Is the invisible hand red or green?

Rudolf F. Klein, PhD | RKlein@dbq.edu
and
Alina F. Klein, PhD | AKlein@dbq.edu

University of Dubuque

JET SET 2022

1. Introduction

- Games and experiments can effectively complement undergraduate-level economics lectures.
- Instructors may be concerned about their uncertain outcomes or about the possible divergence from the theory being taught.
- We propose and analyze a linear version of Bruehler, Grant, and Ghent (2017) Red/Green simulation.
    - We suggest a simple-to-implement and flexible structure.
    - We aim to highlight the abundance of potential applications.

1. Introduction

- Our simultaneous-move game-theoretic experiment uses extra-credit points to incentivize students to rationally choose between:
  - direct individual gains, and
  - indirect collective gains.
- Depending on the red/green choices made secretly and simultaneously by all students in a group, their individual payoffs, for each of the two iterations of the game, can be as high as 7.5 extra-credit points (in courses with a maximum of 200).
- This optimal payoff is obtained by a player only if he/she is the only one choosing green.

1. Introduction

- Players choosing **green do not contribute** to the group wealth while getting a larger proportion of the final total wealth.
- Players choosing **red do contribute** to the group wealth equally, but they get a smaller proportion of the final total wealth.
- All participants have complete information: they know the rules of the game (including strategies and payoffs), and that the rules are common knowledge.

2. Experiment Setup and Outcomes

1) Ideal range of possible payoffs to be earned by individual students. E.g., $0 < \pi \leq 7.5$.
   - First iteration: anonymous;
   - Second iteration: names revealed.
   - Note: either can be skipped.
2) Proportions of the final total of extra-credit points to be awarded to individual students choosing red/green. E.g., red: 1/5 (contribute) and green: 1/2 (don't contribute).
3) The initial endowment (*I*) and the marginal group wealth (*a*) for each additional red.
   - Note: We recommend choosing an initial total group wealth such that, when considering the number of students (*N*) in the group, it results in a round value for the marginal wealth.

2. Experiment Setup and Outcomes

- Given that the optimal case for an individual player is when they are the only one choosing green, which gives them 7.5 points, we obtain:

$$7.5 = \frac{I+(N-1)a}{2} \tag{1}$$

which results in the following equation for the marginal group wealth:

$$a = \frac{15-I}{N-1} \tag{2}$$

2. Experiment Setup and Outcomes

- The payoffs obtained once all responses are submitted can be calculated using the following two formulas:

$$\pi_R = \frac{I+Ra}{5} \tag{3}$$

$$\pi_G = \frac{I+Ra}{2} \tag{4}$$

where π_R is the payoff to each red,
π_G is the payoff to each green, and
R is the number of red players.

2. Experiment Setup and Outcomes

Table 1. Experiment Setup.								
	G1	*G2*	*G3*	*G4*	*G5*	*G6*	*G7*	*G8 (GT)*
Num. Students (N)	7	**19**	12	**4**	10	7	9	5
Initial Endowment (I)	3.0	3.0	4.0	1.5	6.0	9.0	7.0	3.0
Additional Wealth for Each Red (a)	2.0	0.7	1.0	4.5	1.0	1.0	1.0	3.0
Group Payoff If All Green (π_{green})	10.5	28.5	24.0	3.0	30.0	31.5	31.5	7.5
Group Payoff If All Red (π_{red})	23.8	59.5	38.4	15.6	32.0	22.4	28.8	18.0
Maximum Group Payoff (π_{max})	26.0	65.4	43.2	16.5	38.5	32.0	36.3	19.5
Maximum Average Payoff (π_{maxAve})	3.7	3.4	3.6	4.1	3.9	4.6	4.0	3.9
Num. Red for π_{max} (R_{max})	**5**	14	8	3	5	**1**	4	4
Num. Green for π_{max} (G_{max})	**2**	5	4	1	5	**6**	5	1
Minimum Group Payoff (π_{min})	10.5	28.5	24.0	3.0	30.0	22.4	**28.8**	**7.5**
Minimum Average Payoff (π_{minAve})	1.5	1.5	2.0	0.8	3.0	3.2	3.2	1.5

2. Experiment Setup and Outcomes

Table 2. Experiment Outcomes – Anonymous.

	G1	G2	G3	G4	G5	G6	G7	G8 (GT)
Num. Red (R)	4	9	6	3	2	3	5	0
Num. Green (G)	3	10	6	1	8	4	4	5
Payoff to Each Red (π_R)	2.2	1.8	2.0	3.0	1.6	2.4	2.4	N/A
Payoff to Each Green (π_G)	5.5	4.5	5.0	7.5	4.0	6.0	6.0	1.5
Total Payoff (π)	25.3	61.2	42.0	16.5	35.2	31.2	36.0	**7.5**
Average Payoff (π_{Ave})	3.6	3.2	3.5	4.1	3.5	4.5	4.0	**1.5**
Maximum Group Payoff (π_{max})	26.0	65.4	43.2	16.5	38.5	32.0	36.3	**19.5**
Maximum Average Payoff (π_{maxAve})	3.7	3.4	3.6	4.1	3.9	4.6	4.0	**3.9**

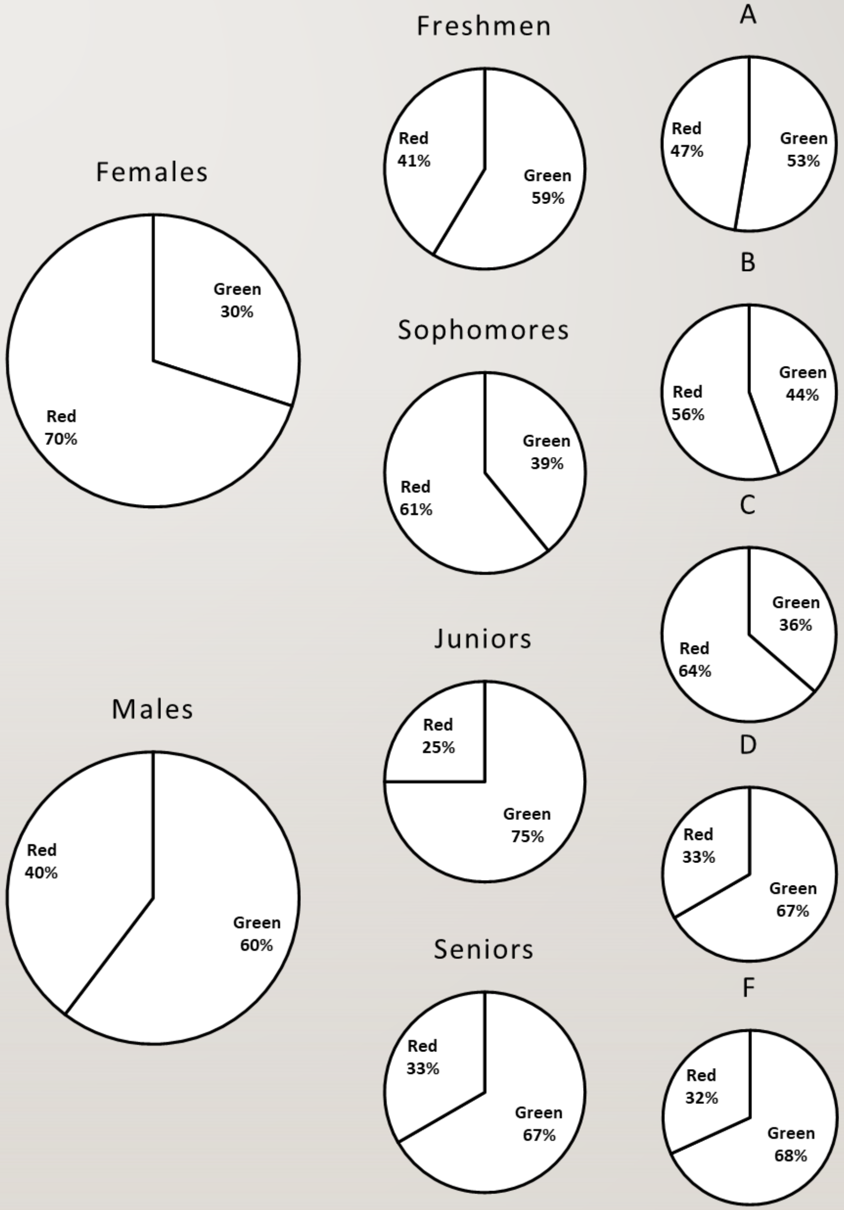
2. Experiment Setup and Outcomes

Table 3. Experiment Outcomes – Names Revealed.

	G1	*G2*	*G3*	*G4*	*G5*	*G6*	*G7*	*G8 (GT)*
Num. Red (R)	5	9	6	3	2	2	8	1
Num. Green (G)	2	10	6	1	8	5	1	4
Payoff to Each Red (π_R)	2.6	1.8	2	3	1.6	2.2	3	1.2
Payoff to Each Green (π_G)	6.5	4.5	5.0	7.5	4.0	5.5	**7.5**	3.0
Total Payoff (π)	26.0	61.2	42.0	16.5	35.2	31.9	31.5	**13.2**
Average Payoff (π_{Ave})	3.7	3.2	3.5	4.1	3.5	4.6	3.5	**2.6**
Maximum Group Payoff (π_{max})	26.0	65.4	43.2	16.5	38.5	32.0	36.3	**19.5**
Maximum Average Payoff (π_{maxAve})	3.7	3.4	3.6	4.1	3.9	4.6	4.0	**3.9**

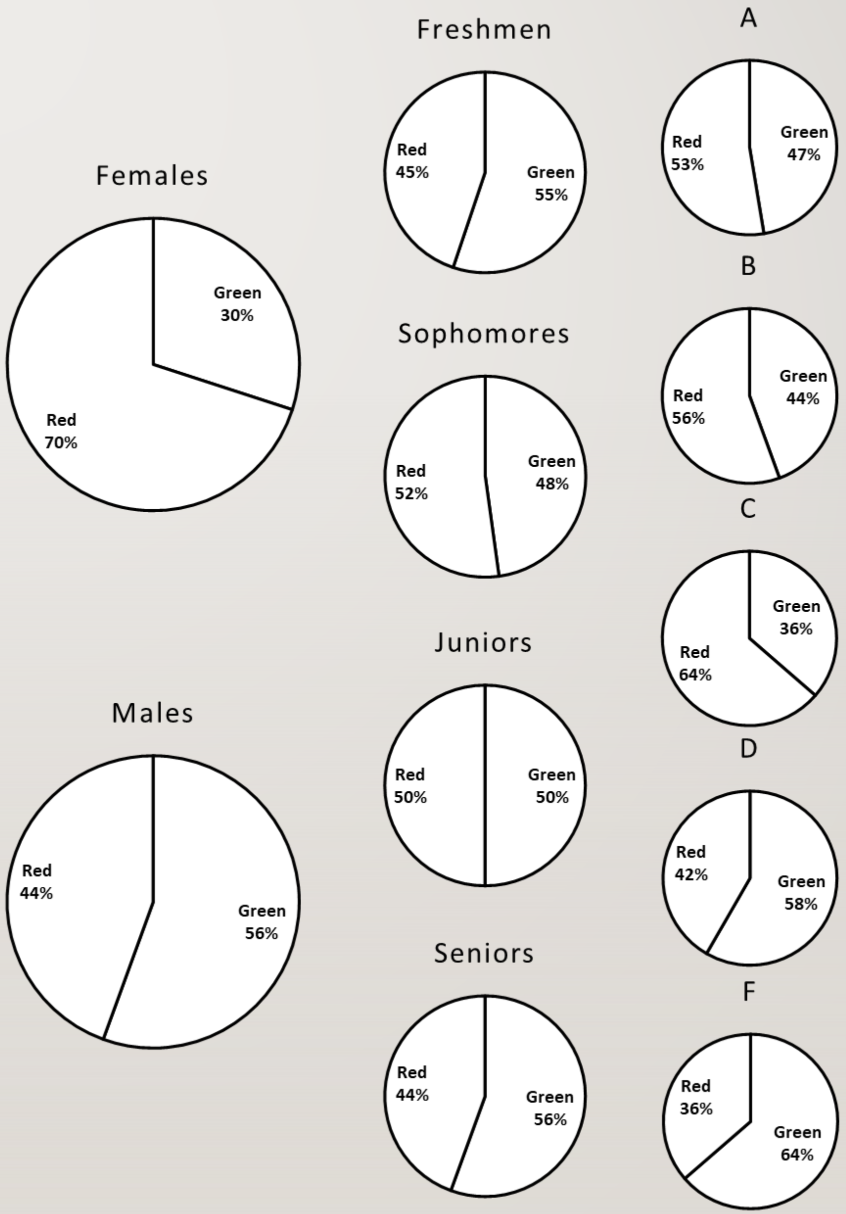
2. Experiment Setup and Outcomes

Figure 1. Action Clocks – Anonymous.



2. Experiment Setup and Outcomes

Figure 2. Action Clocks – Names Revealed.



3. In-class Applications

3.1. Inefficient Pure-Strategy Nash Equilibrium Outcomes

Table 2. Experiment Outcomes – Anonymous.

	G8 (GT)
Num. Red (*R*)	0
Num. Green (*G*)	**5**
Payoff to Each Red (π_R)	N/A
Payoff to Each Green (π_G)	1.5
Total Payoff (π)	**7.5**
Average Payoff (π_{Ave})	**1.5**
Maximum Group Payoff (π_{max})	**19.5**
Maximum Average Payoff (π_{maxAve})	**3.9**
Minimum Group Payoff (π_{min})	**7.5**
Minimum Average Payoff (π_{minAve})	**1.5**

- Many students are puzzled by the possibility that rational players might end up in Pareto-inferior equilibria (see Vriend 2000).
- Inefficient pure-strategy Nash equilibrium: all five in *G8* choose green, and none would be willing to switch to red on their own.
- Their average (or group) payoff is at the minimum level.
- What if there is concern that some participants may choose red?
  - Reduce the value for *a*;
  - Increase *l*;
  - Repeat the game multiple times.
- Once the results are announced and the red players see that their payoffs are lower, they will switch to green and approach the inefficient Nash equilibrium (see Holt and Laury 1997).

3. In-class Applications

3.2. Equality Versus Efficiency and Who "Deserves" More

Table 1. Experiment Setup.

	G1	*G2*	*G3*	*G4*	*G5*	*G6*	*G7*	*G8 (GT)*
Num. Students (*N*)	7	19	12	4	10	7	9	5
Initial Endowment (*I*)	3.0	3.0	4.0	1.5	6.0	9.0	7.0	3.0
Group Payoff If All Red (π_{red})	23.8	59.5	38.4	15.6	32.0	22.4	28.8	18.0
Maximum Group Payoff (π_{max})	26.0	65.4	43.2	16.5	38.5	32.0	36.3	19.5
Group Payoff If All Green (π_{green})	10.5	28.5	24.0	3.0	30.0	31.5	31.5	7.5

- The pursuit of equality, where all players contribute and benefit evenly by choosing red, results in a collective prosperity that is uniformly inferior to the efficient outcome ($\pi_{red} < \pi_{max}$).
- Similarly, if all players value individual rewards more than communal well-being and therefore choose green, then their combined wealth is less than optimal, as they each receive half of the initial endowment ($\pi_{green} < \pi_{max}$).

3. In-class Applications

3.2. Equality Versus Efficiency and Who "Deserves" More

Table 1. Experiment Setup.

	G1	*G2*	*G3*	*G4*	*G5*	*G6*	*G7*	*G8 (GT)*
Num. Red for π_{max} (R_{max})	5	14	8	3	5	1	4	4
Num. Green for π_{max} (G_{max})	2	5	4	1	5	6	5	1

- Efficiency, or maximum group payoff, results from a combination of strictly positive numbers of red and green players. Who supposedly deserves to be green and thus gain a higher payoff?
  - Given that higher risk is associated with higher expected return, perhaps players who need points the most are willing to risk more, hoping to improve their situation (grade in their case) significantly. Unsurprisingly, Figures 1 and 2 show that D and F students participating in our simulation are more likely to choose green.
  - If prior negotiation or group discussion is allowed, such approach will likely reveal that more charismatic players end up earning more points, which offers a way to extrapolate it to an entire society where more influential people do better for themselves.

3. In-class Applications

3.2. Equality Versus Efficiency and Who “Deserves” More

- Who supposedly deserves to be green and thus gain a higher payoff?
  - Zitelmann (2021) points out that lottery winners represent one of the most important categories of people who deserve to be rich according to surveys conducted in seven countries, including the United States.
  - Moreover, given the random nature of lotteries, winners are less envied than those who build their wealth based on merit. This paradoxical observation can be tested using a variation of our experiment:
    - In one iteration, students use their strategic skills, and,
    - In another iteration, the green action is dictated by the outcome of a random event (e.g., a six on a die roll).
    - Then, the red players are surveyed to compare their envy toward the richer green players, across the two scenarios.

3. In-class Applications

3.3. Government Redistribution Versus Private Charity to the Poor

- Roberts (1984) finds that there is more government redistribution than it is desired by altruists.
- One can test this result using a variant of our simulation:
  - A group of students are made aware that some of them (without revealing exactly who) struggle to pass the course and are encouraged to discuss among themselves how contributions from altruists (choosing red) can help improve their situation (grade in the course).
  - Once the results of the experiment are obtained, they can be compared to the case where the government (instructor) decides how the additional wealth is allocated (say, D and F students are green, while the rest are red).

3. In-class Applications

3.4. Why do People Cooperate?

- Fowler (2005) points out that it is more costly to cooperate with people you do not know, because contributors will also pay for the defectors, resulting in a "free-rider" problem for contributors.
- So, why do people still contribute and why has cooperation evolved in the history of humankind?
- In theory, as a game is repeated multiple times (especially if it is played anonymously), more and more people should choose to defect and reap the benefits of the public good without paying for it. This makes the public good diminish more and more, in the absence of government intervention.
- Fowler (2005) posits that there is a certain type of people, which he calls *moralists*, who ignore the nonparticipants and, even though they incur a cost for contributing to the public good, they receive a certain benefit from engaging in an altruistic behavior (in our case, choosing red).

3. In-class Applications

3.5. The Tragedy of the Commons

- The instructor can explain the "tragedy of the commons" based on the famous articles by Lloyd (1833) and Hardin (1968), where they describe how a resource is depleted if it becomes public (i.e., common) property and the government does not intervene to regulate it. This is an example of market failure.
- Quoting James Madison (1788) that "if men were angels, no government would be necessary" Hardin notes that not all men are angels. If only one non-angel acts in his own self-interest and uses the "commons" more than the others, this gives him a comparative advantage and unethical gains. That incentivizes other men to turn into non-angels as well, which depletes the public resource.
- Using our experiment, the instructor can emphasize that, even if initially some students choose red, seeing that the green players consistently outperform them, they will turn green (i.e., into non-angels) in subsequent rounds, which will reduce payoffs, indicating a partial deterioration of the common good.

4. Conclusions

- The economic way of thinking proves to be challenging for many undergraduate students who struggle to assimilate principles or models, even when they are not too abstract or math-intensive.
- One way to solve this problem is to adopt and adapt various in-class games, experiments, or simulations.
- Ideally, these activities:
  - Should be easy to implement and understand,
  - Their outcomes should match the theory's predictions, and, if possible,
  - They should provide a basis for future analyses, later in the semester.
- We believe that our linear adaptation of Bruehler, Grant, and Ghent's (2017) Red/Green simulation meets these criteria.

4. Conclusions

- The simple setup, presented in Section 2, asks for the values of six parameters:
  - number of students in the group
  - maximum individual reward
  - proportion of final wealth that goes to each green
  - proportion of final wealth that goes to each red
  - initial endowment
  - marginal group wealth for each red

  Based on these values and the binary choices made by participants, payoffs are calculated using equations (3) and (4).

- Our results tend to conform with Adam Smith's "invisible hand" theory, in the sense that while individual players are guided by self-interest, collective prosperity is near maximum levels.
- We further propose several in-class applications, from a more specialized exemplification of Pareto-inferior Nash equilibria, to a more general "tragedy of the commons." Other instructors will certainly be able to find additional applications, which they can employ either in introductory or in more advanced chapters or courses.

Thank you!