



Instructor's Guide to Systematic Risk and Asset Pricing

Laboratory implementation, theoretical foundations,
experimental evidence, and variants

Behavioral and Experimental Economics Research Lab
Department of Economics



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How to use this guide

This guide prepares instructors to teach systematic risk and asset pricing through an eight-person market with joint state payoffs. It assumes no prior experience with classroom experiments and follows the English interface.

Begin with resources and the worked wealth example, then move to returns and beta. Select one institutional comparison and use the report definitions to separate accounting, statistical identities and conditional equilibrium predictions. The Spanish guide covers the same family.

Screenshots show genuine interfaces. Public routes identify the prepared product; the delivery record distinguishes local validation from publication. Existing portfolio, bubble and order-market activities remain available as complementary catalogue families.

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For the instructor

Start with cash, securities and one state. Record a prediction before revealing aggregates. Every metric needs an observation unit, and beta needs positive market variance and observed prices.

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Prices, risk and opportunities for learning

1.1 A question individual portfolio choice leaves open

Combining investments whose payoffs do not move together can reduce variation in personal wealth. This observation explains diversification but leaves a different question: when people trade the same securities, which risk remains in the aggregate and how does it relate to prices? The activity starts where portfolio choice at given prices ends. Eight investors receive different cash and security endowments, see a common payoff table and trade. Orders can change individual portfolios without changing the aggregate number of outstanding securities.

The learning objective is to construct an economically meaningful comparison, rather than to make a perfect straight line appear. The instructor can show why two securities with similar variability can contribute differently to aggregate risk, why supply matters for the definition of the market portfolio, and why a realized gain is different from an expected return. Outcomes support discussion of valuation, equilibrium, financial constraints and information. A single classroom market does not establish or reject an entire asset pricing theory.

The family complements risk and return, diversification and bubble activities in the catalogue. The first studies individual allocation; the second works with correlations and exogenous investment opportunities; the third follows a single asset with dividends and a declining horizon. Here several securities have joint payoffs and traded prices, share one budget, and define a supply value-weighted aggregate portfolio. The activity reuses the laboratory's order-priority mechanism. The economic difference lies in the opportunities and diagnostic, while the familiar trading controls reduce the operational burden.

After class, students should be able to reconstruct wealth from cash and positions, distinguish an order from a transaction, calculate a return in a state, explain beta as a statistical sensitivity to the market portfolio, and identify conditions under which the CAPM relates expected premiums to beta. They should also recognize when the data do not support a calculation. Obtaining an undefined value and explaining why can be a useful learning outcome. Arithmetic correctness, interpretation and identification of assumptions are separate competencies.

1.2 Activity summary

Purpose	Connect state-contingent payoffs, supply-weighted aggregate risk and traded asset prices.
Experimental unit	Eight investors per market; shared cash across three asset books.
Basic edition	One market; ten fixed-group markets; ten reassigned markets.
Extended edition	Twelve reference, information, cost, supply, exposure, short-sale and safe-return conditions.
Decision	Limit or best-price orders, quantity, cancellation and closing participation.
Payoff	Terminal wealth from one randomly selected episode, credited once; cash and securities reset each market.
Topics	systematic risk; asset pricing; beta; market portfolio; equilibrium prices; financial constraints
JEL	A22; C92; D53; G11; G12
Participants	Multiples of eight; minimum sixteen with reassignment.
Suggested duration	75–90 minutes with discussion; repeated comparisons can require 90–120.

1.3 Market organization and resources

The interactive unit consists of eight investors. There is no professional buyer opposite a professional seller and no requirement to trade. Everyone may submit purchase and sale orders subject to resources. Different initial holdings create opportunities to redistribute exposures. Four types occur twice: 800 ECU and four A securities; 500 ECU and four B; 500 ECU and four C; and 500 ECU plus one unit of each security. Aggregate supply is ten units of each asset and initial cash totals 4600 ECU. These endowments are resources, not rewards for correctly predicting a state.

ECU means Experimental Currency Units. Wealth is recorded in that accounting unit without a monetary conversion. Every new market resets cash and securities. Wealth from a previous market does not finance the next one. This separates learning and portfolio composition from mechanical accumulation. At completion, one market is selected with equal probability for each person and its terminal wealth is credited once. Choices remain interdependent within a market even though selection for payment is individual. Endowment differences must be considered before comparing levels of wealth across people.

Cash is the safe asset. It does not grow in the reference condition; in the positive safe return condition it earns two percent at settlement. Cash borrowing is prohibited. Securities settle once using the state drawn for that group and episode. They do not pay intermediate dividends and positions do not carry over. A safe return describes the accounting rule within this activity, without making a claim about real investments. All calculations concern the same episode horizon, which is not converted into an annual rate.

What participants will see

Participants see their effective resources, eight-state payoff table, costs and position limits. The operational heading is Asset Markets. Students receive what they need to act; discussion of beta and the CAPM belongs in the instructor's debrief.

The eight states combine three independent signs, each with probability one half. Call them F, Z, U . Reference payoffs are $X_A = 100 + 20F + 20Z$, $X_B = 100 + 20F - 20Z$ and $X_C = 100 + 40F + 20U$. Each combination has probability one eighth. A and B share exposure to F and opposite exposure to Z . C has greater common exposure and an additional component. The distribution is known while the settlement state is not known during trading. The server does not transmit its state draw to participants before closing the market.

The table lets the instructor begin without factor notation. Read it as eight possible situations with payments in columns. Choose one row and add a portfolio's payoffs; then compare rows and ask which payments change together. Introduce common exposure, specific exposure and aggregate portfolio after students have experienced the choices. A component called specific can remain in aggregate supply. Its name does not automatically make it diversified away. Cancellation is a property of quantities and payoff vectors, not a verbal label.

1.4 Orders and budget restrictions

Each asset has its own book. A limit purchase specifies quantity and the highest acceptable price; a limit sale specifies quantity and the lowest acceptable price. Prices range from 1 to 200 ECU in steps of one ECU. The matching engine gives priority to the best price and then to earlier server arrival. An incoming purchase willing to pay 95 that finds an existing sale at 90 executes at 90. Server arrival determines priority, rather than the time a person believes they pressed a button.

A best-available-price order attempts to trade against available orders and cancels an unfilled remainder. Full execution is not guaranteed. Limit orders may execute partially and leave a pending quantity. Participants can cancel their own open orders, cannot cancel other people's orders, and cannot deliberately cross their own orders. Finish trading cancels the participant's pending orders and moves that person to a waiting page. Previously acquired securities remain in the portfolio until settlement. If everyone finishes, the market closes before the time limit.

All books share cash. With 800 ECU, a pending purchase of five units at 100 reserves 500. Only 300 remains for other purchases, including purchases in another book. Canceling releases the reservation; an execution updates cash and securities at the execution price. Three panels do not create three budgets. The screen distinguishes accounting cash, purchase reservations, short collateral and available cash. Available cash is part of accounting cash, not an additional balance that should be added to it.

The reference permits sales only of securities owned and not committed to another pending sale. The short-sale extension permits a minimum position of minus one unit in each asset. Every potential sale that would leave a negative position requires cash covering that asset's maximum payoff. Collateral includes pending sales as well as executed shorts. This conservative solvency rule is stricter than some real trading institutions. It expands feasible positions without adding cash credit or allowing losses beyond resources. Its economic restrictions should remain visible in interpretation.

Checkpoint

Ask students to compute available cash when an investor has 100 ECU and a pending purchase reserves 60. The answer is 40, neither 100 nor 160. Then check that a pending order changes available resources even before a transaction occurs.

1.5 A complete wealth and settlement example

Take the first investor, who holds 800 ECU and four A securities. The investor buys one B at 95 and one C at 100. Without fees, cash becomes 605 and holdings become four A, one B and one C. If $F = 1, Z = -1, U = 1$, A pays 100, B pays 140 and C pays 160. Terminal wealth is $605 + 4(100) + 140 + 160 = 1305$ ECU. Without trading in the same state, wealth would have been $800 + 4(100) = 1200$. The realized difference of 105 depends on prices and the state.

That difference is neither the return on one asset nor a measure of skill. The endowment includes securities and cash; dividing 1305 by 800 incorrectly treats initial securities as free. Wealth without trading provides an accounting comparison using the same endowment and state. It is not the maximum possible wealth or a recommended strategy. It also does not remove preferences from interpretation: a person may prefer lower variation even at the cost of a lower expected outcome. Realized gains and choices should be discussed separately.

With a fee of one ECU per side per unit, the two purchases cost the buyer two additional ECU. Remaining cash is 603. Each seller also pays its own transaction fee, and the fee account receives four ECU across the two transactions. Buyer wealth is then 1303. Trade prices transfer cash from buyers to sellers; fees move cash to a distinct account; terminal security payments follow the activity's external payoff rule. These sources and transfers must remain separate when reconciling aggregate resources.

If cash earns two percent and no fees apply, 605 becomes 617.10 and terminal wealth is 1317.10 in that state. Securities do not receive an additional two percent: their payments are already in the table. A person short one C receives the sale price during trading but owes one C payment at settlement. A negative holding subtracts that payment from wealth. Collateral provides coverage and does not make the obligation costless. The distinction between collateral, proceeds and liabilities is essential for reading the outcome screen.

From state payoffs to valuation

2.1 Returns and the market portfolio

Prices and payments serve different roles. For an asset bought at $P_j > 0$ and paying $X_j(s)$ in state s , the return is $R_j(s) = X_j(s)/P_j - 1$. If A costs 100 and pays 60 or 140, returns in those states are minus forty or plus forty percent. Expected return averages over all states with their probabilities. It does not select the state realized at settlement. All reference securities have expected payoff 100, but different prices produce different expected returns. Expected payoff equality therefore does not imply expected return equality.

The activity's market portfolio contains the total supply of offered risky securities. Given Q_j units and observed price P_j , its value weight is $w_j = Q_j P_j / \sum_k Q_k P_k$. Weights sum to one and $R_M(s) = \sum_j w_j R_j(s)$. Safe cash is outside this risky supply portfolio, although it enters individual wealth. A simple average of personal returns would combine choices and different quantities and would not reconstruct the value of market supply. Quantities should be taken from initial aggregate holdings, not from the number of submitted orders.

With ten units of each security and price 100 for all, weights are one third. The average unit pays $100 + (80/3)F + (20/3)U$. A and B exposures to Z cancel. U remains because C has positive net supply. This result follows from quantities and payoffs, rather than from a high volume of trading. Trading redistributes who bears risk; the aggregate risk of outstanding securities remains determined by supply. A high-volume market and a no-trade market can have the same aggregate payoff distribution.

2.2 Covariance, beta and the expected premium

Variance measures dispersion around a mean. Covariance measures whether two returns depart from their respective means in the same or opposite directions. Beta divides asset covariance with the aggregate portfolio by that portfolio's variance: $\beta_j = \text{Cov}(R_j, R_M) / \text{Var}(R_M)$. Both numerator and denominator use the same probabilities and return units. Beta has no units. A negative beta indicates a hedge against changes in the defined portfolio, without promising a gain whenever any real market declines.

At prices of 100, market variance is $6800/90000$, approximately 0.07556, and standard deviation is about 27.49 percent. A's covariance with the market is $1600/30000$, approximately 0.05333. Their ratio is $\beta_A = 12/17$, or about 0.706. B has the same beta. C has beta $27/17$, or about 1.588. Their value-weighted average is one: twice $12/51$ plus $27/51$. This equality is an algebraic check on the calculation. It does not establish the CAPM or demonstrate equilibrium pricing.

The expected premium is expected return minus the safe return. Under its equilibrium assumptions,

the CAPM proposes $E[R_j] - r_f = \beta_j(E[R_M] - r_f)$. The report calculates the difference between the two sides in percentage points. It does not call that difference a causal estimate or a statistical test. At prices 100 and a zero safe rate, every expected premium is zero. The relation then holds trivially despite different betas. To discuss positive compensation for risk, compare another price vector and identify the assumptions behind its interpretation.

Theoretical foundation

The CAPM relation requires more than a beta formula. It depends on preferences, beliefs, investment opportunities, access to the safe asset and equilibrium. This class has discrete positions, constraints and a finite group, and does not induce mean–variance preferences. Use the equation as a conditional benchmark with those limits stated.

2.3 What the observations can establish

The diagnostic uses the exact announced eight-state distribution. It does not estimate a regression with ten realized returns. Ten episodes provide few realizations and can share participants. Repetition helps examine learning and price evolution; it does not turn dependent records into a large independent sample. Points represent assets within markets. A treatment comparison involving interaction should identify markets or sessions as its relevant independent units. Participant counts alone cannot establish the precision of a market-level result.

An asset without a transaction has no observed last price. The program does not silently turn 100 ECU into a traded price. If any offered asset lacks an observed price, that market is excluded from the CAPM cloud. The evolution section retains its volume and missing prices. A bid or ask is not an executed price either. A class with little trading can discuss liquidity and disagreement without filling in missing observations to make a complete graph. A hypothetical calculation is acceptable only when clearly separated from observed data.

When aggregate payoff is constant, the market variance denominator is zero. Beta is undefined. Replacing it with zero would confuse absence of an identifiable sensitivity with a valid ratio. The table retains the missing-value mark, while the wealth distribution remains interpretable. Ask how individuals can face risk when total payments are constant. The explanation lies in exposures that offset across people or securities, rather than a universal absence of uncertainty. A concentrated endowment is a simple counterexample to the latter interpretation.

Feedback script

First identify which numbers come from choices and which come from rules. Reconstruct the market portfolio using quantities and prices. Only then compare premiums and betas. If prices are missing or a denominator is zero, ask which observation or condition would be needed to make a stronger claim.

Modes and institutional comparisons

3.1 Choose a question for the class

The basic edition offers one market, ten markets with the same group, and ten markets with reassignment. One interaction keeps the session short and focuses on budgets, payoffs and the diagnostic. A fixed group retains the same people while resetting resources and drawing new states. Reassignment forms new groups in each episode and requires at least sixteen people in multiples of eight. It does not guarantee never meeting a previous participant. Position within a group determines the episode's endowment; reassignment does not promise the same initial portfolio type.

Ten markets should serve a learning question rather than merely generate more rows. Ask whether quotations for securities with related payoffs become more similar, whether willingness to hold securities changes, or whether orders execute more quickly. Use the same trading time and explanation throughout the comparison. Keep discussion until completion if feedback during the sequence would change the information environment. A separate practice session can precede the activity, provided it is clearly identified and kept apart from the observations used for discussion.

Extended conditions use ten fixed-group episodes and share the common screens. The menu includes the reference condition for comparisons within the edition. Other conditions change an identified rule or economic component. They are not separate catalogue games or a sequence that must be completed in one class. Choose one comparison while holding language, group size, trading time and disclosure constant. A small session provides illustrations and diagnostics, without automatically providing statistical power to attribute differences to a behavioral mechanism. Record any procedural deviations before interpreting outcomes.

3.2 Information and trading opportunities

Visible aggregate portfolio

This condition publishes initial aggregate quantities and keeps them visible during trading. Payoffs and endowments remain at reference values. The question is whether a summary of supply helps connect private choices with the market as a whole. Aggregate quantities do not change with each trade because securities merely change owners. Their market value changes as prices change. A card listing ten securities of each type therefore does not recommend equal value weights at every price vector.

The instructor's calculation is unchanged. The report reconstructs supply in every condition, but participants see the aggregate during trading only in this variant. Do not publicly announce

quantities in the reference if visibility is the intended contrast. Students could infer supply from communication or other screens; laboratory rules prohibit that communication and preserve private decisions. An inference made independently from prices is different and is not a design error. In the debrief, separate access to a summary from the ability to use it correctly.

Initial aggregate supply is shown here and during trading. {'A': 10, 'B': 10, 'C': 10}

Figure 3.1: The visibility condition publishes aggregate supply.

Bounded short sales

Short selling permits a terminal position of minus one unit per asset. The purpose is to discuss how position constraints can prevent an investor from expressing a valuation or hedging exposure. It is not advice to use leverage. Cash must remain nonnegative, and collateral covers the asset's worst payoff. An order can be rejected even at an apparently attractive price when other books already commit the available funds. The screen shows the resources that make the restriction binding.

Imagine someone without C offering to sell one unit. The reference rejects the order for lack of securities. The short-sale condition can accept it if sufficient cash covers up to 160 ECU, C's maximum payment in this condition. A second sale leading to minus two is rejected. Buying a unit to cover the exposure releases collateral. Negative positions are visible in outcomes, but the position limit and indivisibility prevent extrapolation to unrestricted markets. The conservative collateral rule can itself limit how closely the class approximates a frictionless benchmark.

Private cards about a component

Each investor receives a signal about the sign of F, correct with probability seventy-five percent. Signals are independent conditional on the true sign. The payoff table and prior distribution remain public. The client receives only its own card. Neither the true sign nor other cards is disclosed before settlement. This condition supports discussion of how people with different information may value the same contingent payment differently, even when everyone understands the announced rules.

With prior probability one half and a symmetric signal of accuracy three quarters, a positive card gives posterior probability three quarters that F is positive. This calculation does not resolve the other two state components and does not give everyone a common posterior. The report uses the prior distribution to maintain a reproducible reference and states that limitation. A deviation can reflect private information, preferences or constraints, without proving irrationality. Explain signal generation after trading and avoid revealing individual cards. The comparison concerns information and prices, not a public ranking of who was fortunate enough to receive a correct card.

You receive a private card about the sign of the first state component. It is correct with probability 75%; it does not determine the state with certainty. Other people receive their own cards.

Your card indicates: +

Figure 3.2: Only the investor's own private card is displayed.

Execution commissions

The fee is one ECU per security for each side of a transaction. Posting and canceling orders are free. Trading two units transfers four ECU to the fee account: two from the buyer and two from the seller. Price limits, priorities and payoff distributions remain unchanged. The question is how participation costs affect net trading opportunities and the willingness to redistribute exposures. A low-volume outcome can be economically informative rather than a failure to engage with the interface.

Order counts alone are insufficient. A person may post many orders that never execute or trade several securities through a single order. Read executed volume and wealth together with prices. Returns in the pricing diagnostic are constructed from asset prices and payments; commissions affect personal wealth and transaction costs. Consequently, the CAPM difference is not a personal net return. Discuss the range of inaction introduced by costs without claiming that the condition preserves every assumption of a frictionless equilibrium model.

3.3 Supply and payoff structure

Reduced menu

Only A and B are offered. C endowments become zero and are not replaced by cash. Supply consists of ten A and ten B. This changes opportunities and the initial wealth of types that previously owned C, so it does not isolate a pure completeness effect. It illustrates how the relevant aggregate portfolio changes and why an index depends on the universe of included assets. Students should identify those simultaneous changes before comparing outcomes across conditions.

With equal prices, the average A–B portfolio pays 100 plus 20F. Z cancels, and U disappears because C is unavailable. Do not describe the reference as a complete-markets control. Three risky securities and cash cannot replicate every arbitrary payment across eight states. Both menus are incomplete in that formal sense. The comparison concerns the menu and aggregate exposure. Its limitations belong in the lesson rather than in a footnote that students never read. A useful transfer question is which additional state-contingent payments would expand attainable portfolios.

Unequal aggregate supply

A endowments double, giving twenty A, ten B and ten C. Cash is unchanged. Unequal supply changes wealth and aggregate exposure as well as index weights. At prices 100, A has weight one half and each other asset one quarter. A simple average of three returns would be incorrect. The report uses effective quantities from the session, including after ownership changes through trading. Turnover does not create additional net supply or justify counting executed units as new outstanding securities.

Ask how beta changes when an exposure becomes more prominent in the market. Beta is not an immutable label attached to a security. Keeping its own payments fixed, covariance with a different portfolio can change. Have students calculate the index with unequal quantities before discussing prices. If prices also change, separate those steps to avoid assigning a price-driven difference to supply. This procedure clarifies the distinction between a partial arithmetic exercise and an equilibrium response involving several variables.

Higher common exposure

A and B have coefficient thirty on F and C has fifty; other components are retained. Every state still has positive payments. The condition increases sensitivity to a shared component. It shows why distributing investment across several names does not eliminate exposure appearing with the same sign in all of them. The effective instruction table replaces remembered reference values. Instructors should read those values directly rather than using a single printed formula for all conditions.

Recalculate standard deviations and covariances instead of saying all betas rise proportionally. The market portfolio also changes, affecting numerator and denominator. The weighted average of betas remains one whenever the relevant portfolio has positive variance and consistent weights are used. This is a useful diagnostic for the error of updating each asset's payments while keeping an old market denominator. It also shows why increased total volatility and increased beta are distinct claims that require separate calculations.

Higher risk offset across securities

Z coefficients become plus forty for A and minus forty for B. F and C retain their reference values. A and B each have greater individual dispersion, but equal quantities still offset Z in aggregate. At equal prices, aggregate variance remains unchanged while the variance of those individual securities rises. This gives a direct comparison between total risk and contribution to aggregate risk, using a payoff structure that can be checked by adding columns in the table.

Cancellation requires appropriate quantities and does not imply that each investor is diversified. Someone concentrated in A remains exposed to Z. If prices change, update returns and weights consistently; physical aggregate payments still preserve the cancellation. Ask students to add payments before calculating percentages. That sequence distinguishes a property of supply from a universal property of every portfolio. A follow-up can ask which feasible trade would reduce a particular person's Z exposure and whether a counterparty might want the opposite trade.

Inverse exposure

C pays $100 - 20F + 10U$, while A and B retain reference payments. At equal prices and reference supply, C has negative covariance with the aggregate portfolio. This condition introduces a hedging asset without calling it safe: its payoff still varies. A low or even negative expected premium can be consistent with hedging services under appropriate assumptions, but the activity does not impose that the observed price reaches that result. Students must distinguish the sign of covariance from the sign of realized profit.

Inverse exposure is defined relative to the activity's portfolio. A person with a very different endowment may value the security for another reason. Ask which state is unfavorable for the aggregate and what C pays in that state. Then compare beta's sign with expected premium. Do not classify a security's economic role from one realized return. The condition is particularly useful for showing that an asset can be risky by itself and nevertheless reduce another portfolio's risk.

Positive safe return

Unspent cash earns two percent at settlement, while security distributions remain unchanged. Buying a security now sacrifices both current cash and its safe return. The report subtracts that rate when computing premiums. At price 100 and expected payoff 100, the asset has expected return zero and expected premium minus two percent, before any particular state is observed.

This comparison makes the opportunity cost concrete without adding a separate cash lending institution.

No extra rate is added to security payments, and negative cash lending is not permitted. All payments concern the same episode closing date. Comparing them with an annual real-world market rate would require a horizon and conversion that the activity does not specify. Keep percentages per episode rather than adding fictitious economic precision. In the worked wealth example, apply the safe rate only to remaining cash and then add the announced security payments once.

Constant aggregate portfolio

C pays $100 - 40F$, with no U component. With equal supply, A and B contribute plus forty exposure to F and C contributes minus forty. Z also cancels. Total outstanding securities therefore pay the same amount in all eight states. Prices can differ and individuals can face risk, while the aggregate portfolio has a constant return for a fixed price vector. This construction provides a transparent denominator check using a genuine economic special case.

Market variance is zero, so beta is undefined. The report displays undefined values and omits those points rather than drawing beta zero. This is a conceptual control for interpreting indicators, not a simplified CAPM test with cleaner evidence. If someone argues that no aggregate risk means every asset is safe, reconstruct a concentrated endowment and compare two states. If someone tries to divide by a tiny rounded number, return to the exact payoff cancellation before discussing numerical precision.

Prepare, conduct and interpret the session

4.1 Access and classroom preparation

Start at <https://beer-lab.org/> and open the classroom catalogue at <https://teaching.beer-lab.org/>. Find Systematic Risk and Asset Pricing by its title and topics. The family address is <https://systematicrisk.beer-lab.org/>. The English basic participant room is https://systematicrisk.beer-lab.org/room/systematic_risk_en; the extended room is https://systematicrisk.beer-lab.org/room/systematic_risk_extended. Instructors use <https://systematicrisk.beer-lab.org/demo> and the authenticated administrator. These routes identify the prepared product; the delivery record distinguishes local validation from public deployment.

Demo lists thirty configurations belonging to this family. Rooms contains four rooms: Spanish basic, English basic, Spanish extended and English extended. Each basic room offers three modes; each extended room offers twelve conditions. A basic room must initially select a basic configuration in the correct language. A room is different from a personal participant link, and an instructor report is different from a participant page. If other families appear, do not start the session; ask laboratory coordination to check isolation. The validated local preview opens at <http://localhost:8110/demo> on the same computer.

Fixed groups require multiples of eight with a minimum of eight. Reassignment requires at least sixteen. Both the form and server enforce that requirement. Do not complete a group with a fictional person or share one link between two students. Each link represents one trajectory. Check that enough devices are available, the connection is stable and screens can remain private. Keep the instructor tab separate from student tabs to reduce the chance of accidentally projecting private results or administrative information.

Trading time is configurable between ten and nine hundred seconds; prepared configurations use one hundred eighty seconds. Three minutes permits a brief trading exercise but does not guarantee equilibrium. Ten markets require additional reading and feedback time. For a first use, allow around seventy-five to ninety minutes for one market with discussion; repeated comparisons can require ninety to one hundred twenty. These are planning estimates, not measured durations from a human pilot. Adapt the lesson to students' familiarity without changing economic rules midway through a comparison.

Check current links before distributing them. Creating a new session generates new links. Restarting the server process preserves its database; deleting or replacing the database invalidates old links. A missing-user message commonly indicates a link associated with another database or session. Locate the correct session or create a new one rather than inventing observations to make a trajectory

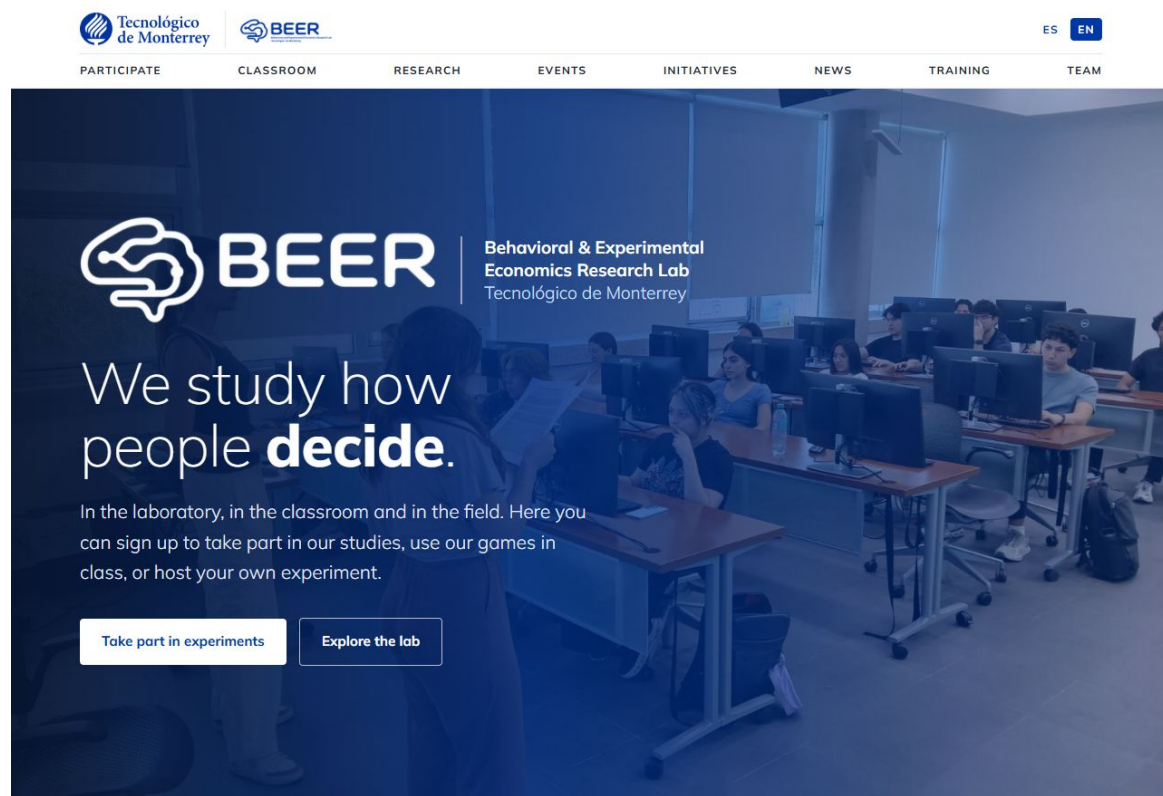


Figure 4.1: Institutional access to the classroom catalogue.

The screenshot displays the BEER Lab website interface. At the top, there are logos for 'Tecnológico de Monterrey' and 'BEER'. A navigation bar includes links for PARTICIPATE, CLASSROOM, RESEARCH, EVENTS, INITIATIVES, NEWS, TRAINING, and TEAM. The 'CLASSROOM' link is highlighted.

The main banner features the text 'INSTRUCTORS AND STUDENTS' and 'Classroom experiments'. Below this, it states: 'Experimental economics games for classroom activities and discussion. Open the game your instructor tells you.' It also provides instructions for instructors and a link to the lab research page.

Below the banner is a search bar with the placeholder text 'Search by title, topic, keyword or JEL code...'. There are dropdown menus for 'Topic' and 'JEL code', and a count of '169 games'.

Two game cards are shown:

- Electoral Accountability and Political Selection**: A study on how the prospect of remaining in office changes an officeholder's behavior. It includes tags for electoral discipline, political accountability, political selection, corruption, information, and political economy. The JEL code is A22 · C92 · D72 · D73. The address is accountability.beer-lab.org.
- Aggregate Demand and Aggregate Supply**: A study on how spending choices aggregate into demand and how equilibrium with supply determines output and prices. It includes tags for aggregate demand, aggregate supply, price level, potential output, and macroeconomic expectations. The JEL code is A22 · C92 · E12 · E31 · E32. The address is adas.beer-lab.org.

Figure 4.2: Public catalogue: find the title and topics of the game.

Demo

Riesgo sistemático — Un mercado
Riesgo sistemático — Diez mercados: grupo fijo
Riesgo sistemático — Diez mercados: reasignación
Riesgo sistemático — Extendido: Referencia
Riesgo sistemático — Extendido: Cartera agregada visible
Riesgo sistemático — Extendido: Ventas cortas acotadas
Riesgo sistemático — Extendido: Señal privada
Riesgo sistemático — Extendido: Comisión por operación
Riesgo sistemático — Extendido: Menú reducido
Riesgo sistemático — Extendido: Oferta agregada desigual
Riesgo sistemático — Extendido: Mayor exposición común
Riesgo sistemático — Extendido: Mayor riesgo compensable entre activos
Riesgo sistemático — Extendido: Activo con exposición inversa
Riesgo sistemático — Extendido: Rendimiento seguro positivo
Riesgo sistemático — Extendido: Cartera agregada sin variación
Systematic Risk — One market
Systematic Risk — Ten markets: fixed group
Systematic Risk — Ten markets: reassignment
Systematic Risk — Extended: Reference

Riesgo sistemático y valoración de activos / Systematic Risk and Asset Pricing — BEER Lab

Seleccione una variante de este juego. Select a version of this game.

Figure 4.3: Isolated Demo with thirty family configurations.

Rooms

Current rooms:

Riesgo sistemático — Básico
Systematic Risk — Basic
Riesgo sistemático — Extendido
Systematic Risk — Extended

Figure 4.4: Four rooms by language and edition.

Room: Systematic Risk — Basic

Create a new session

Session Config

Systematic Risk — One market

Number of participants

Complete groups of 8 participants. Use a multiple of 8; minimum 8.

Create

[Configure session](#) 

App sequence

systematic_risk_game (10 rounds)

0 participants present

Start links

These URLs will stay constant for new sessions, even if the database is recreated.

Room-wide URL

Here is the room-wide URL anyone can use. Don't use this link when testing in multiple tabs on the same browser, because all tabs will be assigned to the same participant, using a cookie.

http://127.0.0.1:8110/room/systematic_risk_en

Figure 4.5: Basic room: check language, mode and multiples of eight.

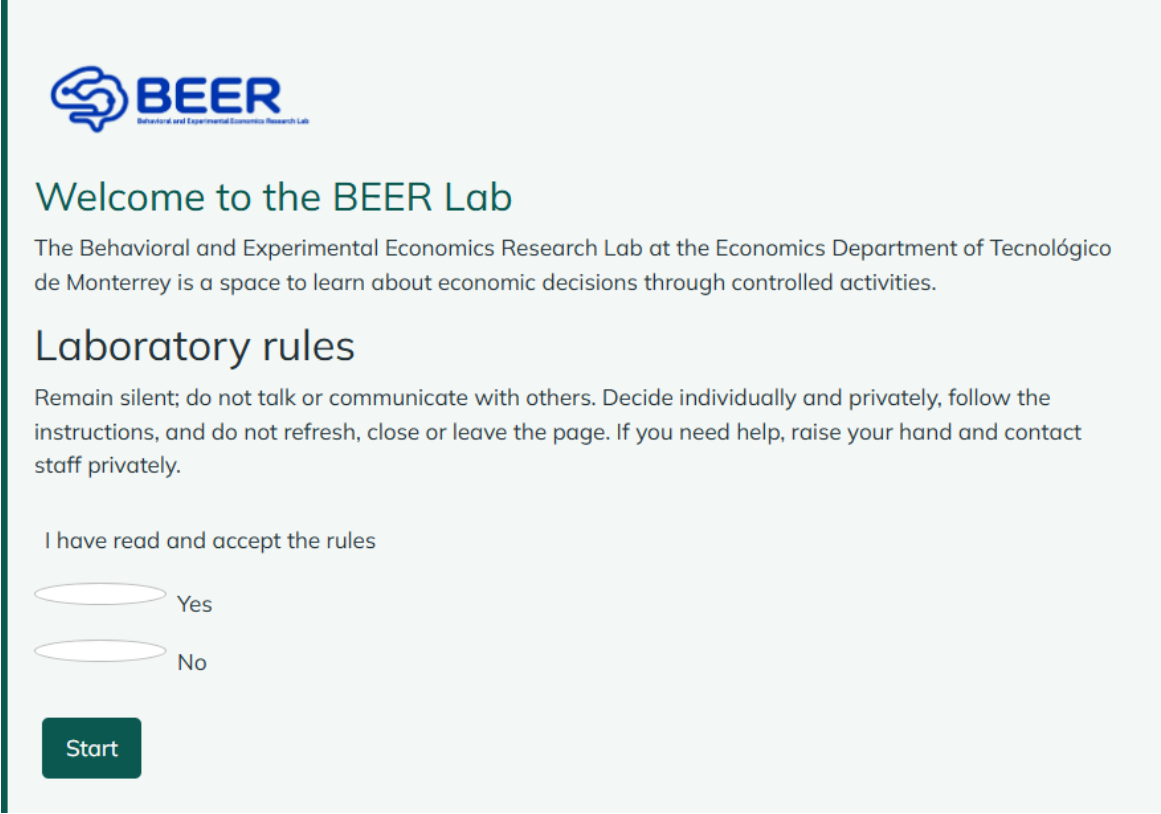
advance. Record which session belongs to which class and download data before maintenance. A recognizable session record also prevents confusing demonstration observations with a classroom cohort.

4.2 The participant sequence

The welcome screen introduces the laboratory, operational rules and Start button. Participants then read instructions, personal resources and the state table. Information conditions display the authorized card or aggregate summary. Comprehension questions concern reserved budgets, the number of states and selection for payment. An incorrect answer receives a question-specific explanation and the other fields are retained. Corrections do not reduce ECU or require adopting a particular strategy. The purpose is rule comprehension, rather than coaching a preferred trade.

Once all eight people complete comprehension, the market clock starts. Everyone sees personal positions and the same set of books, but not other investors' balances or private cards. Orders reach the server, which determines their sequence. A participant can inspect reservations, submit orders and cancel them. Finish trading exits that negotiation and does not automatically sell the entire portfolio. Securities already held continue to have state-dependent payments. An investor who stops early can therefore still experience a change in terminal wealth when the state is revealed.

At closing, open orders are canceled and wealth is calculated. The outcome screen shows cash, positions, terminal payments and wealth without trading in the same state. Participants continue to the next episode or the final screen. Completion identifies the selected episode and credited wealth. Repeated clicks cannot generate additional credits. Someone who finishes before others should remain silent and wait for common instructions. If the lesson includes repeated markets, avoid discussing state outcomes aloud while another group is still trading the corresponding episode.



 **BEER**
Behavioral and Experimental Economics Research Lab

Welcome to the BEER Lab

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

Laboratory rules

Remain silent; do not talk or communicate with others. Decide individually and privately, follow the instructions, and do not refresh, close or leave the page. If you need help, raise your hand and contact staff privately.

I have read and accept the rules

☒ Yes

☐ No

Start

Figure 4.6: Welcome and rules before starting.

Market instructions

Resources and unit of account

Your initial resources: 800.0 ECU and these securities: A: 4, B: 0, C: 0. These endowments reset in each market.

ECU means Experimental Currency Units. It is an accounting unit; no monetary conversion is specified here.

At the end, one market is selected with equal probability and its terminal wealth is recorded once. Wealth is not added across markets.

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

This session does not convert ECU into real money.

Each security pays an amount determined by one of eight equally likely states. The same state determines all payoffs in the market. You may submit limit purchases and sales (1–200 ECU in increments of 1) or trade at the best available price. An unexecuted order is not a transaction. Orders follow price and then arrival priority and execute at the resting order's price.

All three books share your cash. Pending purchases reserve funds; you cannot spend the same balance twice. You may cancel your pending orders. Cash borrowing is prohibited.

Maximum short position: 0 security per asset. Every possible short position, including pending sales, requires cash covering that asset's maximum payoff. This collateral is released when the exposure closes.

Each buyer and seller pays 0.0 ECU per executed security to a fee account. Remaining cash earns 0% at the end.

At the end, one market is selected with equal probability and its terminal wealth is recorded once. Wealth is not added across markets.

Initial aggregate supply is shown here and during trading. {'A': 10, 'B': 10, 'C': 10}

Figure 4.7: Effective resources and state payoffs.

Understanding the rules

Resources and unit of account

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

This session does not convert ECU into real money.

If you have 100 ECU and reserve 60 ECU for a pending purchase, how much remains available for other purchases?

Your answer: 10. The correct answer is 40. $100 - 60 = 40$ ECU available; a pending order reserves funds.

How many possible states have the announced payoffs and probabilities for this market?

How many markets determine the final payment?

Continue

Figure 4.8: Feedback explains the error and retains other answers.

4.3 Monitoring and the private report

The report initially hides aggregates. The instructor can monitor participant counts, completed markets and pending markets without projecting outcomes. Reveal aggregates and Hide aggregates control presentation within authenticated access. Do not distribute the report address to students. Visual hiding is different from server permissions; the report itself requires instructor authentication. Downloads contain technical records and should not be projected with identifying information or used to publicly single out an individual decision. The aggregate display is designed for classroom discussion.

Completed markets count group-by-episode units. Wealth observations count people in completed episodes. Eight people in ten markets generate eighty wealth records, rather than eighty independent investors. The distribution uses wealth intervals and observed frequencies, retaining an open upper interval. Missing outcomes are not zeros. When no market is completed, an implicit zero average would be misleading: there are no complete observations. Read counts first, identify the unit next, and only then interpret distributional differences or changes over time.

The evolution section gives episode, market, last executed prices and volume. A dash for a price means no transaction occurred in that asset. Volume counts executed units, not orders or people. The beta-premium cloud uses only markets with observed prices for every offered asset. The accompanying table gives weights, standard deviations, beta, premiums and the benchmark difference. Percentages are returns per episode; premium differences use percentage points. Their size is not a significance statistic and the cloud is not a regression fitted to realized episode returns.

Each market can contribute several points, one per asset. Those points share an aggregate portfolio and are not independent. Repeated groups also share people. The report preserves

Security exchange

Market 1/1 · Each buyer and seller pays 0.0 ECU per executed security to a fee account. Remaining cash earns 0% at the end.

Maximum short position: 0 security per asset. Every possible short position, including pending sales, requires cash covering that asset's maximum payoff. This collateral is released when the exposure closes.

Cash: 515.00 ECU · Available cash: 515.00 · Reserved for purchases: 0.00 · Short position collateral: 0.00

Seconds remaining: 177

Asset

Limit price (ECU)
Quantity

Asset A

Your position: 5 · Executed volume: 1

Last transaction price: 90

Pending bids

—

Pending asks

—

Your pending orders

—

Asset B

Your position: 1 · Executed volume: 1

Last transaction price: 95

Pending bids

—

Pending asks

—

Your pending orders

—

Asset C

Your position: 1 · Executed volume: 1

Last transaction price: 100

Pending bids

—

Pending asks

—

Your pending orders

—

Figure 4.9: Books share cash and show personal positions.

Asset Markets

Waiting for the other people in the market. Everyone must finish or the trading time must expire.

Figure 4.10: Settlement waits for the rest of the market.

Market outcome

Market 1/1

State: [1, -1, 1]

Cash: 515,0 ECU

Your position: {'A': 5, 'B': 1, 'C': 1}

Payoff per security (ECU): dict_values([515.0, {'A': 5, 'B': 1, 'C': 1}, {'A': 100, 'B': 140, 'C': 160}, [1, -1, 1], 1315.0, 1200.0])

Terminal wealth: 1315,0 ECU

Wealth without trading in the same state: 1200,0 ECU

Continue

Figure 4.11: Wealth uses the same settlement state for every asset.

Activity completed

Market selected for payment: 1

Terminal wealth: 1315.00 ECU

The activity is complete. Please wait for the instructor's directions.

Figure 4.12: Completion and selected episode for crediting wealth once.

State	Probability	A · Payoff per security (ECU)	B · Payoff per security (ECU)	C · Payoff per security (ECU)
- / - / -	1/8	60	100	40
- / - / +	1/8	60	100	80
- / + / -	1/8	100	60	40
- / + / +	1/8	100	60	80
+ / - / -	1/8	100	140	120
+ / - / +	1/8	100	140	160
+ / + / -	1/8	140	100	120
+ / + / +	1/8	140	100	160

Figure 4.13: Eight equally likely states; one common state settles all securities.

denominators and explains exclusions. The private-signal condition adds a note about the prior distribution used for its metrics. When reading evolution, identify whether groups are fixed or reassigned. When comparing conditions, use clearly documented sessions and keep endowment and opportunity differences explicit. A pooled mean can conceal changes in the universe of assets or in the composition of aggregate supply.

Instructor report: systematic risk and asset pricing

Reference · EN

Participants: 8 · Completed markets: 1 · Pending markets: 0

Reference prices without transactions are excluded from the diagnostic. Each beta uses eight states and value-weighted supply, never a regression on realized returns. The CAPM equation is conditional: mean-variance preferences are not induced. Repeated observations share people or groups.

Reveal aggregates

[Download round data](#) · [Download native data](#)

Figure 4.14: The report requires instructor access and initially hides aggregates.

4.4 A classroom script

Allow roughly ten minutes for the economic question, rules and a wealth example. Do not announce which asset students should buy. Use about five minutes for comprehension and private questions. Reserve three effective trading minutes for a single market, with extra time for transitions and outcomes. Then use fifteen minutes to reconstruct two portfolios and ten to move from payments to returns. Remaining time can compare a condition and solve a transfer problem. Adjust these

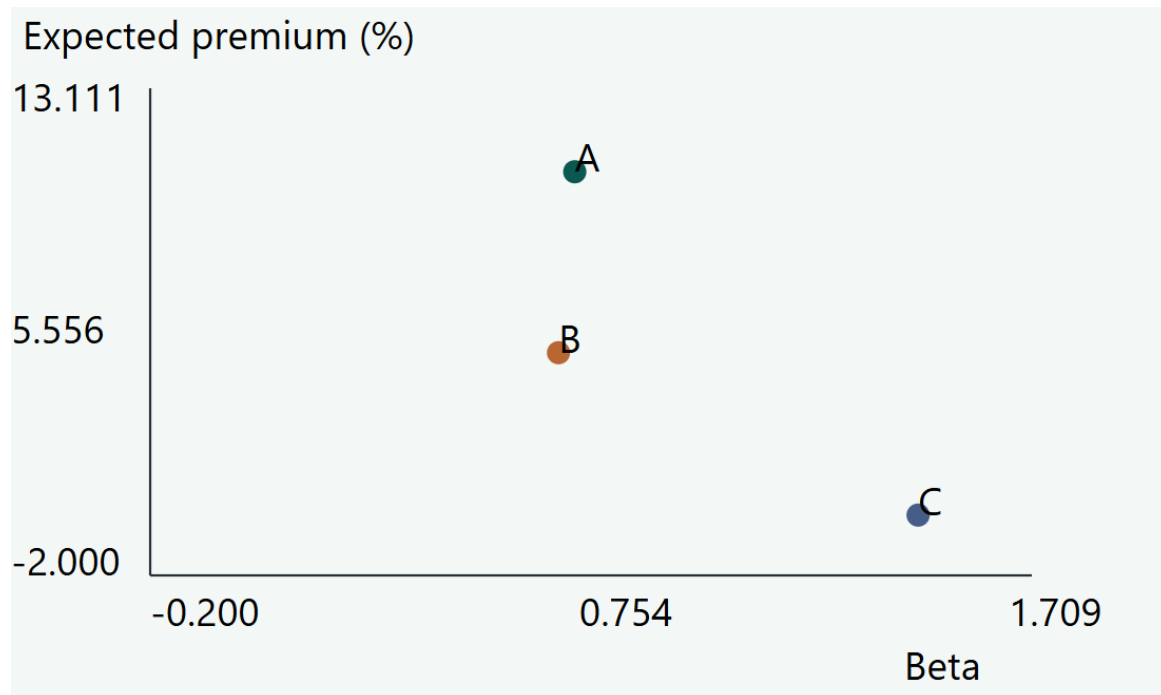


Figure 4.15: Beta and premium: return scales and asset points based on observed prices.

Market	Asset	Transaction price (ECU)	Value weight (%)	Return standard deviation (%)	Beta	Expected premium (%)	CAPM premium (%)	Difference (pp)
1	A	90.000	31.579	31.427	0.745	11.111	3.922	7.190
1	B	95.000	33.333	29.773	0.706	5.263	3.715	1.548
1	C	100.000	35.088	44.721	1.509	0.000	7.941	-7.941

Aggregate portfolio

Market	Expected portfolio return (%)	Portfolio standard deviation (%)
1	5.263	28.934

Terminal wealth distribution

Observations: 8

0–500 ECU: 0

500–750 ECU: 0

750–1000 ECU: 2

1000–1500 ECU: 6

1500–+ ECU: 0

Evolution and prices

Market	Market group	Transaction price (ECU)	Executed volume
1	1	A: 90.000, B: 95.000, C: 100.000	3

Figure 4.16: Aggregate results with denominators and market evolution.

allocations to the group's experience while preserving a consistent protocol.

Before revealing the report, ask for written answers to three questions: what constitutes the aggregate market, which observation is needed to calculate a return, and what it means for an asset to have high total risk. Retain the answers for comparison after discussion. Do not grade students for earning more ECU: endowments, states and preferences affect wealth. Grade coherent calculations and recognition of assumptions. An investor who did not trade can provide a well-reasoned economic explanation, although inactivity can also reflect difficulty using the interface. Ask for the explanation without presuming either interpretation.

During debriefing, choose a transaction and trace both sides. Cash moves from buyer to seller and a security changes owner. Add all holdings to show that supply has not multiplied. Build the index from the value of supply and identify exposures that cancel. Introduce beta as a ratio between joint movement and aggregate variation. Finally write the CAPM relation and ask which assumptions are not guaranteed in the classroom. This order separates accounting, statistics and theory, making it easier to locate an incorrect inference.

For the instructor

A useful class may end with little volume, premiums that do not follow a line, or undefined beta. Pedagogical quality depends on explaining the decisions, constraints and available information that produced those observations. Do not adjust payments or remove markets after seeing outcomes to force a predicted pattern.

An optional closing discussion can connect the activity to index construction. Real indices differ in their asset universe, free-float conventions and rebalancing rules; the classroom portfolio uses the specified outstanding supply and one closing price vector. Students should explain that definition before borrowing an interpretation from a real index. Another useful connection is hedging: a security's appeal depends on the investor's other exposures. Neither connection requires claiming that the simplified market reproduces every feature of a professional exchange or investment fund.

4.5 Transfer exercises with answers

First, offer twenty A at 80, ten B at 100 and ten C at 120. Supply value is 3800 and weights are approximately 0.4211, 0.2632 and 0.3158. A's weight is neither two thirds nor one third: quantity and price both enter. Recalculate after changing only A's price. A correct response keeps quantities fixed and updates numerator and denominator consistently. This exercise detects the common tendency to use physical supply shares as value weights. It also encourages students to state which variables a hypothetical comparison holds constant.

Second, consider an asset priced at 80 that pays 100 with certainty. Return is twenty-five percent. With a zero safe rate, its premium is also twenty-five percent and covariance with any portfolio is zero. Those prices do not satisfy a frictionless CAPM equilibrium relation. Beta is a valid statistical definition, while the premium equation adds a theoretical restriction that prices can violate. Different equalities in a textbook have different logical status. Ask which trade would look attractive and which restrictions could prevent an immediate adjustment of the classroom price.

Third, increase dispersion in Z for A and B with equal quantities. Their combined payoff is unchanged because coefficients have opposite signs. Individual standard deviations increase. Someone holding only A is not protected by cancellation in aggregate. The answer should distinguish the group of investors from each personal portfolio. Ask which trade could reduce that person's exposure while leaving common aggregate risk unchanged, and what type of counterparty might want the opposite exposure. This translates a covariance calculation back into feasible choices.

Fourth, suppose A and B trade but C has no transactions. Do not construct the complete diagnostic using an invented C price. Describe observed volume and, if useful, calculate a clearly labeled hypothetical price vector as a separate exercise. Keep hypothetical calculations apart from the report's observed-price data. Missingness is not a numerical observation. A final question can ask whether a posted ask would solve the problem; it would provide a quotation, not evidence that anyone executed at that price.

Fifth, suppose aggregate payoff is constant but one person holds four A. A's payment still changes across states, so personal wealth can vary. A zero aggregate variance does not imply a zero personal variance. Beta relative to that aggregate remains undefined because its denominator is zero. The explanation should use a concrete pair of states and avoid dividing by a rounded tiny number. This exercise tests whether students understand the economic object behind a metric rather than merely recognizing the metric's name.

4.6 Data, reproducibility and privacy

The round download contains session, technical participant code, round, status, language, edition, treatment, matching, group, selected episode, personal outcome and market state. Market state appears once per group and round in its first position's record, avoiding eight unnecessary copies. It contains endowments, accounts, orders, trades, fees, signals and state draw. This private instructor information is needed to reconstruct settlement and is not intended for participant access during trading. Technical codes identify records, not public participant names.

The file contains ten technical rounds even for one interaction. Active rounds can be complete or pending; others are marked inactive. An outcome not yet produced remains empty instead of being replaced by zero wealth. The native download is wide, with one participant row and columns for rounds. The custom download is long, with one participant-round row. Both refer to the selected session. Before combining files, preserve the rule version, condition and session date. A sensible analysis begins by checking structure and completion status rather than immediately averaging a wealth column.

To reconcile accounting, add cash across accounts and the fee account; before external settlement, that sum equals initial cash. Add positions by asset to recover initial supply, including when shorts exist. Apply the same state and safe rate to each account to reconstruct wealth. Check that only the selected episode is credited at completion. Reconstruct prices from executed trades, rather than prices of expired orders. These checks are useful for both instruction and analysis because they distinguish external payments from transfers within the market and identify the correct unit for each calculation.

No demographic questions are included. Session and participant codes are technical identifiers and should not become public labels. Store files with suitable permissions and share classroom aggregates. Reusing classroom observations for research requires a separate protocol and authorizations; this guide does not claim ethics approval or consent for other uses. Do not automatically merge the records with grades or personal information. The absence of demographic questions reduces unnecessary collection but does not eliminate the need to handle individual trajectories carefully.

A reproducible classroom note should list group size, active episodes, matching mode, condition, effective duration and any interruptions. Keep the announced state table with the exported file so that a future reader can calculate moments without relying on memory. Record whether a session was a demonstration, practice or classroom activity. If a participant disconnects, describe the resulting incompleteness rather than creating a fictional decision. When presenting results, distinguish arithmetic outcomes imposed by payoff definitions from patterns that emerged from trading behavior.

4.7 Troubleshooting and completion

For a rejected order, check integer quantity, allowed price, other books' reservations, available holdings, collateral and time remaining. Check whether the person has finished trading or whether the order would cross their own order. A purchase not executing is not by itself a system failure: there may be no willing counterparty at the required price. For partial execution, separate original, executed and pending quantities before canceling. Read the current account panel rather than reconstructing available cash from memory of an earlier screen.

For a waiting page that does not advance, verify that all eight trajectories belong to the same session and group and have reached the required step. Time closing relies on connected clients receiving updates; abandoning the page is different from finishing. Do not reset the database to resolve a wait. Inspect connection and the family instance. The prepared deployment uses one server worker to serialize actions. Increasing workers requires validating database locking first. The local preview preserves its state when the process restarts, so existing session links can continue.

For an empty report, check completion and session selection. The administrator can open a report from a later technical round; the implementation explicitly gathers active rounds starting at the first. An empty cloud with a populated wealth distribution may reflect missing observed prices or undefined beta. Read the notes before treating an empty graph as a calculation failure. A translation correction requires reviewing the affected interface, without repeating unrelated sessions or calculations. Efficient validation follows distinct mechanisms and visible states, rather than the raw number of labels in a menu.

Attention

Do not share the authenticated report, reset the database during class, or fill missing prices with references. Preserve current sessions when refreshing the server. Verify public deployment separately from local operation.

Operational completion means confirming the final screen, downloading both formats, reviewing denominators and recording the condition used. Conceptual completion asks which risk remains in aggregate supply, what information is needed to value a security, and why an equilibrium relation is different from an accounting identity. A strong response connects decisions, opportunities and assumptions. The activity makes that reasoning inspectable; producing a list of winners is not its teaching purpose. A short written transfer answer gives more useful evidence of understanding than a ranking of terminal balances.

4.8 Bibliographic foundations and the adaptation

The asset pricing model in [Sharpe \(1964\)](#) provides the starting point for relating premiums to aggregate risk exposure under equilibrium conditions. Experiments in [Bossaerts and Plott \(2004\)](#) examine pricing principles in larger experimental markets. [Bossaerts, Plott, and Zame \(2007\)](#) links prices and portfolios in a joint analysis. These references motivate the theoretical questions and the need to observe portfolios alongside prices. They are not presented as an exact recipe for this classroom activity's parameters, sample size or incentives.

The BEER Lab adaptation uses eight people, three assets, eight equally probable states, discrete endowments and short episodes. It adds teaching cases concerning denominators, missing prices and constraints. It does not replicate those papers' samples or results. Extensions are explicit institutional comparisons and are not attributed as literal treatments from every cited source. Official oTree documentation supports groups, pages and exports. Technical tests verify operation, without claiming observed behavioral results or demonstrated learning gains in an actual class.

For an introductory course, focus reading on wealth accounting and the difference between total risk and covariance. In an advanced asset pricing course, ask students to derive weights and moments and discuss the CAPM assumptions. A critical reading should identify which part of an outcome is imposed by payments and which part emerges from choices. No convergence rate or learning result is invented. A subsequent pedagogical pilot can record comprehension and duration, preserving that evidence separately from the delivered software validation. Future parameter changes should be recorded as a new rule version before comparing classroom cohorts.

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