oTree Program Features

1. General Framework

Three types of Group	Two types of Incentives	Two treatment
(1) **Carbon Trading Group:** With trading phase. (2) **Carbon Tax Group:** No trading phase; apply a tax rate per unit of carbon emitted (3) **Control Group:** Identical to the carbon tax condition but without any tax applied.	(1) **Monetary Group:** with only traditional monetary incentives. (2) **Carbon Group:** participants are informed that emissions during the experiment will correspond to actual emissions in reality.	(1) Banking and Borrowing (2) Penalty and Allowing Production Beyond Permit Limits

2. Session Configuration

(1) **Treatment Configurator:** Enable administrators to toggle the following features:

A. Banking and Borrowing: Allow or disallow participants can store unused emission permits for future use or borrow permits from future allocations. (Unused permits can be carried over to future rounds, and participants can also borrow permits from future rounds if they wish to emit more than their current allocation.) Interest rates may be applied as a configurable parameter.

B. Penalty and Allowing Production Beyond Permit Limits:

(1) emission permits become a soft constraint, allowing participants to take risks and produce more units than permitted.

(2) Three levels of penalty : The penalty audit is conducted randomly in each round, and the probability is independent for each firm. A penalty audit probability is applied (e.g., 30%, 20%, 10%, which must be configurable). The probability of being audited and the corresponding fines are the same for all firms. Higher audit probabilities are paired with lower fines, ensuring the expected penalty remains constant. If a firm is audited and found to have exceeded its permit allocation, it will be fined for each unit of excess emissions.

(2) Practice MUDA Session: Add an initial MUDA session.

> To familiarize participants with the experiment, they will first play 3 minutes. These rounds do not involve carbon permits but focus on buying and selling other goods. Participants are assigned a value for the trading items and given a table to understand how the number of goods they hold at the end translates to rewards. During these practice rounds, all participants can act as buyers or sellers.

(3) Experimental Procedure

- Each experiment consists of t rounds, and each round is divided into two stages.
- Add an initial MUDA session if Carbon Trade is exist.

Stage1

- Each participant starts every round with a initial amount of capital.
- The program should allow flexible settings for each participants' participant's production limit, marginal production cost, firm roles and market price. (Some participants may have lower production costs or lower production limits.)
- Assignment of roles and market price. (participants divided into two types of firm roles: high-emission firms and low-emission firms.)

Treatment A or B is allowed	Otherwise
firm roles are fixed. Only marginal costs and market prices are re-randomized each round.	Each round, participants' firm roles (high/low carbon emissions), marginal costs, and market prices are re-randomized.

- General market information is provided, which can include specific details (e.g., price per unit) or probabilistic descriptions (e.g., the likelihood of a certain price occurring).
- Participants can view their firm's production information in a table format, showing the cost and carbon emissions for producing each unit (e.g., cost and emissions for the first unit, second unit, etc.). The production units have an upper limit. (But hide other participants' information)
- Participants can select the number of units to produce, and the system

calculates and shows the required permits and total costs instantly. This should occupy half of the screen if it is Carbon Trading Group and occupy all of the screen if it is Control Group or Carbon Tax Group.

- The other half of the screen displays the carbon trading if they are Carbon trading group.

Carbon Trading Group	Carbon Tax Group, Control Group
Trade.	There is no carbon permit trading phase.

The trading follows a continuous double auction with multiple-unit trading. Participants can act as both sellers and buyers (if they have inventory, they can act as both; without inventory, they can only act as buyers). Buyers and sellers can submit offers simultaneously, indicating how many units they want to buy or sell and at what price.

(For example, a buyer might offer to purchase three units at 100. Potential sellers see this price and decide whether to sell. If no one sells, the offer remains, and the buyer may increase the price to purchase three units. Sellers submit offers similarly.)

- At the end of stage 1, participants receive their final carbon permit allocations.

Stage2

- Clear market price information is provided in stage, showing the exact unit price of the product to help firms decide how many units to produce.
- Production Limit: Each firm can produce fewer units but are limited by the maximum number of carbon permits obtained at the end of Phase 1 for that round.
- Each firm makes its actual production decisions.
- Other costs:

Carbon Tax Group	Carbon Trading group, Control Group
A carbon tax is applied for each unit of production based on the carbon emissions it generates.	No carbon tax. (Control Group is similar to the carbon tax group but without a carbon tax.)

- At the end of stage 2, participants are shown the results and their rewards for the round.
- Real Rewards:

Treatment A or B is allowed	Otherwise
Since participants now complete a continuous 10-round experiment, their rewards are based on the total	Since the 10 rounds are independent, participants' rewards are based on a randomly selected round.

results of all 10 rounds.	

4.Data Collection

- Record participant-level and market-level metrics for econometric analysis.

5.Export Data

- Export CSV files containing:
    - Participant-level data (emissions, profit, permits held, violations, etc.).
    - Market-level metrics (aggregate emissions, average permit price, etc.).
- Enable session-specific identifiers for reproducibility.