current sacrifice and the future consequence visible during a short laboratory horizon.

3.3 Comprehension check

Before the first choice, three questions verify that saving becomes investment, higher depreciation leaves less capital, and the descriptive observation is an economy in a period. Incorrect answers produce feedback and allow another attempt. The instructor should clarify rules without identifying the rate that maximizes a score or the rate associated with a theoretical benchmark.

If many participants miss the same item, pause and give a neutral numerical example. With output 40 and a saving rate of 25 percent, investment is 10 and consumption 30. Do not solve more of the transition than the question requires. One short explanation to the room preserves comparability better than different private hints.

3.4 Saving and investment decision

The decision screen displays period, starting capital, output, productivity, depreciation, and population growth. A slider selects a rate from 0 to 80 percent. Live boxes calculate planned consumption and investment. The participant can inspect the immediate tradeoff before confirmation. English and Spanish use different decimal presentation but identical numerical logic.

The capital icon makes a stock salient while output, consumption, and investment are period flows. Labels distinguish starting capital from next-period capital. This prevents the common error of adding capital and output as though they were measured in the same way. In a debrief, ask students to classify each displayed variable as stock, flow, parameter, or rate.

3.5 Period result and completion

After confirmation, the program reports saving, consumption, investment, undepreciated capital, next capital, capital growth, sustainable consumption, a long-run reference, and the score. A flow diagram reconstructs the calculation, and a trajectory locates the new capital stock. Participants can verify that the result follows from the selected rate and announced parameters.



Basic version

How the economy works

Resources and unit of account

Your economy's initial capital: 60 capital units. It is a productive stock, distinct from results expressed in ECU.

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

This session does not convert ECU into real money.

You manage an economy over time. At the beginning of each period, you will observe its capital and available output.

Manager of one economy

Your economy is independent. You have no partner, and your outcome does not depend on other participants' decisions.

Sequence in each period

1. Available capital produces goods and services.
2. You choose the percentage of output that is saved and invested.
3. The remaining output is consumed during the period.
4. Part of capital wears out and population may change.
5. Investment and remaining capital determine capital in the next period.

Visible relationships

$$\text{Output} = \text{productivity} \times \text{capital raised to } 0.35$$

$$\text{Investment} = \text{saving rate} \times \text{output}$$

$$\text{Next capital} = (\text{undepreciated capital} + \text{investment}) \div (1 + \text{population growth})$$

ECU score

The score combines 65% of current consumption and 35% of the consumption that accumulated capital could sustain. It recognizes both current living standards and future productive capacity.

Worked example

With capital 100, output 50, and a 30% saving rate, the economy consumes 35 ECU and invests 15 ECU. If depreciation is 10%, next capital is $90 + 15 = 105$.

Session condition: Benchmark with stable productivity and depreciation.

[Continue](#)

Powered by [oTree](#)

Figure 3.2: Current instructions for the basic edition: initial resources, decision rules, and experimental units.

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



Comprehension questions

1. If the saving rate rises, the saved part of output becomes:

- ☐ Investment added to capital
- ☒ Output that disappears
- ☐ Additional depreciation

Your answer: Output that disappears. The correct answer is Investment added to capital. Review your answers: saving finances investment, depreciation reduces remaining capital, and each participant manages an individual economy.

2. A higher depreciation rate, holding everything else constant:

- ☒ Reduces capital carried into the next period
- ☐ Automatically raises output
- ☐ Does not affect accumulation

3. What is the main unit of observation?

- ☒ One individual economy in one period
- ☐ The whole class as one economy
- ☐ A pair of participants

Continue

Powered by [gTree](#)

Figure 3.3: Current comprehension check with an incorrect answer, its specific explanation, and retained responses.

MANAGER OF ONE ECONOMY

Saving and investment decision

Choose the share of output that will be saved and invested. The remainder will be available for current consumption.

Productive conditions remain stable.



Starting capital

60.0

Available productive capital

Output

41.91

Productivity

10.0

Depreciation

10.0%

Population growth

0.0%

Percentage of output to save



Allowed value: 0% to 80%.

Planned consumption
27.24 ECU

Planned investment
14.67 ECU

Continue

Figure 3.4: Basic decision with capital, parameters, and live flow preview.

MANAGER OF ONE ECONOMY

Period outcome

Saving rate

15.0%

Current consumption

35.63

Investment

6.29

Capital after depreciation

60.0 – 6.0

Next capital

60.29

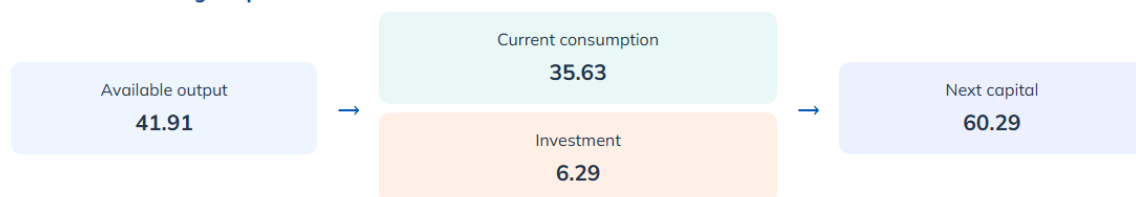
Capital change

0.48%

Benchmark sustainable
consumption
35.95

Period score
35.74 ECU

Resource flow during the period



Output is split between consumption and investment. Investment is added to capital that did not depreciate.

Steady-state capital at this rate

64.47

Golden-rule capital

237.4

Your capital path

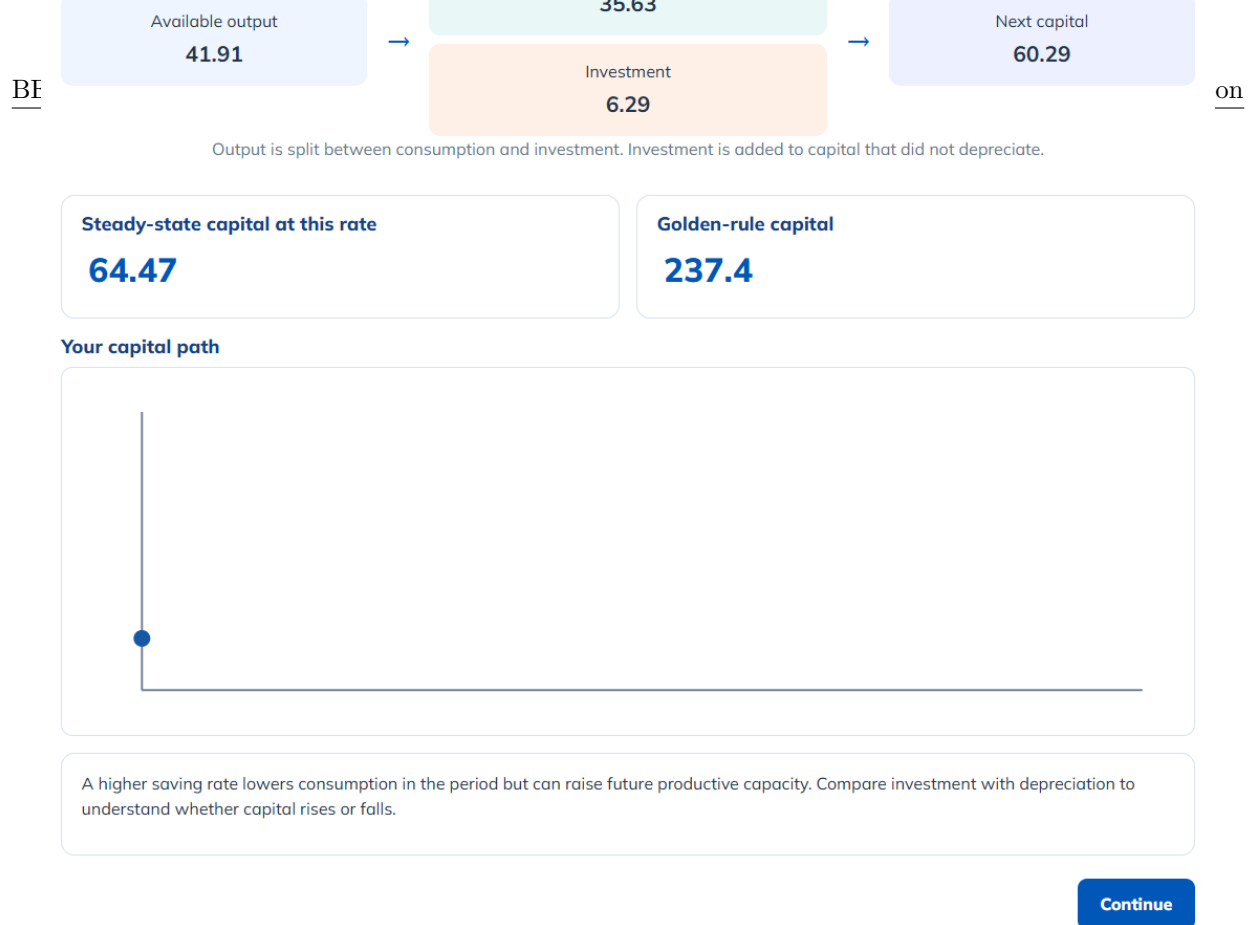


Figure 3.6: Period result and the transition of capital. Continuation 2/2.

In a ten-period session, saving can change. The steady state associated with a period is therefore the reference implied by that period's rate, not an unavoidable endpoint for the full path. When a participant changes saving, the reference also changes. This distinction supports a discussion of constant policies versus adaptive decisions.

The completion page states clearly that the activity has ended and summarizes mean saving, total consumption, total investment, final capital, and accumulated score. Students stay there during instructor feedback. The interface avoids a technical “No more pages left” message and never exposes debug information

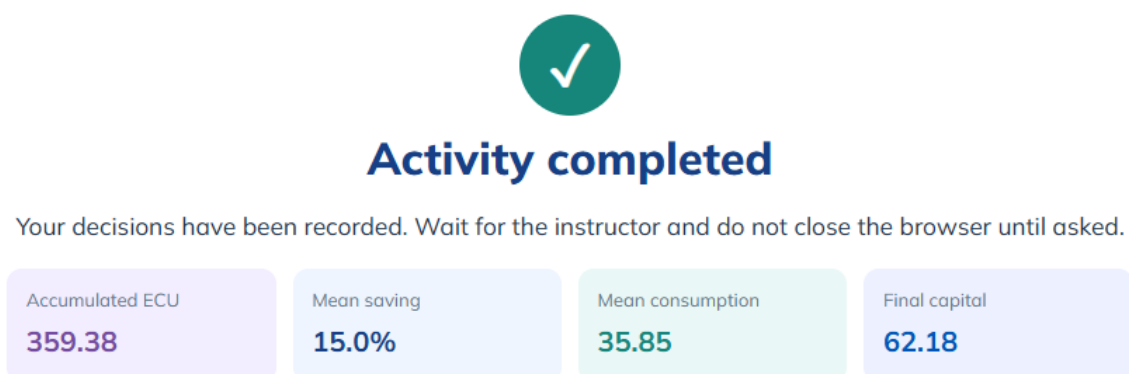


Figure 3.7: Explicit completion page with an individual trajectory summary.

Economic model and predictions

4.1 Production and diminishing returns

The benchmark uses a per-worker production function

$$Y_t = A_t K_t^\alpha, \quad \alpha = 0.35,$$

where K_t is productive capital, A_t productivity, and Y_t output. With $0 < \alpha < 1$, the marginal product of capital is positive and diminishing. More capital raises output, but an additional unit contributes less when the economy already has a large stock. Curvature creates convergence to a finite stock under constant parameters.

Benchmark productivity is 10. At $K = 60$, output is about 41.91. Doubling capital raises output by less than 100 percent. The implication is conditional: holding productivity, saving, depreciation, and population constant, physical returns are higher from a low stock. It does not imply automatic convergence across real countries with different institutions and technologies.

Theoretical foundation

The program represents a simplified per-worker economy. It omits chosen labor, human capital, government, trade, prices, and financial markets. Its pedagogical advantage is an isolated intertemporal transition. Its limitation is that every conclusion depends on what is held fixed.

4.2 Saving, consumption, and investment

The participant chooses s_t between 0 and 0.80. Investment and consumption are

$$I_t = s_t Y_t, \quad C_t = (1 - s_t) Y_t.$$

Within the period, a higher rate reduces consumption and increases investment dollar for dollar. The accounting identity does not determine the preferred rate. Evaluation requires comparing current sacrifice with future capital and future consumption.

Saving is assumed to become productive investment immediately. The game omits hoarding, banking frictions, default, misallocation, and unproductive projects. This assumption keeps attention on accumulation. When applying the model to a real economy, the instructor should reintroduce institutions that connect household saving to productive capital.

4.3 Law of motion

With depreciation δ and population growth n , capital per worker follows

$$K_{t+1} = \frac{(1 - \delta)K_t + s_t A_t K_t^\alpha}{1 + n}.$$

The first component retains undepreciated capital; the second adds investment; the denominator spreads the stock over a larger population. With $n = 0$, capital grows when investment exceeds depreciation. With population growth, replacement investment is approximately $(\delta + n)K$ in per-worker terms.

The screen reports $(K_{t+1}/K_t - 1)100$ as capital growth. It can be positive while output growth slows, or negative after a shock. It is not aggregate GDP growth when population changes. The interface uses the shorter label “capital,” while the economic interpretation is capital per worker.

4.4 Steady state

For constant s , A , δ , and n under Cobb–Douglas, the steady state satisfies

$$sAK^\alpha = (\delta + n)K,$$

and, for positive saving,

$$K^* = \left(\frac{sA}{\delta + n} \right)^{\frac{1}{1-\alpha}}.$$

Below K^* , investment exceeds replacement and capital rises. Above it, replacement exceeds investment and capital falls. A steady state means no growth in capital per worker, not zero production, investment, or consumption. Investment remains necessary to replace depreciation and dilution.

A higher saving rate raises steady-state capital, but it does not guarantee higher steady-state consumption. Initially, saving cuts consumption. Over time, additional capital raises output. Beyond a point, maintaining the larger stock absorbs so much replacement investment that sustainable consumption falls. This non-monotonicity motivates the golden rule.

4.5 Golden rule

Sustainable consumption at capital K is

$$c(K) = AK^\alpha - (\delta + n)K.$$

The golden-rule stock maximizes this expression. The condition $\alpha AK^{\alpha-1} = \delta + n$ equates the marginal product of capital to effective replacement. Under Cobb–Douglas, the corresponding saving rate is $s = \alpha = 0.35$. The information treatment displays the capital and consumption reference implied by current parameters.

The golden rule is not a universal policy command. It maximizes steady-state consumption and omits discounting, inequality, risk, transition costs, and the welfare of specific generations. An economy below it must sacrifice current consumption to accumulate. An economy above it may raise present and future consumption by decumulating under particular conditions. The activity exposes this distinction without treating 35 percent as general advice.

4.6 Pedagogical score

The period score is

$$\text{score}_t = 0.65C_t + 0.35 [A_t K_{t+1}^\alpha - (\delta + n)K_{t+1}] ,$$

bounded between 0 and 100 ECU. The first term rewards current consumption. The second approximates sustainable-consumption capacity supported by next capital. The weights keep both horizons salient within a short experiment.

The score is not a microfounded intertemporal utility function. A Ramsey–Cass–Koopmans planner maximizes a discounted stream of utility over a long or infinite horizon. The score instead offers transparent immediate feedback. Instructors should separate the law of motion, which follows the growth model, from the evaluation rule, which is a teaching adaptation.

4.7 Worked example

Let $K_1 = 60$, $A = 10$, $\alpha = 0.35$, $\delta = 0.10$, $n = 0$, and saving be 35 percent. Output is $10(60)^{0.35} \approx 41.91$. Investment is 14.67 and consumption 27.24. Six units depreciate. Therefore,

$$K_2 = 60 - 6 + 14.67 = 68.67.$$

Capital grows about 14.45 percent. Next-period output is larger, but proportionally less than the stock increase because of diminishing returns.

At 10 percent saving, current consumption rises to 37.72, investment falls to 4.19, and $K_2 = 58.19$. At 70 percent, consumption falls to 12.57, investment rises to 29.34, and $K_2 = 83.34$. Maximizing one-period consumption, stock growth, or sustainable consumption therefore represents three different objectives.

Theory and experimental evidence

5.1 Solow and Swan

The models of [Solow \(1956\)](#) and [Swan \(1956\)](#) organize growth around accumulation, diminishing returns, technical progress, and population. With an exogenous saving rate, capital per worker converges to a steady state. Differences in saving, depreciation, population growth, and productivity generate different income levels. In the standard model, sustained per-worker output growth ultimately requires technological progress.

The laboratory preserves the central transition while turning the saving rate into a decision. Participants can experience the current cost and future consequence of accumulation. The activity does not estimate a country's saving rate or test every growth mechanism. Ten periods compress hypothetical decades and omit many expectations, institutions, and distributional conflicts.

5.2 Ramsey, Cass, and Koopmans

In [Ramsey \(1928\)](#), as developed by [Cass \(1965\)](#) and [Koopmans \(1965\)](#), saving arises from an optimal path of consumption. The Euler condition connects consumption growth to the marginal product of capital, depreciation, impatience, and utility curvature. The decision is a path rather than an isolated percentage.

Repeated choices in the laboratory preserve the idea of a path while simplifying the objective. Every period reports consumption and sustainability. This makes the task usable before optimal-control methods. In an advanced course, compare the score with a discounted utility sum and ask how impatience or intertemporal substitution would change choices.

5.3 Phelps and the golden rule

[Phelps \(1961\)](#) formalized the comparison of steady states by sustainable consumption. The golden rule identifies possible underaccumulation or overaccumulation. The information treatment reveals the stock and consumption that maximize the measure under current parameters. It does not force imitation; participants may value current consumption or continue exploring.

Dynamic efficiency is not the same as complete optimality. Being below the golden rule does not prove that higher saving is a Pareto improvement for every generation, because transition costs fall on someone. Being above it can make decumulation attractive. Horizons and intergenerational distribution remain central.

5.4 Laboratory evidence

Lei and Noussair (2002) studied an optimal-growth environment under individual planner, collective planner, and decentralized-market institutions. Participants often produced paths related to dynamic predictions, while learning, coordination, and institutional differences also mattered. The BEER Lab design is closest to an individual-manager framing but does not reproduce the asset market or objective function of that study.

The connection is methodological. A dynamic model becomes experimentally tractable when future consequences are visible and incentives are explicit. A finite session also creates an endpoint. Participants may consume more in late periods because no later period remains inside the task. Such behavior does not by itself refute an infinite-horizon prediction; it shows that horizon design changes incentives.

5.5 Plausible behavioral patterns

Participants may save heavily at first and reduce saving as output grows or the endpoint approaches. They may settle near 35 percent, oscillate while exploring, or consume heavily from the beginning. Dispersion is not simply error. It may represent different objectives, learning, attention to the score, a finite horizon, or preference for immediate consumption.

A mean of 35 can describe uniform choices at 35 or polarization between low and high rates. Those patterns have different interpretations. Similar terminal capital may also emerge from different paths. The report therefore combines histograms, period means, trajectories, and a detailed table.

Feedback script

Require three sentences before interpretation: an observable fact, the model mechanism that connects it, and a limitation. Example: “Mean capital rose in every period; investment exceeded replacement; but ten decisions under one score do not represent a national growth path.”

Instructor report and result interpretation

6.1 Predict before revealing

Report opens from the administrative session. While choices remain incomplete, it displays participants, expected decisions, completion, and pending observations, but keeps figures hidden. At completion, the reveal button becomes active. Ask for predictions about mean saving, terminal capital, and convergence before pressing it.

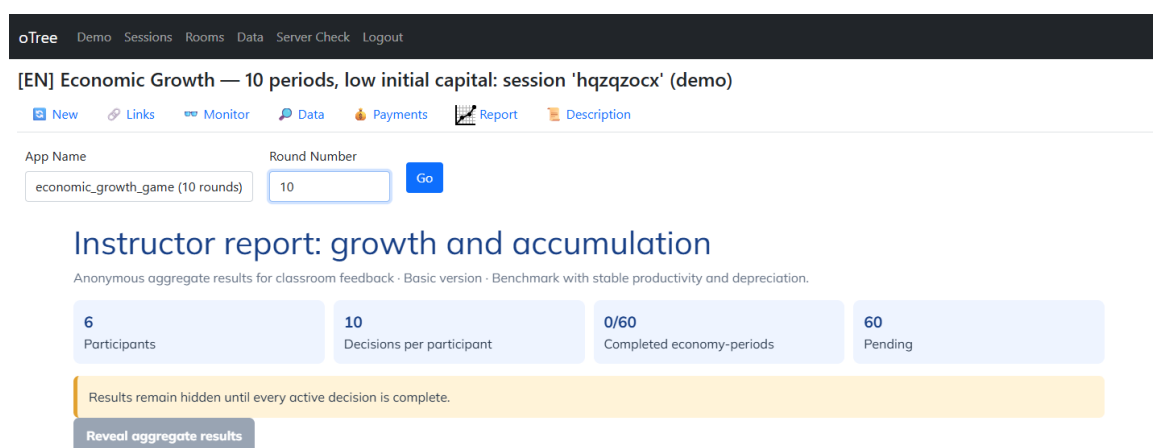


Figure 6.1: Instructor report hidden while predictions are collected.

The revealed report includes seven indicators: mean saving, consumption, investment, capital growth, terminal capital, distance to the golden rule, and score. It shows capital, output, consumption and investment paths; saving and terminal-capital distributions; an investment-replacement diagram; and period details.

6.2 Recommended reading order

Start with the saving distribution. Ask whether choices are concentrated, polarized, or exploratory. Move to consumption and investment by period; they should sum to output up to rounding. Inspect capital and compare it with the golden rule. Use the investment-replacement diagram to locate the steady state associated with mean saving. Finally, use the table to identify when a trajectory changes.

Do not start from score rankings. Doing so can turn the exercise into a contest before the



Figure 6.2: Revealed instructor report with trajectories, distributions, diagram, and table.
Continuation 1/2.



Figure 6.3: Revealed instructor report with trajectories, distributions, diagram, and table.
Continuation 2/2.

mechanism is understood. The score supports a later discussion of incentives and horizons. Do not treat mean terminal capital as the capital of a representative participant either; the average path may correspond to no actual economy.

6.3 The phase diagram

The orange curve is sAK^α at the observed mean saving rate. The blue line is $(\delta + n)K$. Their intersection is the steady state. To the left, investment exceeds replacement and capital rises; to the right, replacement exceeds investment and capital falls. A green line marks terminal capital and a purple line the calculated steady state.

The graph uses mean saving as a summary. When people choose different rates or vary them across periods, it is not the exact path of every economy. It links aggregate observations to the theoretical condition. Under AK technology, the relationship changes and a finite positive intersection may not exist; the report states that limitation.

6.4 Inference and limits

Each participant manages one economy, but ten periods within a person are correlated. Descriptive means and histograms are appropriate for feedback. A treatment comparison should use the participant or session as the independent unit according to assignment rather than every economy-period row. Preserve anonymous identifiers, treatment, and round so analysis can cluster errors or summarize by person.

Assignment matters. If one section receives the benchmark and another high depreciation, time, course, or composition may be confounded with treatment. A stronger comparison randomizes conditions and holds instructions and order constant. An ordinary class need not become a research study, but the instructor should state the limits of the evidence.

Extended-family treatments

All treatments retain the institutional cover, comprehension check, individual-economy structure, ten-period horizon, score explanation, completion page, and anonymous instructor report. Each profile below describes only what changes.

7.1 Diminishing-returns benchmark

Configuration: `economic_growth_extended_baseline`.

Mechanism

The benchmark keeps initial capital at 60, productivity at 10, depreciation at 10 percent, constant population, and Cobb–Douglas output. Every participant decides for ten periods. Saving choices and their accumulated effect on capital are the only sources of change. This configuration reproduces the low-capital basic design inside the extended room and supplies the comparison condition for all other treatments.

Prediction

With a constant positive saving rate, the path approaches its associated steady state. An economy below the reference accumulates; one above it decumulates. Changing saving moves the reference and can create oscillation. Diminishing returns gradually reduce capital growth even while investment remains positive.

Reading the report

Use the histogram to decide whether a mean describes similar choices. Look for a narrowing gap between investment and replacement and a flattening capital path. Compare participants reaching similar stocks through different rates. Ask whether the consumption sacrifice during transition is recovered within ten periods.

Implementation

Use this treatment to introduce the family. Collect one prediction before period one and another before revealing period ten. Do not describe the golden rule as the score solution: the theoretical reference maximizes sustainable consumption, while the score also rewards current consumption.

7.2 High depreciation

Configuration: `economic_growth_extended_high_depreciation`.

Mechanism

Depreciation rises from 10 to 20 percent while all other parameters remain fixed. A larger fraction of the existing stock disappears before investment is added. The change is announced and visible in the dashboard; it is not a surprise. The treatment isolates the distinction between gross and net investment.

Prediction

At every capital level and saving rate, replacement requirements are higher. The steady state and golden-rule stock are lower. A rate that generated accumulation in the benchmark may merely maintain the stock or generate decline. Current consumption does not change mechanically at the first instant, but lower future capital reduces future output.

Reading the report

Compare terminal capital, investment, and distance to the new golden rule. The replacement line is steeper. Identify a rate that changes from positive to negative capital growth. Do not interpret lower capital as lower effort; the environment destroys more of the stock.

Implementation

Run the treatment after the benchmark across groups or with a balanced order. Ask which real technologies and policies reduce depreciation, including maintenance and resilient infrastructure. Distinguish routine depreciation, obsolescence, and a discrete disaster.

7.3 Population growth

Configuration: `economic_growth_extended_population_growth`.

Mechanism

Population grows by 3 percent. Output and capital are interpreted per worker. At the end of the period, the stock is spread over a larger population. The dashboard displays the parameter and the equation retains the denominator $1 + n$.

Prediction

The investment required to maintain capital per worker rises. For a given saving rate, the steady state falls relative to constant population. Aggregate capital could rise while capital per worker falls, but the activity reports the latter. Higher saving can offset dilution at the cost of current consumption.

Reading the report

Inspect effective replacement and compare per-worker capital growth with gross investment. Ask why positive investment does not ensure positive growth of the reported stock. Use the table to find periods in which investment does not cover depreciation and dilution.

Implementation

Confirm that students distinguish aggregate and per-worker variables. Do not frame population growth as inherently harmful; within this model it dilutes capital per worker. Real economies may have scale, composition, innovation, and human-capital effects that are absent.

7.4 Productivity takeoff

Configuration: `economic_growth_extended_productivity_takeoff`.

Mechanism

Productivity begins at 10 and permanently rises to 13 at the start of period six. Capital does not jump; each unit of the existing stock produces more. The screen announces the condition and permits a direct period-five to period-six comparison.

Prediction

With unchanged capital and saving, output, consumption, and investment increase. The investment curve shifts upward and the steady state rises. Capital moves toward a higher reference. Behavioral saving may stay fixed, rise to speed transition, or fall as the participant consumes part of the gain.

Reading the report

First compare output in periods five and six, then saving and investment. Separate the mechanical effect of A from the response. If saving falls while investment rises, productivity more than offsets the percentage reduction. Identify whether the score rose through current consumption, sustainability, or both.

Implementation

You may leave the date of the change unannounced if the goal is response to news, while warning that conditions can change. Use period five as the immediate counterfactual. The treatment connects growth to technology without modeling where innovation comes from.

7.5 Capital destruction

Configuration: `economic_growth_extended_disaster`.



Period 6 of 10

MANAGER OF ONE ECONOMY

Saving and investment decision

Choose the share of output that will be saved and invested. The remainder will be available for current consumption.

A technological improvement raises productivity from this period onward.



Starting capital

101.32

Available productive capital

Output

65.45

Productivity

13.0

Depreciation

10.0%

Population growth

0.0%**Percentage of output to save**

Allowed value: 0% to 80%.

Planned consumption

42.54 ECU

Planned investment

22.91 ECU**Continue**

Figure 7.1: Treatment-specific screen for productivity takeoff.

Mechanism

The economy starts with capital 120. At the beginning of period six, a disaster destroys 35 percent of the stock before production. Productivity, ordinary depreciation, and population remain at benchmark values. This one-time shock differs from permanently high depreciation.

Prediction

Output falls with capital but less than proportionally because the exponent is 0.35. The marginal product of capital rises, so a given saving rate may create faster percentage growth during reconstruction. Returning to the old level takes time and foregone consumption. Convergence to the same steady state does not erase cumulative output loss.

Reading the report

Mark the break between periods five and six. Compare consumption, investment, and percentage growth before and after it. Rapid growth from a low base is not complete recovery. Distinguish level, growth rate, and distance from a no-disaster counterfactual.

Implementation

Use the version to discuss resilience and opportunity cost without mapping student choices onto real victims. A follow-up exercise can calculate the area between observed output and a no-shock reference as a simplified measure of loss.

7.6 Low-capital trap

Configuration: `economic_growth_extended_poverty_trap`.

Mechanism

Productivity is 7 below capital 100 and becomes 11 once the threshold is reached. The discontinuity represents a complementarity or fixed cost such as infrastructure, networks, coordination, or technology that functions only beyond minimum scale. The threshold and current condition are visible.

Prediction

An economy can remain trapped when saving is insufficient to cross 100. Crossing raises output and investable resources, creating a different path. The necessary rate depends on starting capital and earlier decisions. Consuming less today can therefore change the qualitative future, not merely the speed of convergence.

Reading the report

Separate economies that cross from those that do not. A mean can conceal two clusters. Compare the date of crossing, sacrifice, and persistence above the threshold. Ask whether final gaps came

from initial decisions, productive feedback, or both. Do not label current-consumption choices irrational.

Implementation

Present the trap as a hypothetical mechanism rather than an automatic diagnosis of national poverty. Ask what evidence would establish the complementarity. Discuss temporary finance, aid, or coordination as possible responses and state the assumptions each requires.

7.7 AK technology

Configuration: `economic_growth_extended_ak_technology`.

Mechanism

Production becomes $Y = 0.45K$. The marginal product of capital is constant, so diminishing returns are removed. The law of motion is proportional to the stock. The report does not display a finite positive steady state when net accumulation remains positive.

Prediction

With constant population and depreciation 10 percent, capital grows if $0.45s > 0.10$, so saving must exceed about 22.22 percent. Above the threshold, a constant rate can sustain growth; below it, capital declines. Economies with different initial stocks do not mechanically converge to the same level.

Reading the report

Ask whether log capital would follow an approximately linear trend under constant saving. Compare the path with Cobb–Douglas: in AK, the investment-replacement gap is proportional to the stock. A trajectory that does not flatten is an implication of the specification rather than a display error.

Implementation

Use AK only after the steady state is understood. Explain that AK summarizes mechanisms that can offset diminishing returns, such as knowledge or externalities, without identifying them. Derive the saving threshold and test rates on both sides.

7.8 Golden-rule information

Configuration: `economic_growth_extended_golden_rule`.

Mechanism

All benchmark parameters remain unchanged. A box adds the golden-rule capital and sustainable-consumption values. This is an information treatment: it changes neither production nor depreciation nor the law of motion. It separates the effect of knowing a benchmark from a change in incentives.



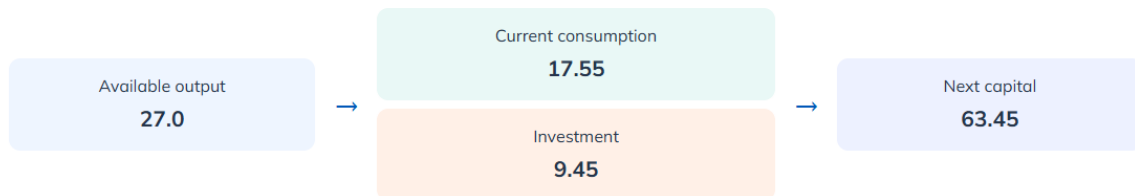
Period 1 of 10

MANAGER OF ONE ECONOMY

Period outcome

Saving rate 35.0%	Current consumption 17.55	Investment 9.45	Capital after depreciation 60.0 – 6.0	Next capital 63.45	Capital change 5.75%
Benchmark sustainable consumption 22.21	Period score 19.18 ECU				

Resource flow during the period



Output is split between consumption and investment. Investment is added to capital that did not depreciate.

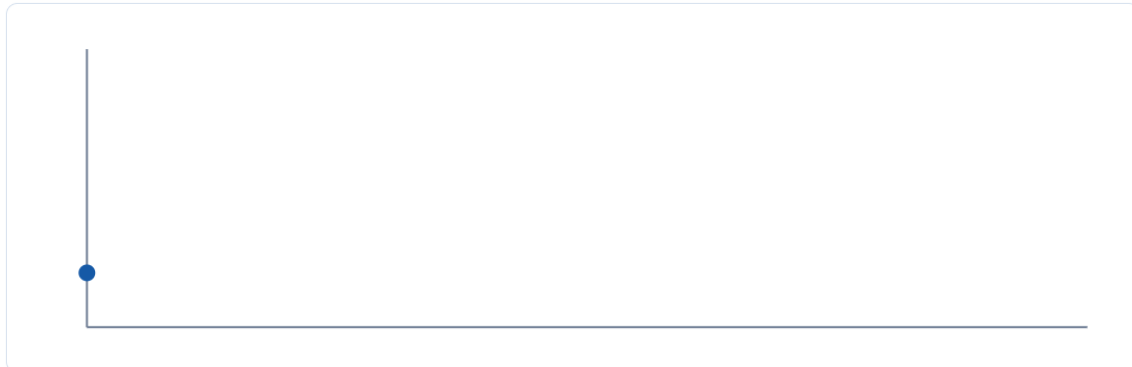
Steady-state capital at this rate

There is no finite steady state under this technology.

Golden-rule capital

There is no finite steady state under this technology.

Your capital path



A higher saving rate lowers consumption in the period but can raise future productive capacity. Compare investment with depreciation to understand whether capital rises or falls.

[Continue](#)

Figure 7.2: Treatment-specific screen for ak technology.

Prediction

Information may concentrate choices near 35 percent but need not do so. The score also values current consumption, the horizon is finite, and participants may explore. Differences from the benchmark can reflect salience, understanding, perceived instructor norms, or belief updating.

Reading the report

Compare distributions rather than only means. Look for bunching exactly at 35 and movement toward the displayed stock. Ask whether participants read the reference as prediction, recommendation, or constraint. A reduction in dispersion is different from a change in the average.

Implementation

Run it after a condition without information or across groups. Do not state that the golden rule maximizes the game score. Ask why sustainable-consumption maximization does not generally maximize discounted welfare or a ten-period score.



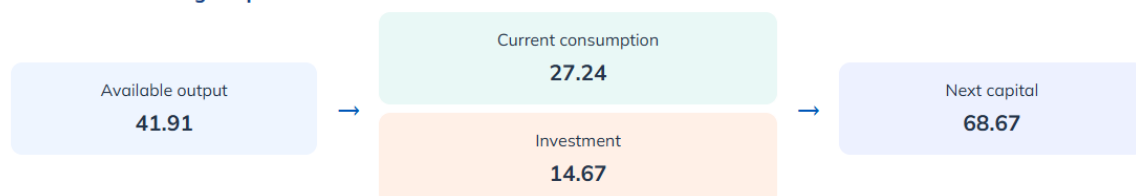
Period 1 of 10

MANAGER OF ONE ECONOMY

Period outcome



Resource flow during the period



Output is split between consumption and investment. Investment is added to capital that did not depreciate.

Figure 7.3: Treatment-specific screen for golden-rule information. Continuation 1/2.

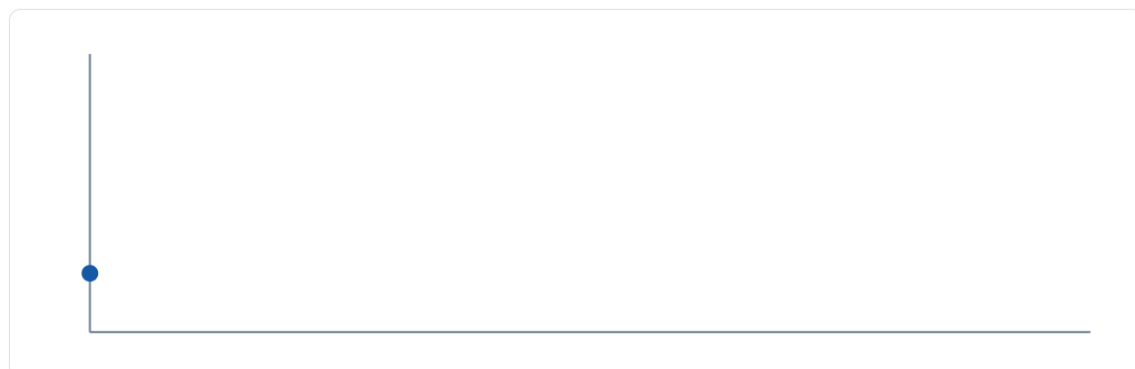
Steady state capital at this rate

237.4

Golden-rule capital

237.4

Your capital path

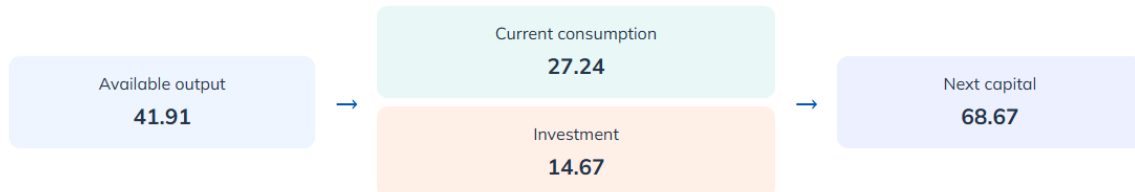


MANAGER OF ONE ECONOMY

Period outcome

Saving rate 35.0%	Current consumption 27.24	Investment 14.67	Capital after depreciation 60.0 – 6.0	Next capital 68.67	Capital change 14.45%
Benchmark sustainable consumption 37.07	Period score 30.68 ECU				

Resource flow during the period



Output is split between consumption and investment. Investment is added to capital that did not depreciate.

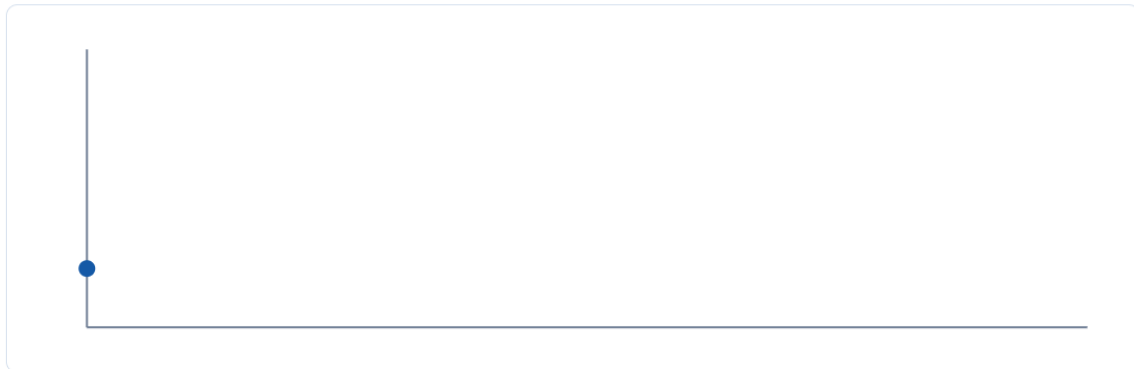
Steady-state capital at this rate

237.4

Golden-rule capital

237.4

Your capital path



A higher saving rate lowers consumption in the period but can raise future productive capacity. Compare investment with depreciation to understand whether capital rises or falls.

[Continue](#)

Figure 7.4: Treatment-specific screen for golden-rule information. Continuation 2/2.

Class plans and extension activities

8.1 A 50-minute plan

During the first five minutes, ask: “What share of output would you consume and invest if investment raises future capacity?” Collect a private answer. Spend ten minutes on welcome, instructions, and comprehension. Run one decision and reconstruct the calculation on the board. Then run ten low-capital periods for fifteen minutes. Reserve the final twenty minutes to keep the report hidden, record predictions, reveal, and derive investment equal to replacement.

The short plan should deliver three distinctions: stocks versus flows, consumption versus investment, and transition versus steady state. Do not attempt poverty traps, AK, and the golden rule in the same short meeting. An exit ticket can request one observed fact, one equation that explains it, and one assumption that limits the inference.

8.2 A 90-minute plan

Use the basic sequence in the first half. After a conceptual pause, assign one extension. High depreciation suits maintenance and infrastructure; population growth clarifies per-worker variables; productivity takeoff introduces technology; disaster introduces reconstruction; the trap introduces complementarities; AK introduces endogenous growth; and golden-rule information introduces salience and normative benchmarks.

Before opening the treatment, students predict the direction of output, consumption, investment, and terminal capital relative to the benchmark. After revealing, complete a table of prediction, result, and explanation. End by asking which variable changed directly and which responded endogenously. This discipline prevents every movement from being attributed to the treatment.

8.3 Low versus high initial capital

Divide the room between identical parameters and different starting stocks. Ask whether paths will converge. Theory predicts movement toward the steady state associated with saving, but saving itself is chosen and may differ. The comparison is conditional convergence: initial conditions shape transition and selected policies also matter.

Use figures to distinguish convergence in levels, growth rates, and distance from a steady state. A low-capital economy can grow faster and remain poorer. A high-capital economy can shrink while sustaining higher consumption. These combinations correct the idea that a high growth rate is a high level.

8.4 Quantitative follow-up

Have students calculate K_{t+1} under three saving rates and check the screen. Fix $s = 0.35$ and solve for K^* . Change δ from 0.10 to 0.20 and find the new steady state. Add $n = 0.03$. Require signs before calculators.

For the golden rule, maximize $AK^{0.35} - (\delta + n)K$ and derive $s = 0.35$. Under AK, derive $s > (\delta + n)/0.45$. For disaster, construct a no-shock counterfactual and calculate cumulative lost output. For the trap, find the investment required to cross the threshold from a stated stock.

What participants will see

Suggested exit question: “Choose one period from your economy. Explain why capital rose or fell, what sacrifice your saving rate required, and what would change with higher depreciation. Use one reported number.”

Discussion and assessment bank

9.1 Conceptual questions

1. Why does positive investment not guarantee capital growth?
2. How do output, consumption, investment, and capital differ?
3. Why do diminishing returns produce convergence under constant parameters?
4. What remains active in a steady state?
5. Why can higher saving raise steady-state capital without always raising sustainable consumption?
6. What exactly does the golden rule maximize, and what does it omit?
7. How does population growth alter replacement requirements?
8. Why is a productivity takeoff different from an immediate capital increase?
9. How does rapid reconstruction growth differ from complete recovery?
10. What mechanism can justify a low-capital trap?
11. Why can AK sustain growth without a finite steady state?
12. What goes wrong if ten periods from one person are treated as ten independent observations?

An excellent answer names the parameter, predicts a direction, uses report evidence, and states a limit. An adequate answer identifies the mechanism with partial evidence. A weak answer lists numbers without connection, calls every rate near 35 optimal, or extrapolates a laboratory session to national economies without discussing assumptions.

9.2 Questions for interpreting data

Does the average represent the distribution? Did two participants with similar terminal capital follow the same path? How much of a period-six change was mechanical and how much behavioral? Did mean saving move before or after consequences became visible? Is terminal capital to the left or right of the steady state in the diagram? Did distance to the golden rule fall because capital changed, the rule changed, or both?

These questions move discussion from description to mechanism. “The class saved a lot” requires a reference: relative to consuming everything, the golden-rule rate, the positive-growth threshold, or another session. Require one comparison sentence and one limitation sentence.

9.3 Short rubric

Score conceptual precision, evidence, causal explanation, and limits. A strong answer distinguishes stocks and flows, cites report values, connects equations to a direction of change, and avoids overinterpretation. A middle answer predicts the sign without explaining the transition. A weak answer confuses a saving rate with investment units or treats the score as social welfare.

Operations, data, and troubleshooting

10.1 Data and reproducibility

The export should preserve session, anonymous code, round, language, edition, treatment, starting capital, productivity, depreciation, population growth, saving, output, investment, consumption, next capital, capital growth, long-run references, score, and completion. Keep a session record with date, course, configuration, participant count, interruptions, and reveal time.

Document treatment order. When each person plays two conditions, account for repeated measures and learning. When whole sections receive different conditions, do not attribute every difference to treatment. Descriptive summaries are enough for teaching. Research requires consent, protocol, assignment, and analysis appropriate to the question.

10.2 Privacy and responsible language

Codes coordinate the platform and should not be publicly linked to names. Project aggregates. Do not use saving choices to label a participant patient, prudent, or irrational. Choice responds to rules, comprehension, horizon, score, and exploration. The design identifies decisions, not complete motives or stable preferences.

When discussing poverty, disasters, or population, avoid moralizing national outcomes. Treatments are abstract mechanisms. Institutions, conflict, health, education, distribution, gender, geography, and politics are omitted. Naming those omissions strengthens rather than weakens the lesson.

10.3 Frequent problems

If a live preview displays “NaN,” the page is mishandling decimal localization; stop and report the version. If somebody sees “Please wait,” inspect Monitor. Individual decisions should not wait for a partner, although the server may be processing or the session may have ended. “No more pages left” means the completion sequence is missing.

If the report is empty, verify complete decisions and press reveal. If bars are absent, verify observations and the current browser version. If Demo or Rooms lists other games, the instance is not isolated. If an old route says the participant does not exist, the database changed and a new session must be distributed.

Attention

Never run `resetdb` or a development server against production during class. Local tests use the isolated economic-growth database on port 8060. Production changes require a backup, no active sessions, and a rollback procedure.

10.4 Closing checklist

Confirm that participants reached the final summary; record pending cases; export when needed; close the active room session; save configuration and treatment; log incidents; and retain only necessary data. Before the next class, test Demo, Rooms, one English session, one Spanish session, and the report. This routine turns an improvised demonstration into reproducible teaching practice.

Deeper teaching notes

11.1 Separating accounting, behavior, and equilibrium

Students often collapse three different statements. The first is an accounting relationship: output is divided between consumption and investment. The second is behavioral: a participant chooses a saving rate in response to information, incentives, and experience. The third is an equilibrium proposition: under constant parameters and a constant rate, investment eventually equals effective replacement. A correct debrief names which type of statement supports each claim. Accounting holds by construction in every completed period. Behavior must be read from choices. Convergence is a conditional prediction that may be interrupted when choices change.

This separation is particularly useful when results appear surprising. Suppose mean capital does not flatten during ten periods. The model may still be working exactly as specified. Starting capital may be far from its steady state, the horizon may be too short, or saving may change every period. The appropriate test is not whether the line looks flat, but whether the sign of capital change agrees with investment minus replacement at the current stock. The detailed table lets the class perform that check.

11.2 Levels, growth rates, and welfare

A second recurring problem is the use of “better” without a criterion. A treatment can produce faster capital growth, lower current consumption, higher terminal production, and a lower accumulated score at the same time. A disaster economy can grow faster after the shock because it starts from a lower stock while remaining below the no-shock level. A high-saving economy can have more capital and less consumption within the observed horizon. Ask students to state whether they compare a level, a rate, a cumulative total, sustainable consumption, or the pedagogical score.

The golden rule supplies one criterion: the steady-state stock that maximizes sustainable consumption. It does not rank every transition. A planner who cares strongly about the current generation may choose a slower transition; a patient planner may accumulate more rapidly. Distribution can matter even when aggregate consumption is unchanged. The laboratory deliberately leaves these normative dimensions open so that the instructor can introduce discounting, utility curvature, intergenerational equity, or social welfare after the mechanics are understood.

11.3 Counterfactual reasoning

Every treatment is most useful when paired with an explicit counterfactual. For high depreciation, ask what the same saving path would have produced under 10 percent depreciation. For population

growth, distinguish capital per worker from a hypothetical aggregate stock. For productivity, compare period six with both period five and a no-takeoff projection. For disaster, continue the period-five path without destruction. For the trap, calculate the path if the threshold did not raise productivity. For information, the appropriate counterfactual is the same environment without the golden-rule box.

The software provides observed outcomes but not every counterfactual automatically. That omission is productive: students must use the equations. A worksheet can assign each group one observed path and ask it to recalculate a single parameter change. Comparing the recalculated path with the treatment result distinguishes the direct mechanical effect from the participant's behavioral response. This is the same logic used in empirical work, expressed in a transparent model.

11.4 Horizon effects and terminal behavior

The session ends after one or ten decisions. A participant who knows the endpoint may save less in the final period because no later production occurs inside the activity. This is a rational response to a finite teaching horizon, even though the score retains a sustainability term. The instructor should inspect the round profile rather than discarding late choices as mistakes. A drop near period ten creates an opportunity to compare finite-horizon backward reasoning with the infinite-horizon language common in growth theory.

Several teaching responses are possible. Keep all periods in the report and discuss the endpoint openly. Select one period at random for payment so every decision might matter, which changes incentives but complicates explanation. Add a continuation probability, which better approximates an indefinite horizon but increases implementation demands. The current family chooses transparency: ten known periods and an explicit score. Any alternative would constitute a different design and should receive its own documentation.

11.5 Connecting the activity to empirical growth

The laboratory supplies a mechanism, not a cross-country growth regression. Empirical convergence is usually studied by relating subsequent growth to initial income while conditioning on saving, population, education, technology, and institutions. Unconditional convergence may fail even when the Solow mechanism is present because countries differ in their steady states. The low-versus-high configurations illustrate convergence only under common parameters and participant choices that may themselves differ.

Use this limitation constructively. Ask students which variables from the experiment would enter a conditional-convergence regression and which important variables are missing. Saving, depreciation, population, productivity, and initial capital are present. Human capital, governance, openness, conflict, health, geography, and measurement error are not. The answer turns a compact laboratory activity into a bridge between theory and applied macroeconomics without claiming that the class has reproduced historical development.

11.6 Extensions for advanced courses

An advanced course can replace the pedagogical score on paper with discounted CRRA utility, $\sum_t \beta^t (C_t^{1-\sigma} - 1)/(1-\sigma)$, and compare the implied path with observed choices. Students can derive the Euler equation, compute a shooting path, or simulate how β and σ alter initial consumption. The oTree data then provide a behavioral path against which to compare the planner solution.

Another extension decomposes the change in output between two periods into a capital contribution and a productivity contribution. With Cobb–Douglas, log differences satisfy approximately $\Delta \ln Y = \Delta \ln A + \alpha \Delta \ln K$. The productivity-takeoff treatment makes both terms visible. A third extension studies dynamic efficiency by comparing the marginal product with depreciation and population growth. These exercises preserve the same interface while raising the analytical level.

References and recommended reading

Foundational sources are [Solow \(1956\)](#) and [Swan \(1956\)](#). The golden rule is developed by [Phelps \(1961\)](#). Intertemporal choice appears in [Ramsey \(1928\)](#), [Cass \(1965\)](#), and [Koopmans \(1965\)](#). [Lei and Noussair \(2002\)](#) provides the closest experimental connection. Macroeconomics and growth texts can extend the discussion to human capital, innovation, institutions, and empirical convergence.

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