A Classroom Market for Extra Credit: a Semester-Long Experiment

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Abstract: This paper describes an innovative pedagogical technique, applicable to most economics courses, which offers students a deeper understanding of market equilibrium, inflation, real and nominal interest rates, intertemporal choice, and financial markets. Students earn extra credit by correctly answering in-class clicker questions; earned extra credit is pooled together for the entire class. Correctly answering questions also earns students classroom currency, which they can use to "purchase" extra credit from the pool. The creation and purchase of extra credit establishes an endogenous market system in which the price of extra credit clears the market. The experiment can be augmented with (i) a bank that allows students to borrow classroom currency, (ii) bonds to enable direct transfers between students, and (iii) stocks which produce randomly generated payouts.

Key words: in-class experiment, extra credit, classroom market, clicker questions

JEL classification: A22

This paper outlines a semester-long economics experiment in which students, using clicker quizzes as a production technology, create an endogenous market for extra credit (EC henceforth) that can be applied to their homework assignments and exams. Given the subpar outcomes of the traditional chalk-and-talk teaching practices (see, for example, Walstad and Allgood, 1999, Walstad and Rebeck, 2002, and Watts and Schaur, 2011), this methodology offers an alternative way for students to engage with economic principles without too much disruption to course content and structure.

One of the drawbacks of teaching economics (rather than, say, natural science) is the lack of lab work. Chemistry students, for example, can actually see how elements react with each other in labs, which supplements the material they learned during lectures. In economics, it is
much harder to run experiments that allow students to see the theory at work. To address this issue, many economics instructors have introduced in-class demonstrations into their courses.¹

A typical demonstration is set up as a double-sided auction in which students represent buyers and sellers.² Students walk around the classroom trying to find someone with whom to trade and subsequently negotiate a trade price. Such a demonstration can show students how markets price goods and allocate resources. Typically, student sellers are assigned a reservation price below which they are not willing to trade, and student buyers are assigned maximum values for the good above which they are not willing to buy. Given the artificial nature of these price assignments, most instructors introduce additional incentives for students to behave optimally. For example, in the field of experimental economics, many researchers offer participants monetary rewards for excelling in a market or game. However, paying for participation is feasible almost exclusively for faculty members with outside funding (and who are typically restricted by the conditions of the grant to exploring new economic questions). Other instructors may instead offer candy or other non-monetary rewards.

The EC generated by answering clicker questions, as described in this paper, offers a very inexpensive alternative reward to create a realistic market with properly aligned incentives. By answering questions in class, students create EC. The EC, however, is not transferred directly to the student who created it; instead, a market system is implemented to price EC and allocate it to the students who desire it the most. This market can be manipulated by the instructor to give students hands-on experience with many economic topics such as inflation expectations and game theory. Moreover, extensions of the experiment allow the instructor to add a financial intermediary, bonds, and stocks to the basic market framework, expanding the range of topics to risk aversion, hedging, and peer-to-peer lending.
In response to the forces of supply and demand and to the incentives set up by the instructor, students create market outcomes that can be immediately used as teaching moments. For example, demand for EC increases during exams, driving up its price; the instructor can use this outcome to illustrate the effect of a shift in demand on market equilibrium. Fluctuations in the price of EC throughout the semester can lead to a discussion of the optimal EC price, which can be derived using the basic concepts of game theory. Using the framework described in this paper, instructors can generate specific market outcomes and the corresponding teaching moments to fit into many different economics courses.

In addition to providing students with a personal incentive to behave optimally, this experiment is also more immersive than those traditionally used because it runs for the entire semester rather than for part of a class period. Thus, it is similar to the technique employed by Green (2014), who simulates a semester-long economy in his classroom, and Bergstrom and Miller (2000), who build an entire microeconomics course around experiments. The extended duration of the experiment allows students to become familiar with its framework, enabling them to critically think about the impact of economic forces on their welfare instead of focusing on the rules of the game.

Arguably, the easiest way to implement in-class quizzes is through clicker technology, which has been successfully integrated into many courses already; however, teachers are often reluctant to ask students to purchase yet another item for the class. As Imazeki (2014) points out, the ubiquitous nature of smart phones and the creation of free clicker apps have significantly reduced the startup costs of employing this technology.³

Clicker questions alone as a pedagogical tool provide a number of benefits. Salemi (2009) provides a thorough overview of the literature on clicker use and argues that students gain
a deeper understanding of economics in classes with clickers, since they are forced to engage
during lectures. Furthermore, if the responses to the clicker questions impact student grades, then
students have a positive incentive to attend class and pay attention to the material. If some of the
questions pertain to required readings, then students also have an incentive to read those
assignments in advance of the lecture, facilitating better discussion and improving retention
rates. The professor can also use the questions to obtain instant feedback on whether students
understand a concept immediately after it is explained in class. Finally, the questions can be used
to challenge students’ thinking in order to prepare them for a new topic. Hoekstra and Mollborn
(2012) provide evidence that a variety of pedagogical strategies—for example, facilitating
opportunities for group discussion, a la Mazur (1997), and identifying students’ preconceptions
about course material—can be improved by using clicker technology.

The appeal of combining clicker questions with the EC market—rather than counting the
questions as a portion of the students’ final grade, as in, for example, Salemi (2009)—is that
instructors can ask more challenging questions without upsetting students who may feel
underprepared for the material. Additionally, because students receive EC on a regular basis,
instructors are able to create more challenging assignments (homework and exams), since EC
will offset the lower average assignment grades. Table 1 demonstrates that, on average and given
the setup described below, students added 5-6 percentage points of EC to their overall grade.

[Insert Table 1 about here]

As an added benefit, after the implementation of the EC market, class attendance rose
considerably (compared with classes taught by the same instructor which did not feature this
experiment), with most students missing at most one lecture during the entire semester (see
Table 1). These rates are very similar to Salemi (2009), who notes that clicker use in his lectures
increased his class attendance to 92% compared with similar courses taught by other professors in his department that had 70-75% attendance rates.

The remainder of the paper is organized as follows. The next section describes the basic design of the experiment. I then discuss several extensions that allow the experiment to be tailored to different economics courses. The final section concludes.

**MARKET DESIGN**

Implementing the market described above takes relatively little class time. Approximately twenty minutes are required at the beginning of the semester to describe the project, and the occasional five minute segments are needed when assignments are due to describe the current state of the economy. For a class of approximately thirty students, the instructor should anticipate to spend about five to ten minutes after each lecture tabulating market outcomes and adjusting students’ grades. Larger class sizes typically have teaching assistants, who can significantly reduce the workload of the instructors when it comes to recording EC market transactions.4

The typical structure of a class in which this experiment has been used includes approximately six homework assignments due every two weeks, two midterm exams after the first and second thirds of the course, and one final exam. During regular class periods, three clicker questions are asked at approximately half hour intervals throughout the lecture. During classes that occur immediately before a test, ten clicker questions are asked as a form of test review. Students are not required to attend class, and attendance is not graded as such.

Clicker questions fall into four categories: attendance and attention, reading, understanding, and challenge. Attendance and attention questions credit students for simply showing up to class and paying attention to the lecture; thus, the questions are fairly easy.
next type of questions test whether a student did the required reading(s) before attending class. These questions are also relatively easy to answer as long as the student arrived to lecture prepared. Questions on understanding check whether a particular topic covered in class was understood by most students; Salemi (2009) calls these “Are you with me?” questions. The questions typically ask students to apply a theoretical model to a specific numerical question, and should be challenging enough to allow the instructor to discern if the material is understood at a sufficient level. Finally, challenge questions are designed to help students find flaws (if any) in their understanding of basic economic mechanisms. These questions can be used to start a discussion or introduce a new topic. It is not uncommon for the majority of students to answer the challenge questions incorrectly. Salemi (2009) adapted these types of questions for clickers from Mazur’s (1997) concept of peer instruction, because they afford students the opportunity to discuss material and learn from each other once the answer is revealed.

**Production and Supply**

Clicker questions are interpreted as the production technology of the classroom economy. Each student who attends class and correctly answers a question creates one point of EC. All EC points are then placed in a pool that will be accessible for the next graded assignment (homework or exam). EC is perishable: all points that are created on any given day can only be applied to the subsequent assignment. EC for homework assignments is created during regular classes, while EC for tests is created during review classes. Thus, the supply of EC is produced endogenously based on students’ attendance, preparedness, and understanding of the material. The allocation of this EC, however, depends on markets forces.

In a standard class, each student has the opportunity to produce between nine and twelve points of EC for a homework assignment (three clicker questions are asked during each of the
three to four lectures between homework assignments). Review sessions allow each student to produce up to ten points of EC. The total amount of EC given to a class on an assignment can be altered by changing the frequency of assignments, the number of clicker questions asked per class, or the difficulty of the questions. It is not recommended to make the questions too hard, however, as this may shut some students out of the market completely, as explained below.

**Wage Income and Demand**

Since students do not get to keep the EC that they have generated (it all goes into a commonly shared pool), they must be rewarded in some way for answering clicker questions correctly. To create the appropriate incentives, students are paid a “wage” for answering questions correctly. The wage level is exogenously determined by the instructor, but for most classes paying one unit of in-class currency for each point of EC created works quite well.

In all current uses of the experiment, the currency has been called Gronks (an homage to the author’s favorite NFL player, Rob Gronkowski of the New England Patriots). While instructors are free to use a different name for the in-class currency, it may be prudent to not use the term “dollar,” as it may appear to outside observers that students are paying actual money to get better grades. Additionally, the use of a point system based on the concept of wages grants the experiment an assessment aspect of gamification which may make students engage more in class. Deterding et al. (2011) suggest that gamification, which they define as “the use of game design elements in non-game contexts,” increases the level of participant engagement by making the experience more enjoyable (see Landers, 2014, for a more in-depth introduction to gamification and its components).

The instructor tracks individual currency holdings of the students in a spreadsheet and reports them in the same manner as regular grades (for example, via Blackboard). Unlike EC, the
classroom currency, henceforth Gronks, is not perishable. Thus, even though students must use all of the EC currently in the pool on the next assignment, they can save some of their Gronks for future use.

When an assignment is due, students are first informed of the current state of the economy. This information always includes the number of EC points in the pool and the aggregate number of Gronks currently held in the economy. Other pieces of information may include interest rates, borrowing limits, stock payouts, etc. See the extensions below for a full explanation of what may be included in the economic report.

After being apprised of the state of the classroom economy, students individually decide how many of their Gronks (if any) they wish to spend on EC for the assignment. They indicate their expenditure amount on the cover of their assignment right before it is turned in. The aggregate spending of the entire class on one assignment comprises the demand for EC.

Example: Mary, Sam, and Eric are the only students in the class. During a regular lecture, Mary correctly answers two of three clicker questions, Sam gets only one correct answer, and Eric gets all three. Six EC points (aggregate supply) are placed in the pool. Mary, Sam, and Eric earn 2, 1, and 3 Gronks, respectively, which are theirs to spend as they individually see fit. For the next homework, Mary wishes to spend both of her Gronks, Sam none, and Eric one, resulting in the aggregate demand of three Gronks.

Price of EC and Market Clearing

The EC market clears when the price of EC equates the quantity supplied, $S$, to the quantity demanded, $D$:

$$P = \frac{D}{S}$$
Here $D$ is measured in Gronks, while $S$ is measured in EC points. In the above example, since six points of EC are available on the assignment and students’ aggregate demand for extra credit is three Gronks, then the market clearing price of EC is 0.5 Gronks per EC.

In addition to determining the price of EC on a particular assignment, the market also allocates the EC from the pool. Since Mary spent two Gronks, she would be awarded four points of EC on the assignment in question; Sam does not buy any EC, and Eric receives two points. Forcing students to compete with one another for the EC in the pool adds the conflict aspect of gamification to the experiment, thereby increasing the level of student engagement, according to Landers (2014).

When handing the assignment back to the students, the instructor reveals the price of EC. Additionally, a second, weighted price can be announced, which tells students how many Gronks they would have to spend to add one point of EC to their overall course grade. The weighted price, $\rho$, of extra credit is given by the following equation:

$$\rho = \frac{P}{V}$$

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The weighted price of EC controls for the value of an assignment, $V$, so that all assignments can be compared regardless of their weight in the class. Suppose, for example, that the price of EC on the first midterm is 2 Gronks; at first glance, it may seem that adding EC to the homework (at the above price of 0.5) is a better deal. However, if the homework is worth 2 percent of the overall grade in the class and the midterm is worth 25 percent, then the weighted prices of EC are 25 and 8 Gronks per point, respectively. Thus, in the above example, each Gronk spent on the midterm increases the student’s overall grade by more points than each Gronk spent on the homework; of course, students cannot know the relative prices of EC until after they submit their desired expenditures.
The Bank of Extra Credit

The EC market is intertemporal, since students are allowed to save their earnings for future use. In order to fully take advantage of this feature, the instructor can easily add a bank (which I call the Bank of Extra Credit, or BEC) which adds the mechanics of debt, interest rates, and borrowing limits into the above framework.

Once the BEC is added to the setup, all students are assumed to keep their Gronks in the bank in the form of deposits. Each time period is represented by an assignment, with the final exam representing the last time period. When describing the state of the economy prior to an assignment, the instructor provides students with three additional pieces of information: the lending interest rate, \( i_l \), the borrowing interest rate, \( i_b \), and the borrowing limit, \( \bar{B} \).

The lending interest rate represents the return on savings that a student earns for not spending all of her Gronks on the current assignment. The borrowing interest rate represents the cost of spending more Gronks on the assignment than a student currently possesses. Interest earnings and payments are calculated immediately after the students choose their desired expenditure amounts, but before the Gronks for newly answered clicker questions are added to a student’s balance sheet.

Example: Continuing with the previous example, Sam and Eric would earn the lending interest rate (of, for example, 5 percent) on their savings of one and two Gronks, respectively. Thus, for the subsequent assignment, they would bring in 1.05 and 2.1 Gronks, respectively, in addition to any new earnings they may accrue during the next several lectures.

The borrowing limit allows the instructor to prevent students from becoming so indebted that they can never pay off their debts. This limit may start high at the beginning of the semester and be slowly reduced as the final exam approaches. Obviously, no borrowing is allowed on the
final exam. Finally, all loans are paid off automatically as soon as the student earns new Gronks in class.

The framework described above generates a market with endogenous demand and supply, in which students have a strong incentive to behave optimally. Appendices A, B, and C provide detailed instructions on how to set up the Excel spreadsheets needed to track the classroom economy, how the instructor should run the experiment in class, and what students need to know to participate in the market, respectively. I next describe several ways in which this setup can be used to supplement the teaching of economic principles.

**COURSE APPLICATIONS**

The real value of this tool lies in creating an endogenous market for EC that can be manipulated to illustrate various economic principles to students. The framework has been adapted to four different courses: microeconomic principles, microeconomic theory, macroeconomic principles, and money and banking. However, it can be easily used in a variety of other economics courses.

The following subsections are presented as a series of questions that instructors can pose in class, on homework assignments, or on exams. If the economic theory in question was tested within the framework, I also briefly analyze the results of the test. All questions have been vetted in the author’s courses, and only questions which led to productive discussion are included below. Appendix D contains a more in-depth discussion of how the market for EC connects to each of the questions below.

**Microeconomic Principles**

The most basic economics course, microeconomic principles, provides the ideal platform to discuss the fundamental structure of the market for EC. The application of the framework
focuses on the roles of supply and demand in determining the market clearing price and the allocation of EC. The BEC is not used in this course. The results for the microeconomic principles course are provided in Table 2.

Question 1: What should happen to the price of a good if it becomes more desirable?

Results 1: Figure 1, which tracks the price of EC in four microeconomic theory courses and one microeconomic principles course, clearly shows the spikes in the price of EC on the three exams.

Question 2: How does an increase in the number of clicker questions asked before an assignment impact the market for EC?

Results 2: Refer back to Figure 1. The number of clicker questions asked before homework assignments 1 and 2 was 12 and 9, respectively. The price of EC increased on the second assignment relative to the first for all courses.

Question 3: What is the price elasticity of supply for EC?

Question 4: How does the free rider problem impact the production of public goods?

Microeconomic Theory

In microeconomic theory, the BEC should be introduced on the first assignment due date. The borrowing limit in the setup outlined in the previous section starts at fifteen Gronks, is reduced to ten Gronks after the first midterm, further reduced to five Gronks after the second midterm, and finally reduced to zero Gronks for the final exam. Two applications have been developed for microeconomic theory courses: intertemporal choice and game theory. The results from a representative microeconomic theory course is provided in Table 3.
Question 1: How do interest rates influence borrowing and lending? How does inflation change these decisions?

Results 1: Before homework 3 is due in the microeconomic theory courses, the nominal interest rates are lowered from 5 percent for lenders and 10 percent for borrowers to 1 and 6 percent, respectively. Additionally, the wages paid on all of the days from the first midterm until the third homework are increased from one to two Gronks per correct answer. According to economic theory (see Appendix D for further discussion), current consumption should increase and, given the fixed supply of EC points, drive up the price of EC. Figure 2 plots the behavior of the weighted EC price over the course of the semester; as predicted, inflation expectations cause the price of EC on homework 3 to increase in all four courses (compare the price $\rho$ between rows Midterm 1 and HW3 in Table 3). Additionally, high inflation causes the \textit{ex-post} real interest rates to turn negative. More importantly, once it was announced that the wages will return to the original level (of one Gronk per correct answer) after homework 3, the price of EC for homework 4 returns to its midterm level, and the resulting deflation causes a sharp increase in the \textit{ex-post} real interest rates $r_l$ and $r_b$.

Question 2: What is the optimal strategy for getting as much EC added to your overall course grade as possible?

Results 2: Note that the analysis presented in Appendix D relies on three assumptions which do not hold in any of the courses: constant wages of one Gronk per EC, interest rates of zero, and constant EC amounts for all assignments. However, in the microeconomic principles course, only the last of these assumptions fails. According to the calculations in the appendix, a
course with six homework assignments, two midterms, and one final exam should have a
weighted price of approximately 9 Gronks per EC point. An analysis of the weighted price
movements throughout the semester (Figure 2, Principles I) reveals that it stays slightly above
the expected optimal level; however, a weighted average of the weighted price—9.2 Gronks per
EC—is very close to its predicted value. Moreover, Figure 2 shows that the volatility of the
weighted price of EC falls as the semester progresses, and its value approaches the optimal level.
Thus, students learn to anticipate the market fluctuations to avoid making suboptimal decisions.9

Macroeconomic Principles

The following questions were used in the first part of money and banking courses, but
since they cover concepts of inflation and intertemporal choice, they can be directly incorporated
into macroeconomic principles courses.

To help students better grasp the concept of inflation, it is recommended in this course to
have wages rise throughout the semester. They start off at one Gronk per correct question and
rise by one Gronk after every three lectures; by the end of the semester wages should reach
between eight and nine Gronks per correct clicker question. The BEC should be introduced later
in the semester, after the lecture on interest rates.

Question 1: What is the relationship between wage movements and inflation? Do higher
wages make you better off?

[Insert Figure 3 about here]

Results 1: Figure 3 shows the rise in wages creates a subsequent increase in the price of
EC over the course of the semester in two money and banking classes.10

Question 2: How should we measure inflation?
**Results 2:** Figure 3 shows the price of EC rising on each exam. However, from the perspective of a student trying to use EC to maximize her overall grade in the class, this is not the most helpful measure of inflation. Figure 4, which shows the behavior of the weighted price in the money and banking courses, reveals a different aspect of inflation. Once adjusted for the project weights, EC points are often cheaper during exams than on regular assignments.

[Insert Figure 4 about here]

**Question 3:** How does inflation impact your ability to plan for future spending?

**Results 3:** Compare Figure 2 and Figure 4. Clearly, in a market with almost no wage inflation (Figure 2) the weighted price of EC becomes fairly stable and predictable by the middle of the semester. On the other hand, a market with high wage inflation (Figure 4) is characterized by very volatile prices throughout the semester. Just like in the real world, high levels of inflation cause much of the information contained in prices to be lost.

**Question 4:** How do interest rates and inflation influence borrowing and lending? Who benefits from inflation: borrowers or lenders?

**Question 5:** How does a bank’s balance sheet change over time?

**Money and Banking**

The framework described in this paper was originally designed for a money and banking course; therefore, most of its applications are designed for this class. Ongoing wage inflation should be introduced immediately, as described in the previous subsection; the BEC should be added later in the semester once financial intermediaries are introduced during lecture. The market for EC allows the instructor to discuss the following topics: bonds, banking, stocks, risk, leverage, and hedging. All of the questions listed in the macroeconomic principles subsection may be added to the money and banking course as well.
**Bonds:** After the first two assignments are handed in (and the students have a good understanding of the functioning of the EC market), the instructor should discuss the effects of inflation of their saving/borrowing choices. Once students understand the resulting wealth redistribution between lenders and borrowers, they can begin borrowing and lending from one another. Right before turning in the third assignment, students should be given 1-2 minutes to participate in the bond market. The process is quite simple: students who wish to make a transaction with each other agree on the number of Gronks to be lent and repaid; these amounts represent the price \( P_B \) and the face value \( F_B \) of the bond, respectively. Students cannot set a repayment due date, since it is unknown how long it will take a borrower to earn enough Gronks to pay off his debt. Subsequently, both parties must agree on when the repayment is to take place before the instructor transfers any funds back to the lender. Repayment may occur in multiple installments. The nominal interest rate of each bond can be calculated as follows:

\[
i = \frac{F_B - P_B}{P_B}
\]

The EC market data generated in a representative money and banking course is shown in Table 4. The interest rates are calculated using equation (3); in case of multiple bond issues, only the last transaction is reported. If the BEC operates concurrently with a student-to-student bond issue, the table shows the bond interest rate (3); otherwise, the bank’s lending rate is listed. For any period when there was no borrowing, the nominal interest rate is assumed to be zero.

[Insert Table 4 about here]

**Question 1:** What are the considerations that go into determining the terms of a loan?

**Results 1:** The two money and banking classes were very small (fifteen and seven students, respectively), so there were only six bonds issued in the first course and zero bonds issued in the second course. Given the high levels of inflation throughout the semester, the
optimal strategy would have been to borrow more early in the semester and take advantage of the negative real interest rates. Interestingly, students typically issue loans to people engaged in the same extracurricular activity (soccer players lent to other soccer players, etc.). In the absence of loan repayment enforcement mechanism, students use their social networks to minimize adverse selection in the loanable funds market and increase the probability of repayment.

Question 2: How does the banking section improve the market for loanable funds in the economy?

**Stocks:** Stocks can be a fun and useful application of the experiment, but they should only be used if the instructor is willing to let a portion of the EC be randomly generated. Stocks pay off a random amount determined by the roll of a die before each assignment is due. Three different types of stock are used in the course: a safe stock, a risky stock, and a hedge stock. It is best to introduce stocks one at a time, preferably during review lectures right before exams.

Each unit of the safe stock pays off the roll of a six-sided die minus two points of EC; thus, the highest, lowest, and expected payouts are four, negative one, and 1.5 points of EC. All safe stocks pay out the same amount of EC. For each point of EC generated by a stock (which gets added to the EC pool), the student who owns the stock earns a number of Gronks equal to the current wage rate. A good time to introduce the safe stock is following the lecture on expected values and standard deviations.

The risky stock pays out the roll of a twenty-sided die minus eight. The expected payoff of this stock is 2.5 points of EC with a maximum of 12 points and a minimum of negative seven points.

The hedge stock pays out fourteen minus the roll of one six-sided die and minus the roll of one twenty-sided die in points of EC. The die results from the hedge stock come from the rolls
for the safe and risky stocks, respectively. For example, if the results of rolling the six- and the twenty-sided dice are 2 and 11, respectively, the safe, risky, and hedge stocks produce 0, 3, and 1 EC points, respectively. The expected value of the hedge stock is zero with a maximum of twelve and a minimum of negative twelve points. In order to avoid too much randomness in the EC production, it is advisable to introduce the hedge stock shortly after the risky stock.

Students purchase stocks from the instructor through a second-price sealed-bid auction. Each student who wishes to own the stock writes how much he is willing to pay for it on a piece of paper and hands it in to the professor (clickers can be used to speed up this process). The highest bidder receives one unit of the stock and pays the second highest bid price. The auction is repeated until all units of the stock are sold. The total number of stocks is determined by the instructor; five units of each type of stock are offered in the money and banking course.

After the “initial public offering” (IPO), students can buy and sell the stocks from each other; students should be given a few minutes to trade stocks before each assignment is handed in, and stock prices should be tracked by the instructor. After all trades have taken place, the stocks pay out their random production, and students’ Gronk holdings are adjusted accordingly.

**Question 3**: How do expected returns impact stock prices?

**Results 3**: The prices, trade volumes, and nominal returns of the three stocks are listed in Table 5; the listed prices represent the price of the last unit of stock bought (if no stocks were bought before assignment \( i \), the table lists the price of the stock bought before assignment \( i - 1 \)). As reflected in the low trade volumes, stocks were rarely traded; it is likely that a more efficient trading system with lower transaction costs can increase the number of trades (for example, using the clicker technology to collect and display bid and ask prices from the students).
stock (1) is issued early in the semester after the lecture on stocks, while the risky (2) and the hedge stocks (3) are offered later in the semester following the discussion of leverage, risk spreading, and risk hedging. Based on equation (4) in Appendix D, a risk-neutral student in the money and banking course should have been willing to pay 13 and 55 Gronks at the time of issuance for the safe and risky stocks, respectively. The actual price during the IPO turned out to be much lower, as shown in Table 5, suggesting that students are risk-averse. A risk-neutral student should price the hedge stock at zero Gronks.

[Insert Table 5 about here]

**Question 4:** How does risk impact stock prices?

**Results 4:** The data in Table 5 can be used to calculate students’ approximate level of risk aversion. For the safe stock, the market price corresponds to 54 percent discounting, while the risky stock is discounted by 78 percent. Quite intuitively, higher level of risk results in a larger degree of discounting.

**Question 5:** How does co-movement between stock payouts impact their prices? How can you structure your portfolio to minimize risk?

**Results 5:** Even though the hedge stock is risky and has an expected payoff of zero, students find it attractive because it allows them to lower their portfolio risk. This finding illustrates the value agents place on stocks with negative betas (i.e., whose payouts are negatively correlated with aggregate market indices).

The final subject that may be covered in this course is high frequency and insider trading; however, it is not advisable to allow students to actually become high frequency or insider traders. The instructor can explain high frequency trading as being akin to allowing several students to see how much everyone else is spending on EC on an assignment before deciding
how much they would like to spend. Obviously, this gives an advantage to the high frequency traders since they can buy EC when its price is low and defer their purchases when the price is high. Insider trading can be modeled by allowing a few students to observe the value of the stock dice rolls before trading starts. The instructor should point out that the identity of the inside traders would have to be kept secret or no one would be willing to trade with them (in accordance with the no-trade theorem demonstrated in Milgrom and Stokey, 1982).

**CONCLUSIONS**

By combining the established teaching techniques of in-class clicker questions and market simulations, the experiment detailed in this paper allows students to experience economics in a tactile manner while properly incentivizing them to attend class, do the assigned readings, and pay close attention to the in-class lectures and discussion. In addition to these benefits, the creation of a market for extra credit (EC) in the classroom provides ample teaching moments to connect economic theories developed during lectures to market simulations. The baseline experiment takes very little time to run; however, a number of extensions allow students to experience firsthand the forces of supply and demand, the functioning of bond and stock markets, the effects of inflation on borrowing and lending, and the pros and cons of financial intermediation.

The results of running the experiment have been very encouraging. Although hard to gauge without a formal controlled experiment, it appears that students gain a deeper understanding of the forces of supply and demand throughout the course of the semester. The convergence of the weighted price of EC to its theoretically predicted Nash equilibrium value over the course of the semester, as well as the concurrent reduction in its variance, indicate that students become better at anticipating market behavior and incorporating expectations into their
choices. Additionally, student feedback has been almost unanimously positive, with many students noting that the in-class currency is the best part of the course.\textsuperscript{14}

Two other useful features of the EC framework were hinted at but not explored in depth in this paper, and thus offer promising avenues for further study. The first is the opportunity this framework affords economics instructors to assess the depth of students’ understanding of various economic mechanisms. For example, when wages for EC questions rise steadily during the semester, many students appear to not fully grasp the redistributive effects of inflation and therefore do not borrow to take advantage of the negative real interest rates. This observation may prompt the instructor to spend more class time on the Fisher equation and the optimal consumption-savings decisions.

Second, the EC market can be adopted by researchers as another tool for conducting behavioral economics experiments. Such experiments typically rely on monetary rewards—which often have to be very substantial—to elicit effort on the part of the participants. Using Gronks, on the other hand, is a virtually free way to generate genuine incentives for students to behave optimally. Students are clearly motivated by their course grade, and granting Gronks for behaving optimally does not add any EC to the pool. The caveat is that such experiments must be embedded in a course which already uses the Gronks framework.
Table 1: Extra Credit Statistics

<table>
<thead>
<tr>
<th>Course</th>
<th>Mean</th>
<th>Median</th>
<th>St. Dev.</th>
<th>Min.</th>
<th>Max.</th>
<th>Students</th>
<th>Attendance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microeconomic Principles</td>
<td>5.86</td>
<td>5.94</td>
<td>1.00</td>
<td>3.76</td>
<td>7.94</td>
<td>28</td>
<td>91%</td>
</tr>
<tr>
<td>Microeconomic Theory I</td>
<td>5.05</td>
<td>4.76</td>
<td>1.58</td>
<td>3.10</td>
<td>9.36</td>
<td>28</td>
<td>91%</td>
</tr>
<tr>
<td>Microeconomic Theory II</td>
<td>5.26</td>
<td>5.32</td>
<td>1.47</td>
<td>1.97</td>
<td>8.00</td>
<td>30</td>
<td>96%</td>
</tr>
<tr>
<td>Microeconomic Theory III</td>
<td>5.21</td>
<td>5.14</td>
<td>1.72</td>
<td>2.20</td>
<td>8.89</td>
<td>24</td>
<td>96%</td>
</tr>
<tr>
<td>Microeconomic Theory IV</td>
<td>5.52</td>
<td>5.92</td>
<td>1.42</td>
<td>2.68</td>
<td>7.61</td>
<td>28</td>
<td>93%</td>
</tr>
<tr>
<td>Money and Banking I</td>
<td>6.70</td>
<td>6.63</td>
<td>1.47</td>
<td>4.07</td>
<td>9.23</td>
<td>13</td>
<td>93%</td>
</tr>
<tr>
<td>Money and Banking II</td>
<td>6.88</td>
<td>6.25</td>
<td>2.45</td>
<td>4.03</td>
<td>10.76</td>
<td>7</td>
<td>90%</td>
</tr>
</tbody>
</table>

*Notes:* These statistics indicate how much extra credit as a percent of his or her total grade a student in each course gained from participating in the experiment. Both sections of money and banking included the use of stocks (see subsection on money and banking), increasing the total and average extra credit awarded in the course.
Table 2: Microeconomic Principles

<table>
<thead>
<tr>
<th>Assignment</th>
<th>EC awarded (EC)</th>
<th>Wage</th>
<th>Gronks spent (G)</th>
<th>$P$</th>
<th>$\rho$</th>
<th>$\pi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW1</td>
<td>193</td>
<td>1.00</td>
<td>28</td>
<td>0.15</td>
<td>4.84</td>
<td>-</td>
</tr>
<tr>
<td>HW2</td>
<td>102</td>
<td>1.00</td>
<td>42</td>
<td>0.41</td>
<td>13.73</td>
<td>184%</td>
</tr>
<tr>
<td>Midterm 1</td>
<td>176</td>
<td>1.00</td>
<td>258</td>
<td>1.47</td>
<td>5.86</td>
<td>-57%</td>
</tr>
<tr>
<td>HW3</td>
<td>161</td>
<td>1.00</td>
<td>85</td>
<td>0.53</td>
<td>17.60</td>
<td>200%</td>
</tr>
<tr>
<td>HW4</td>
<td>185</td>
<td>1.00</td>
<td>74</td>
<td>0.40</td>
<td>13.33</td>
<td>-24%</td>
</tr>
<tr>
<td>Midterm 2</td>
<td>151</td>
<td>1.00</td>
<td>292</td>
<td>1.93</td>
<td>7.74</td>
<td>-42%</td>
</tr>
<tr>
<td>HW5</td>
<td>190</td>
<td>1.00</td>
<td>62</td>
<td>0.33</td>
<td>10.88</td>
<td>41%</td>
</tr>
<tr>
<td>HW6</td>
<td>175</td>
<td>1.00</td>
<td>62</td>
<td>0.35</td>
<td>11.81</td>
<td>9%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>163</td>
<td>1.00</td>
<td>593</td>
<td>3.64</td>
<td>11.37</td>
<td>-4%</td>
</tr>
</tbody>
</table>

Notes: Wage reported in the table represents the average of the wages between the two most recent assignments. $\bar{P}$ and $\rho$ denote the nominal (Gronks per point of EC) and weighted (Gronks per each point added to the overall class grade) prices. $\pi$ measures the growth rate of the weighted price $\rho$. There are 28 students in the course.
Table 3: Microeconomic Theory

<table>
<thead>
<tr>
<th>Assignment</th>
<th>EC</th>
<th>Wage</th>
<th>G</th>
<th>P</th>
<th>$\rho$</th>
<th>$\pi$</th>
<th>$i_l$</th>
<th>$i_b$</th>
<th>$r_l$</th>
<th>$r_b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW1</td>
<td>235</td>
<td>1.00</td>
<td>105</td>
<td>0.45</td>
<td>22.34</td>
<td>-</td>
<td>5%</td>
<td>10%</td>
<td>-22%</td>
<td>-18%</td>
</tr>
<tr>
<td>HW2</td>
<td>110</td>
<td>1.00</td>
<td>66</td>
<td>0.60</td>
<td>30.00</td>
<td>34%</td>
<td>5%</td>
<td>10%</td>
<td>366%</td>
<td>388%</td>
</tr>
<tr>
<td>Midterm 1</td>
<td>165</td>
<td>1.00</td>
<td>279</td>
<td>1.69</td>
<td>6.76</td>
<td>-77%</td>
<td>1%</td>
<td>6%</td>
<td>-79%</td>
<td>-78%</td>
</tr>
<tr>
<td>HW3</td>
<td>142</td>
<td>2.00</td>
<td>91</td>
<td>0.64</td>
<td>32.04</td>
<td>374%</td>
<td>1%</td>
<td>6%</td>
<td>438%</td>
<td>464%</td>
</tr>
<tr>
<td>HW4</td>
<td>191</td>
<td>1.00</td>
<td>23</td>
<td>0.12</td>
<td>6.02</td>
<td>-81%</td>
<td>1%</td>
<td>6%</td>
<td>-59%</td>
<td>-56%</td>
</tr>
<tr>
<td>Midterm 2</td>
<td>128</td>
<td>1.00</td>
<td>469</td>
<td>3.66</td>
<td>14.66</td>
<td>143%</td>
<td>5%</td>
<td>10%</td>
<td>201%</td>
<td>215%</td>
</tr>
<tr>
<td>HW5</td>
<td>166</td>
<td>1.00</td>
<td>17</td>
<td>0.10</td>
<td>5.12</td>
<td>-65%</td>
<td>5%</td>
<td>10%</td>
<td>-53%</td>
<td>-51%</td>
</tr>
<tr>
<td>HW6</td>
<td>136</td>
<td>1.00</td>
<td>31</td>
<td>0.23</td>
<td>11.40</td>
<td>123%</td>
<td>5%</td>
<td>10%</td>
<td>41%</td>
<td>48%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>166</td>
<td>1.00</td>
<td>534</td>
<td>3.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-26%</td>
</tr>
</tbody>
</table>

Notes: Wage reported in the table represents the average of the wages between the two most recent assignments. $P$ and $\rho$ denote the nominal (Gronks per point of EC) and weighted (Gronks per each point added to the overall class grade) prices. $\pi$ measures the growth rate of the weighted price $\rho$. The nominal borrowing and lending rates are indicated by $i_b$ and $i_l$, respectively. The ex-post real lending interest rate is calculated as $r_{lt} = \frac{1+i_{lt}}{1+\pi_{t+1}} - 1$; the real borrowing rate $r_b$ is calculated analogously. There are 28 students in the course.
### Table 4: Money and Banking

<table>
<thead>
<tr>
<th>Assignment</th>
<th>EC</th>
<th>Wage</th>
<th>$\pi_w$</th>
<th>G</th>
<th>$P$</th>
<th>$\rho$</th>
<th>$\pi$</th>
<th>$i$</th>
<th>$r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW1</td>
<td>69</td>
<td>1.00</td>
<td>-</td>
<td>41</td>
<td>0.59</td>
<td>35.65</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HW2</td>
<td>91</td>
<td>1.69</td>
<td>69%</td>
<td>98</td>
<td>1.08</td>
<td>64.62</td>
<td>81%</td>
<td>25%</td>
<td>144%</td>
</tr>
<tr>
<td>HW3</td>
<td>58</td>
<td>2.33</td>
<td>38%</td>
<td>32</td>
<td>0.55</td>
<td>33.10</td>
<td>-49%</td>
<td>0%</td>
<td>129%</td>
</tr>
<tr>
<td>Midterm 1</td>
<td>107</td>
<td>3.00</td>
<td>29%</td>
<td>309</td>
<td>2.89</td>
<td>14.44</td>
<td>-56%</td>
<td>30%</td>
<td>-84%</td>
</tr>
<tr>
<td>HW4</td>
<td>59</td>
<td>3.41</td>
<td>14%</td>
<td>114</td>
<td>1.93</td>
<td>115.93</td>
<td>703%</td>
<td>25%</td>
<td>2%</td>
</tr>
<tr>
<td>HW5</td>
<td>63</td>
<td>4.00</td>
<td>17%</td>
<td>149</td>
<td>2.37</td>
<td>141.90</td>
<td>22%</td>
<td>5%</td>
<td>273%</td>
</tr>
<tr>
<td>HW6</td>
<td>111</td>
<td>5.00</td>
<td>25%</td>
<td>74</td>
<td>0.67</td>
<td>40.00</td>
<td>-72%</td>
<td>10%</td>
<td>-11%</td>
</tr>
<tr>
<td>Midterm 2</td>
<td>122</td>
<td>6.00</td>
<td>20%</td>
<td>1210</td>
<td>9.92</td>
<td>49.59</td>
<td>24%</td>
<td>20%</td>
<td>-53%</td>
</tr>
<tr>
<td>HW7</td>
<td>107</td>
<td>6.23</td>
<td>4%</td>
<td>224</td>
<td>2.09</td>
<td>125.61</td>
<td>153%</td>
<td>20%</td>
<td>16%</td>
</tr>
<tr>
<td>HW8</td>
<td>85</td>
<td>7.00</td>
<td>12%</td>
<td>184</td>
<td>2.16</td>
<td>129.88</td>
<td>3%</td>
<td>0%</td>
<td>-16%</td>
</tr>
<tr>
<td>HW9</td>
<td>88</td>
<td>8.00</td>
<td>14%</td>
<td>227</td>
<td>2.58</td>
<td>154.77</td>
<td>19%</td>
<td>0%</td>
<td>129%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>115</td>
<td>8.00</td>
<td>0%</td>
<td>2331</td>
<td>20.27</td>
<td>67.57</td>
<td>-56%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** Wage reported in the table represents the average of the wages between the two most recent assignments. $P$ and $\rho$ denote the nominal (Gronks per point of EC) and weighted (Gronks per each point added to the overall class grade) prices. $\pi$ and $\pi_w$ measure the growth rate of the weighted price $\rho$ and the wage, respectively. The nominal and real interest rates are indicated by $i$ and $r$, respectively. There are 13 students in the course.
Table 5: Money and Banking Stocks

<table>
<thead>
<tr>
<th>Assignment</th>
<th>$P_1$</th>
<th>$R_1$</th>
<th>$Vol_1$</th>
<th>$P_2$</th>
<th>$R_2$</th>
<th>$Vol_2$</th>
<th>$P_3$</th>
<th>$R_3$</th>
<th>$Vol_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW1</td>
<td>6</td>
<td>0</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HW2</td>
<td>25</td>
<td>-4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HW3</td>
<td>25</td>
<td>10</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HW4</td>
<td>25</td>
<td>24</td>
<td>0</td>
<td>12</td>
<td>-30</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HW5</td>
<td>25</td>
<td>28</td>
<td>0</td>
<td>12</td>
<td>63</td>
<td>0</td>
<td>5</td>
<td>-63</td>
<td>5</td>
</tr>
<tr>
<td>HW6</td>
<td>25</td>
<td>10</td>
<td>0</td>
<td>12</td>
<td>-35</td>
<td>0</td>
<td>1</td>
<td>35</td>
<td>3</td>
</tr>
<tr>
<td>HW7</td>
<td>20</td>
<td>24</td>
<td>1</td>
<td>15</td>
<td>-32</td>
<td>1</td>
<td>1</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>HW8</td>
<td>20</td>
<td>28</td>
<td>0</td>
<td>15</td>
<td>80</td>
<td>0</td>
<td>1</td>
<td>-72</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes: $P_i$, $R_i$, and $Vol_i$ denote the price, payout (calculated as Wage times the result of the appropriate die roll), and trade volume of the safe ($i = 1$), risky ($i = 2$), and hedge ($i = 3$) stocks. There are 13 students in the course.
FIGURES

Figure 1: Evolution of EC Price for Microeconomic Principles and Theory

Notes: This figure represents the evolution over the course of the semester of the price of EC for microeconomic principles and microeconomic theory.
Figure 2: Weighted Prices of EC for Microeconomic Principles and Theory

Notes: This figure represents the evolution over the course of the semester of the weighted price of EC for microeconomic principles and microeconomic theory.
Figure 3: Prices and Wages for Money and Banking

Notes: This figure represents the evolution over the course of the semester of the price of EC and the wages for money and banking.
Notes: This figure represents the evolution over the course of the semester of the weighed price of EC for money and banking.
APPENDIX A: Accounting Note

A pre-set Excel file to accompany these instructions is available from the author upon request. It is recommended that instructors use Socrative (Socrative.com) to administer in-class clicker questions, since the application reports the outcomes in an Excel file easy transfer into the master spreadsheet. Below, I describe the setup of the spreadsheet used to track the EC economy described in the body of the paper. Instructions in **bold** must be completed by the instructor either at the beginning of the semester, after an assignment is turned in, or after each lecture.

The Excel file contains four sheets: Cover, Gronks, Assignments, and Labor. Other sheets can be added later to track the BEC, bonds, and each of the stocks. In the screenshots below, items that must be entered by the instructor are highlighted in red; everything else is automatically calculated by the program.

1. **Determine the number of students, lectures, and assignments in the course.**

   **Assignments must each be given a weight in the total course grade.**

   a. Example: 30 students, 24 lectures, and nine assignments. Each of six homework assignments is worth 4%, each of two midterms is worth 20%, and the final exam is worth 36%.

2. The Labor sheet consists of one row per student, and two columns (Production and Income) for each lecture.
a. Wages: Each lecture is assigned a wage (Gronks per correct answer). The wages can be chosen at the beginning of the semester or as the course progresses.

b. Production columns: Input the number of Socrative questions correctly answered by each student \( i \) after each lecture \( k \): \( S_{i,k} \).

i. During the first lecture, Anne, Ben, and Catherine correctly answered 3, 3, and 2 questions, respectively (column C).

c. Income columns: Each student’s wage income for each lecture is calculated as
\[ WI_{i,k} = S_{i,k} \times W_k. \]

i. During the fifth lecture, Anne, Ben, and Catherine correctly answered 3, 0, and 3 questions, respectively (column K).

ii. Given \( W_5 = 2 \), the students’ incomes are 6, 0, and 6 Gronks, respectively (column L).

d. At the beginning of the semester, lectures should be split into groups to clearly indicate the assignment to which the EC is to be applied.

i. Example: Lectures 1-4 create EC for homework 1, lectures 5-7 create EC for homework 2, lecture 8 creates EC for midterm 1, etc.

3. The Assignments sheet consists of one row per student, and two columns (Spending and EC) for each assignment.
a. Supply: Above each assignment \( t \), individual student productions from the appropriate lectures are summed: \( S_t = \sum_i \sum_{k \in t} S_{i,k} \).

i. From item 2.b.i. above, \( S_1 = 3 + 3 + 2 = 8 \) (cell C1).

b. Spending column: **Instructor will record the number of Gronks spent by each student after the assignment is turned in**: \( D_{i,t} \).

i. On the first assignment, Anne, Ben, and Catherine spend 2, 1, and 1 Gronks, respectively (column C).

c. Demand: Above each assignment, individual student demands for each assignment are summed: \( D_t = \sum_i D_{i,t} \).

i. Calculate aggregate demand as \( D_1 = 2 + 1 + 1 = 4 \) Gronks (cell C2).

d. Price of EC: For each assignment, use equation (1) to calculate the market clearing price of EC.

i. \( P_1 = \frac{D_1}{S_1} = \frac{4}{8} = 0.5 \) Gronks per EC (cell C3).

e. EC column: Automatically calculates the EC earned by each student as \( EC_{i,t} = \frac{D_{i,t}}{P_t} \), rounded to the nearest EC point for simplicity (for example, column D).
Instructors should transcribe these numbers onto the graded assignments before handing them back.

4. The Gronks sheet (populated automatically) consists of one row per student, with columns to record wage income, interest, stock returns, spent and current Gronks, and current outstanding bonds.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Last Name</td>
<td>First Name</td>
<td>Wages</td>
<td>Interest</td>
<td>Stock Returns</td>
<td>Loans</td>
<td>Spent</td>
<td>Bonds</td>
<td>Current</td>
</tr>
<tr>
<td>2</td>
<td>Anne</td>
<td>$ 9.00</td>
<td>$ (1.00)</td>
<td>$ 2.00</td>
<td>-</td>
<td>$ 2.00</td>
<td>$ 1.00</td>
<td>$ 7.00</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Ben</td>
<td>$ 3.00</td>
<td>$ 1.00</td>
<td>-</td>
<td>-</td>
<td>$ 5.00</td>
<td>$ (1.00)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Catherine</td>
<td>$ 8.00</td>
<td>-</td>
<td>-</td>
<td>$ 3.00</td>
<td>-</td>
<td>-</td>
<td>$ 5.00</td>
<td></td>
</tr>
</tbody>
</table>

a. Wages column: Calculates cumulative income from the beginning of the semester for each student as $Wl_t = \sum_k Wl_{t,k}$.

i. According to the Labor sheet above, Anne earned 3 Gronks during lecture 1 and 6 Gronks during lecture 5, giving her a total of 9 Gronks (cell C2).

b. Interest column: Sums students’ returns ($l_t$) from the Bonds and the BEC sheets, if available. See below for more details.

c. Stock Returns column: Sums students’ returns ($R_t$) from stock trading and stock payouts, if available. See below for more details.

d. Loans column: Students’ outstanding loans from the BEC, if available. See below for more details.
e. Spent column: Calculates each student’s cumulative spending on all assignments as
   \[ D_i = \sum_t D_{i,t}. \]
   i. According to the Assignments sheet above, Anne spent 2 Gronks on assignment 1 and 0 Gronks on assignment 2, resulting in the cumulative spending of 2 Gronks (cell F2).

f. Bonds column: Tracks the net outstanding bond holdings of each student.

g. Current column: Total Gronks currently available, calculated as \( \text{Current}_i = Wl_i + I_i + R_i + \text{Loans}_i - D_i - \text{Bonds}_i. \) This number should be made available to students (for example, via Blackboard) before each assignment is turned in.

5. The Cover sheet (populated automatically) consists of one row per assignment, with columns for supply, demand, price of EC, weighted price of EC, inflation, wages, wage inflation, nominal lending rate, nominal borrowing rate, real lending rate, and real borrowing rate. Additionally, it displays the aggregate money supply.

<table>
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a. Supply column (\( S_t \) defined in 3.a.): Transcribes the aggregate supply numbers from the Assignments sheet for ease of reference.
b. Spending column ($D_t$ defined in 3.c.): Transcribes the aggregate demand numbers from the Assignments sheet.

c. Price of EC column ($P_t$ from 3.d.): Transcribes the market clearing price of EC from the Assignments sheet.

d. Value of assignment column ($V_t$): **Determined by instructor at the beginning of the semester.**

e. Weighted Price of EC column: Calculated from equation (2).

   i. For example, $\rho_1 = \frac{0.5}{0.1} = 5$ Gronks per EC on final grade.

f. Inflation column: Rate of change of the weighted price of EC, $\pi_t = \frac{P_t - P_{t-1}}{P_{t-1}}$.

g. Average Wage column: the average wage paid during an assignment period, calculated as $\overline{W}_t = \frac{\sum_{k=1}^{K} W_{i,k} I_{i,k} \cdot \sum_{k=1}^{K} S_{i,k}}{\sum_{k=1}^{K} \sum_{i=1}^{I} I_{i,k} \cdot \sum_{k=1}^{K} S_{i,k}}$, with both $W_{i,k}$ and $S_{i,k}$ defined in item 2 above.

h. Wage Inflation column: Rate of change of the average wage, $%\Delta \overline{W}_t = \frac{\overline{W}_t - \overline{W}_{t-1}}{\overline{W}_{t-1}}$.

i. Nominal Lending Rate column ($i_{l,t}$): Transcribes the interest paid on savings from the BEC sheet, if available, zero otherwise. See below for more details.

j. Nominal Borrowing Rate column ($i_{b,t}$): Transcribes the interest charged on loans from the BEC sheet, if available, zero otherwise. See below for more details.

k. Real Lending Rate column: Calculated as $r_{l,t} = \frac{i_{l,t} + 1}{\pi_{t+1} + 1} - 1$. If the BEC is not available, set $i_{l,t} = 0$.

l. Real Borrowing Rate column: Calculated as $r_{b,t} = \frac{i_{b,t} + 1}{\pi_{t+1} + 1} - 1$. If the BEC is not available, set $i_{b,t} = 0$. 
m. Money Supply: Sum of the Current column from the Gronks sheet; measures the total number of Gronks in the economy.

6. The BEC sheet consists of three tables. Additionally, it displays the BEC’s cash and equity.

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a. The Savings table consists of one row per student, with columns for deposits, loans, and returns.

i. Deposits column: All current Gronk holdings of each student are assumed to be held in the BEC as a deposit; therefore, this column repeats the Current column from the Gronks sheet.
ii. Loans column: If a student spends more Gronks on an assignment than she has, reflected by a negative entry in the Deposits column (C), it is assumed that the balance is financed by a loan from the BEC. **Enter the corresponding loan amount into the Loans column (D) to offset the negative value in the Deposit column.**

1. For example, on assignment 2, \(i_l = 10\%\) and \(i_b = 20\%\).

iii. The Returns column: Cumulative returns from the Interest Paid table (see below). It is linked to the Interest column on the Gronks sheet, as explained in item 4.b. above.

b. The Current Interest table consists of one row per student, and two columns per assignment.

   i. Lending and Borrowing Interest Rates: **Above each assignment column,** enter the nominal interest rates \(i_l\) and \(i_b\). These can be determined at the beginning of the semester or as the course progresses.

   ii. Savings Return column: The product of the Deposits column and \(i_l\).

   iii. Borrowing Cost column: The negative product of the Loans column and \(i_b\).

c. The Interest Paid table copies the values from the Current Interest table.

   i. **After the spending amounts** \(D_{lt}\) **are entered into the Assignments sheet, and after loans are issued to offset any negative deposit account balances, copy and paste special (values) the Savings Return column and the Borrowing Cost column into the corresponding columns of the Interest Paid table.**
ii. For example, Anne’s holds 7 Gronks as deposits at the BEC after Midterm 1 and earns 0.70 Gronks in interest (cell M3 in Screenshot 1). After the Interest Paid table is updated (Screenshot 2), her deposits rise to 7.70 Gronks (cell C3).

d. Bank Capital and Cash

i. Bank Capital is calculated as the **starting equity amount chosen at the beginning of the semester** (for example, 1000 Gronks) minus the sum of the Returns column (which measures cumulative net interest paid to all students since the beginning of the semester).

ii. Bank Cash is the sum of the Deposits column plus the Bank Capital minus the sum of the Loans column.

iii. For example, once a total of 1.20 Gronks in interest is paid out to Anne and Catherine after midterm 1, bank capital falls to 998.80 Gronks (compare screenshots 1 and 2).

7. The Bonds sheet consists of two tables.

<table>
<thead>
<tr>
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<th>A</th>
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<tbody>
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<td>1</td>
<td>Bonds</td>
<td>Outstanding Debt</td>
<td>Outstanding Loans</td>
<td>Returns Earned/Lost</td>
<td>Period</td>
<td>Borrower</td>
<td>Lender</td>
<td>Price</td>
<td>Face Value</td>
<td>Repayment Period</td>
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</table>

a. Bonds table consists of one row for each student, and columns for outstanding debt, outstanding loans, and returns earned/lost.
i. Outstanding Debt column: **When a student issues a bond, enter the price of the bond in this column. When the bond is repaid, reduce to zero.**

ii. Outstanding Loan column: **When a student buys a bond, enter the price of the bond in this column. When the bond is repaid, reduce to zero.**

The Bonds column in the Gronks sheet is automatically calculated as Outstanding Loans minus Outstanding Debt.

iii. Returns Earned/Lost column: **When a bond is repaid, enter the difference between the price and the face value of the bond in bond issuer’s row, and the difference between the face value and the price in the bond buyer’s row. Returns of multiple bonds should be summed together.**

iv. For example, Ben has an outstanding bond issued to Anne at a price of 1 Gronk. In addition, from past transactions, Anne has paid 1 Gronk in interest to Ben. See the Gronks sheet screenshot for cross-reference.

b. Bond History table consists of one row for each bond issued, and columns for assignment, issuer, lender, price, face value, and repayment period. **A new row should be populated each time a bond is issued and updated when the bond is repaid.**

i. Assignment: Indicates the assignment before which the bond was issued.

ii. Issuer: Indicates the name of the bond issuer.

iii. Lender: Indicates the name of the bond purchaser.
iv. Price: Indicates how much money the lender gives and the issuer receives at the time the bond is issued.

v. Face Value: Indicates how much money the lender receives and the issuers pays at the time the bond is repaid.

vi. Repayment Period: Indicates the assignment before which the bond was repaid.

8. The Stock sheet consists of one row per student, and three columns per assignment.

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a. Wage: The appropriate wage for each assignment is transcribed from the Labor sheet.

i. For example, assignment 1 is due on the fifth lecture, during which $W_5 = 2$ (see the Labor sheet screenshot).

b. Production: **Determined randomly via a die roll each time right before an assignment is turned in.**
i. Example: Stock 1 produces the number of EC equal to the roll of a four-sided die minus one. Right before assignment 2, the die roll is 3 resulting in the production of 2 EC points.

c. Sales column: If a student sells a stock, enter its sale price; if a student buys a stock, enter the negative of its sale price.

   i. For example, right before assignment 1 was due, Anne bought one unit of the stock from the instructor for 2 Gronks.

d. Stock column: Indicates the number of units of a stock held by each student.

   Must be updated by instructor when new stocks are issued or when a stock is transferred between students.

   i. For example, Anne buys 1 unit of the stock right before assignments 1 and still holds that unit right before assignment 2.

e. Dividend column: Calculated as the product of the Stock Column, the Wage, and Production.

   i. For example, Anne receives $1 \times 2 \times 2 = 4$ Gronks when the stock pays out right before assignment 2.

f. Output row: Sums the Stock column and multiplies it by the Production for each assignment.

   i. For example, right before assignment 2, each unit of the stock produces 2 EC points. Since only Anne owns one unit of stock, the output is 2 EC points.

g. Dividend row: Sums the Dividend column for each assignment.
h. Note that the Stock Return column in the Gronks sheet is calculated as the sum of the Sales and Dividend columns across all assignments and all stocks for each student.

i. If stocks are used, then the Supply in the Assignment sheet is calculated as the $S_t$ (see item 3.a.) plus Output.

   i. For example, the supply for assignment 2 (cell E1 in the Assignments sheet screenshot) is equal to $3 + 0 + 3 = 6$ correct answers plus 2 EC points generated by the stock.
APPENDIX B: Instructor Note

The following describes how to successfully run the experiment in class, and assumes that the instructor has already prepared an Excel file as described in Appendix A. **Bold** font indicates actions that the instructor must take at the beginning of the semester, during each lecture, after each lecture, when assignments are due, and when assignments are returned.

1. Preparation: Prior to the beginning of the semester.
   
   a. **Set up the Excel file for your class as described in Appendix A.**
   
   b. **Download the Socrative App for teachers onto your smart phone (or use the website).**
   
   c. **Enter the questions for each lecture on the Socrative website.**
      
      i. Example: The paper describes a setup in which three questions are asked during most lectures and ten questions are asked during exam review lectures.

2. Introducing the experiment: First lecture of the semester.
   
   a. **Give students printouts of Appendix C; only give them the first section if financial markets and the BEC are not used in the course.**
   
   b. **Describe the experiment using a simple numerical example. Refer to Appendix A for variable definitions.**
      
      i. Assume the students in a class are Anne, Ben, and Catherine; wages are one.
      
      ii. During lecture Anne and Ben answer three Socrative questions correctly, while Catherine answers two questions correctly; therefore, the supply \( S = 8 \).
iii. Wage earnings are as follows: $WI_A = 3$, $WI_B = 3$, and $WI_C = 2$.

iv. On the assignment, Ben and Catherine each spend one Gronk and Anne spends two Gronks; therefore, $D_A = 2$, $D_B = 1$, and $D_C = 1$.

v. Aggregate demand is the sum of individual demands: $D = D_A + D_B + D_C = 4$.

vi. The price of extra credit that clears the market is $P = \frac{D}{S} = 0.5$.

vii. Assume the assignment is worth 10% of the grade: $\rho = \frac{P}{V} = 5$.

viii. Extra credit is distributed to students: $EC_A = \frac{D_A}{P} = 4$, $EC_B = 2$, and $EC_C = 2$.

ix. Gronk savings are wage earnings minus spending: $G_A = W_A - D_A = 1$, $G_B = 2$, and $G_C = 1$.

3. During each lecture: Write your Socrative classroom number and the current wage on the board at the beginning of class. If the wage never changes, there is no need to list it.

4. After each lecture: Update the Labor Sheet from Appendix A.

5. On assignment due dates: Report the state of the economy in class right before an assignment is due.

   a. Show students the Cover sheet from Appendix A; focus on the number of extra credit points available (column B) and the current number of Gronks in the economy (cell B14).

   b. If the BEC is used in the course, see item (7) below.

   c. If bonds are used in the course, see item (8) below.

   d. If stocks are used in the course, see items (9), (10), and (11) below.
6. When an assignment is returned: Report the *ex-post* state of the economy.

   a. **Show students the Cover sheet from Appendix A**: focus on prices $P$ and $\rho$ (columns D and F) and inflation (column G).

   b. **If BEC and inflation are covered in class, discuss the real interest rate** (columns L and M) and the savings decisions made by the students.

7. **BEC**: If the BEC is used in class, show the students the current nominal borrowing rate ($i_b$), nominal lending rate ($i_l$), and borrowing limit ($\bar{B}$) right before an assignment is handed in.

   a. Example for an economy without inflation: $i_b = 10\%$, $i_l = 5\%$, and $\bar{B} \in \{15,10,5\}$. The borrowing limit starts high and is lowered after each midterm; this prevents students from carrying debt into the final exam.

   b. Example for economy with inflation: $i_b = 20\%$, $i_l = 10\%$, and $\bar{B} \in \{40\}$. Inflation automatically reduces the real borrowing limit as the semester progresses.

8. Bonds: If there is a market for bonds allow one to two minutes before an assignment is handed in for students to issue bonds to one another. **Instructor should track bond issuance and repayment on the Bonds sheet (see Appendix A).**

9. Issuing stocks: If stocks are used in the course, the instructor can choose to issue all stocks on the same day or issue different stock types one at a time throughout the semester. Stocks begin paying out on next the assignment after they are issued.

   a. **Describe the production ($Y$) and dividends ($Div$) of a stock to be issued.**

      Discuss expected value and standard deviation of $Y$. 
i. Example one: The safe stock’s production is given by the roll of a four-sided die minus one, with the dividend equal to production times the current wage.

ii. Example two: The risky stock’s production is given by the roll of a six-sided die minus two, with the dividend equal to production times the current wage.

iii. Example three: The hedge stock’s production is six minus the results of the safe and the risky stocks’ die rolls from above, with the dividend equal to production times the current wage.

b. Second-price sealed-bid auction: **Use Socrative to allow students to make one bid for a unit of stock. Do not reveal the bids until all students have responded. The highest bid wins, but the winner pays the second highest price. In case of a tie, the first bid submitted wins. Add one to the number of stocks the winner holds and record its price in the Stock sheet (see Appendix A).**

c. **Issue each unit of stock one at a time; use a new auction each time.**

   i. Example: Issue a number of stock equal to the number of students in the course divided by three. Given the expected values of the three types of stock, this issuance will add on average 1 point of EC per assignment for each student.

10. Stock market: Students may trade the stocks they already own. **Use Socrative to allow each student to place either a bid or an ask price. Do not hide the results as they come in. This should be done once for each stock type available in the market.**
a. Example: If a student wishes to buy a stock for 45 Gronks, she should type “bid 45” into Socrative. This bid is accepted if another student types “ask 45” or any ask price below 45. The initial price posted is the transaction price. If all bid prices offered are lower than the lowest ask price, no transactions occur.

b. **Record any successful stock transactions on the Stock Sheet (Appendix A).**

11. Stock production: **Roll the relevant die to determine stock production and dividends.**

   a. **Add production to the Stock sheet in (Appendix A).**

   b. Production increases the EC available for the upcoming assignment.

   c. Dividends increase the income of students who own the stock.
APPENDIX C: Student Note

The following describes how to successfully participate in the EC economy. **Bold** font indicates actions that students must take at the beginning of the semester, during each lecture, and right before turning in their assignments.

1. **Preparation:** Download Socrative App for students onto your smart phone and get the Socrative classroom number from the instructor.

2. **Production:** Attend class and answer questions with your phone or laptop to produce extra credit and earn income.
   a. Each correct answer creates one point of extra credit which is put into a shared pool for the next assignment.
   b. Each time you answer a question correctly, you are paid a wage in units of the classroom currency. The instructor determines the wage level before each lecture and announces it at the beginning of class.

3. **Accounting Services:** The instructor tracks the number of Gronks each student has and reveals that information before assignments are due.

4. **Consumption:** On the day an assignment is due, the instructor describes the current state of the classroom economy, and then each student decides how much classroom currency he or she wishes to spend on extra credit for that assignment.
   a. The instructor reveals the aggregate money supply in the economy and the total number of extra credit points available for the current assignment. Additional information may be given if the economy is more complex.
   b. If stocks or bonds are available in the course, students can buy or sell them as appropriate.
c. **Write on the top of your assignment how much of your currency you wish to spend** \((D_i, \text{ where } i \text{ represents a particular student})\).

5. **Market Clearing:** After class, the instructor determines the market-clearing price of extra credit and allocation of extra credit among students.

   a. The instructor sums the total student spending to determine market demand \((D = \sum_{i=1}^{n} D_i)\) and divides it by the number of extra credit points available for the assignment \((S)\) to determine the market-clearing price \((P = D/S)\).

   b. You receive the number of extra credit points \((EC_i)\) on the assignment equal to your spending divided by the price of extra credit \((EC_i = D_i/P)\).

   c. Note that extra credit points cannot be saved for future assignments, but your currency can be.

6. **Reflection:** When assignments are returned, the instructor will reveal the relevant market outcomes so that you can learn and modify your spending behavior on future assignments.

   a. After an assignment is handed back, the instructor reveals the market price of extra credit for the assignment.

   b. The instructor also reveals the weighted price of extra credit \((\rho)\), which is the price divided by the value of the assignment \((V)\) in the course \((\rho = P/V)\). The weighted price measures how much you would have needed to spend on the assignment to add one point to your overall grade in the course. This price can be easily compared across all assignments to determine when the cost of extra credit is high and when it is low.
7. Application: **Be prepared to answer classroom, homework, and exam questions about the in-class currency!**

8. Bank of Extra Credit (BEC): If your class has a bank in it, you will be able to borrow in order to increase your spending on certain assignments. Or, if you save, you might be able to earn interest.
   a. When the instructor announces the state of the economy before an assignment is turned in, he or she will tell you the nominal lending rate \((i_l)\), the nominal borrowing rate \((i_b)\), and the borrowing limit \((\bar{B})\).
   b. The nominal lending rate applies to your currency holdings which you do not spend on the current assignment.
   c. The nominal borrowing rate is charged on a loan you take from the bank.
   d. The borrowing limit is the maximum amount of currency you can borrow from the bank.
   e. **In order to borrow, choose a spending amount \((D_t)\) on your assignment that is higher than your current currency holdings; in order to save, choose a spending amount lower than your savings.**

9. Inflation: If your class covers inflation as a topic, it can be calculated by the instructor and discussed during reflection.
   a. Inflation is the percent change in the weighted price of extra credit from one assignment to the next \((\pi_t = \frac{\rho_t - \rho_{t-1}}{\rho_{t-1}}, \text{where} \ t \ \text{represents a particular assignment})\).
   b. If wages change during the semester, the instructor can calculate and present wage inflation when describing the economy \((\pi_{wt} = \frac{W_t - W_{t-1}}{W_{t-1}})\).
10. Real Interest Rates: If the bank and inflation are covered in your class, then real interest rates can be covered as well. There is a corresponding real rate for each nominal rate: lending and borrowing.

   a. The real lending and borrowing rates are calculated as follows:
      \[ r_l = \frac{1 + i_l}{1 + \pi_{t+1}} - 1 \]
      and \[ r_b = \frac{1 + i_b}{1 + \pi_{t+1}} - 1. \]

   b. Note that the above formulas use future inflation; this means that you cannot know until after the next assignment is returned whether saving on the current assignment was a good or a bad idea.

11. Bonds: If bonds are available in your course, the instructor will give you several minutes before you turn in an assignment to issue or buy bonds.

   a. A bond issuer and buyer must agree on the bond price and face value.

   b. The buyer pays the bond price to the issuer at the time the bond is issued.

   c. The issuer pays the face value to the buyer at the time the bond is repaid.

12. Stocks: If stocks are available in your course, the instructor will issue them before an assignment is due. The instructor will also run a stock market exchange through Socrative on a regular basis.

   a. When a stock is issued, the instructor describes the payoff system including EC production \( Y \) and dividends \( Div = W \times Y \) of each stock.

   b. Stocks pay out before each assignment except the one when they are issued.

   c. Stocks are issued one at a time through a second-price sealed-bid auction on Socrative; you should bid the maximum you are willing to pay for the stock.

   d. Stocks may be traded on Socrative right before an assignment is due. If you own a stock, you may list an ask price at which you are willing to sell it. If you
wish to buy a stock, you may list a bid price at which you are willing to buy it.
APPENDIX D: Course Application Discussions

Microeconomic Principles

Discussion 1: In the microeconomic principles and theory classes, midterms are worth 25 percent of the course grade, whereas each homework assignment is worth 2 or 3 percent. Thus, each point of EC is more valuable (and therefore desirable) when applied to a midterm. In response to an increase in demand for EC, we should expect its price to rise.

Discussion 2: Recall that in the basic setup outlined above, students are asked 9-12 questions before any given homework assignment and ten questions before each exam. The impact of asking more questions is twofold. First, a greater number of questions increases the supply of EC as long as the rate of correct responses remains constant. Second, more correct answers mean higher wage income, which increases students’ purchasing power and thus their demand. An outward shift of both supply and demand curves increases the quantity of EC sold, but has an ambiguous effect on the price. This gives the instructor an opportunity to discuss consumers’ savings behavior. Every extra point of EC created must be consumed, but as long as students save some of the extra Gronks, we should expect an increase in the number of questions before an assignment to reduce the price of EC. This prediction can be tested using equilibrium prices before and after a change in the number of questions.

Discussion 3: It should be immediately clear that the supply of EC does not depend on price, since it is determined prior to students’ expenditure decisions; therefore, EC in the experiment exhibits perfectly inelastic supply. A fairly straightforward real world analogy is the market for agricultural goods after harvest. No matter how much food the market demands, the harvested output cannot be easily changed (setting aside considerations of storage and international trade).
Discussion 4: While it is not recommended to actually implement the following strategy, the instructor can ask the students to think through what would happen if they were not paid for producing the EC, but instead all students split it evenly. In this instance, the EC becomes a public good. Clearly, there would be less incentive for students to show up to class or be prepared to answer questions, lowering the equilibrium quantity of EC.

Microeconomic Theory

Discussion 1: Having introduced the BEC at the beginning of the semester, it is a good idea to change (in the same direction) the borrowing and lending rates for the assignment immediately preceding the lecture on intertemporal choice, which usually comes immediately after the first midterm exam. Simultaneously, wages should be increased from one to two Gronks to cause temporary inflation. This exercise presents a good opportunity to discuss the difference between expected (ex-ante) and actual (ex-post) inflation, and the effects of the former on consumer behavior. According to the Fisher equation, \( r_t^e = \frac{i_t + 1}{\pi_t + 1} - 1 \), a decrease in the nominal interest rate, coupled with a rise in expected inflation cause the expected real interest rate to fall. Students should realize that the overall effect of this change on borrowers is to borrow more, whereas the effect on lenders is ambiguous. Assuming that for lenders the substitution effect dominates, current consumption increases, driving up the price of EC. Thus, inflation expectations lead to an actual increase in price, and consequently a drop in the ex-post real interest rate, \( r_t = \frac{i_t + 1}{\pi_t + 1} - 1 \) (refer to row Midterm 1 in Table 3 through Error! Reference source not found. to see the negative real interest rate). In the following period, the mechanism is reversed: the wage is lowered to the original level, inflation falls, and the real interest rate rises.
Discussion 2: This question should be discussed only if the course is covering some basic game theory. It takes at least 40 minutes to work through the arguments described below; however, students benefit from and greatly enjoy seeing the solution to a problem they have been trying to solve for several months.

The optimal solution to the EC problem relies on three simplifying assumptions: (1) interest rates are zero for borrowers and lenders, (2) wages are always equal to one Gronk per correct answer, and (3) the expected number of EC points earned before each assignment is constant.

The solution procedure relies on the guess-and-verify method; the initial guess for the expected average price of EC over the course of the semester is one Gronk per point, since under the assumptions (1) and (2) there is exactly one Gronk for each point of EC in the economy. The instructor can then show that the Nash equilibrium outcome is for students’ spending levels to be such that the weighted price of EC remains constant for all assignments. The explanation for this is simple. If the student chooses to spend more Gronks on a particular assignment than the optimal amount when all weighted prices are the same, then the weighted price of EC on that assignment will rise just when the student is spending a relatively large amount of money. This is suboptimal, and the student should in fact spend less. Conversely, if the student decides to spend less than the optimal amount on a particular assignment, then the real price of EC will fall; this is also suboptimal, since the student could maximize her total EC points by spending more. Thus, if the weighted price of EC is the same across all assignments, students should have no reason to deviate from their spending levels.

To solve for the optimal spending allocation, these considerations must be expressed mathematically. The initial guess for the expected average price of EC can be written as follows:
\[ E[\bar{P}] = E\left[ \frac{\sum_{i=1}^{n} P_i}{n} \right] = 1 \]

Here \( n \) equals the number of total assignments in the course (in my example with six homework assignments, two midterms, and one final exam, \( n = 9 \)). Additionally, the weighted price of extra credit should be equal across all assignments:

\[ \rho_{H,k} = \rho_{M,j} = \rho_{F} = \rho^* \]

Here the subscripts indicate homework (\( H_k \), for \( k = 1, \ldots, 6 \)), midterm (\( M_j \), for \( j = 1, 2 \)), and final exam (\( F \)) prices. Recall the equation that links prices to weighted prices from equation (2):

\[ \rho_a = P_a / W_a \]

for \( a \in \{ H_k, M_j, F \} \).

Combining these three equations with the fact that the assignment weights must add up to one hundred percent,

\[ \sum_a W_a = 1 \]

reveals that the weighted price for EC should be equal to the number of assignments in the class, \( n \):

\[ E \left[ \sum_{i=1}^{n} W_a \rho_a \right] = n \]

and so

\[ \rho^* = n \]

Furthermore, there are three other pieces of information that each student has available before turning in an assignment: the aggregate number of Gronks in the economy (\( G \)), the total number of EC points available for the assignment (\( EC_a \)), and the number of Gronks the student possesses (\( G_i \)). With this information, the student can calculate exactly how many Gronks she
should spend based on the optimal weighted price, $\rho^*$. The first step is to calculate the (non-weighted) price of EC: $P_a = W_a \rho^*$. Then the student can derive the total optimal quantity demanded (D): $D = P_a EC_a$. Based on the percent of the Gronks the student controls in the economy ($\frac{G_i}{G}$), she can finally find her optimal individual quantity demanded:

$$D_i = \frac{G_i}{G} D = \frac{G_i}{G} W_a \rho^* EC_a$$

If every student follows this strategy, the EC for all of the assignments up to the final exam will sell for the Nash equilibrium nominal price. Additionally, it can be numerically verified that if assumption 3 holds, then the expected price of EC on the final exam will also be equal to its Nash equilibrium level.

**Macroeconomic Principles**

*Discussion 1:* Wage movements are a good way to endogenously generate inflation. Increasing the market wages from one to two Gronks does not affect productivity (the number of EC points per correctly answered question), but does increase nominal wealth. This leads to an outward shift in demand and a subsequent rise in the price of EC. Higher wages, coupled with increased prices, leave students’ purchasing power intact, thus not making them better off. Once the first two assignments have been turned in, the instructor can use the increase in the EC price to demonstrate the degree of pass-through from wages to inflation.

*Discussion 2:* Two possible measures of inflation exist in the EC market: the change in the price of EC and the change in the weighted price of EC. Given that the students aim to maximize their overall grade, they should find the weighted inflation measure more informative. These two metrics provide an opportunity to discuss the strengths and limitations of the several measures of inflation that exist in the real world.
For example, the consumer price index (CPI) measure of inflation fixes a basket of goods and tracks their change in price. However, this measure does not control for the substitution effect: consumers buy fewer items whose prices have risen and more items whose prices have fallen. In much the same way, the price of EC does not control for the fact that some assignments have more value than others. The personal consumption expenditure (PCE) price index, on the other hand, does control for the substitution effect, just like the weighted price of EC controls for the change in the value of assignments. Thus, CPI and the price of EC are good measures of current prices, while PCE price index and the weighted price of EC are better measures of purchasing power over time.

**Discussion 3:** In the presence of unexpected inflation, students have a harder time predicting the future prices of EC. Because of this, it is less likely that they will be able to optimize their spending over the course of the semester.

**Discussion 4:** The BEC should be introduced after the discussion of interest rates. Giving students the ability to borrow and save provides a natural opportunity to discuss nominal and real interest rates and inflation. The instructor can use the future inflation rate calculated as the change in the weighted price of EC to find the real interest rates, which help students to determine whether their saving/borrowing decisions were optimal. Since inflation is created exogenously, students should conclude that borrowing against future “earnings” allows them to maximize their grade. Lenders, on the other hand, are harmed by inflation, as the value of their savings is quickly reduced. As the demand for loanable funds increases, the BEC can lower the borrowing limit or raise interest rates to make sure students do not borrow more than their expected future “income”.
Discussion 5: The BEC’s balance sheet consists of assets (loans to students and cash holdings) and liabilities (students’ deposits) with bank capital defined as the difference between the two. The BEC also keeps track of financial flows—interest paid out on deposits and received on loans—which alter the value of assets and liabilities over time. In the EC framework, the BEC typically loses capital throughout the course of the semester since the majority of students prefer to save their Gronks for future assignments. For example, in Microeconomic Theory I, bank capital falls from 100 Gronks at the beginning of the semester to 55.16 Gronks by the end of the semester.15

Money and Banking

Discussion 1: This discussion can take place as soon as at least one bond has been issued. When determining the amounts $R$ and $L$, each student must (at least implicitly) consider the following variables: (1) expected rate of inflation based on the previous data, (2) expected number of class periods before the borrower is capable of repaying the amount $R$, and (3) closely connected to (2), the probability of a partial or complete default. The instructor can then help the students to explicitly analyze their choices of $L$ and $R$. The bond’s nominal interest rate, $i$, should be greater than the expected rate of inflation; otherwise, the lender will expect to take real losses on the loan. The larger the amount lent, the higher $i$ should be to compensate for the length of time it will take for the loan to be repaid. And, because there is no enforcement mechanism to insure against default risk, lenders must have considered several idiosyncratic characteristics of their classmates, such as major, attendance, or extracurricular activities, when issuing a loan.

Discussion 2: Once banking is discussed in class, the BEC should be introduced as an alternative to peer-to-peer bond issuance. As described in Cecchetti and Schoenholtz (2011), the role of banks in the macroeconomy consists of pooling savings, providing accounting services,
providing liquidity, diversifying risk, and aggregating information. Clearly, students pool their savings in the cashless classroom economy by holding bank deposits. The instructor, via the BEC, also offers students accounting services so that they can track the currency holdings, debt, and the corresponding interest payments. Loans are more readily available with a bank than with peer-to-peer lending due to lower transactions costs, since students no longer have to spend time finding a willing lender and negotiating the terms of the loan. Borrowing becomes easier and more liquidity is available. Risk is diversified because individual students no longer face default risk: if a borrower does not earn the Gronks needed to pay off a loan by the end of the semester, the loss is covered by the bank. Finally, the bank aggregates information because it (i.e., the instructor) knows how likely students are to pay back loans based on how many questions each student answers correctly on average. In return for providing these services to the economy, the bank earns money via the interest rate spread. As discussed previously, social networks help lenders and borrowers to forgo financial intermediaries and thereby avoid paying the spread.

**Discussion 3:** In theory, if agents are risk neutral, stock prices should be equal to the present discounted value of the stock’s future payments. When setting the bid prices, students should therefore take into account the number of assignments left in the semester (recall that stocks pay out EC points right before students submit their homework and take their exams), the expected stock returns, and expected future real interest rates. The first step is to calculate the expected number of EC points the stock will add to the overall grade by the end of the semester (I call this quantity the stock’s real price, $p$):

$$p = E \left[ \sum_{i=1}^{n} \frac{V_i Y}{(1 + r)^i} \right]$$

Here $n$ represents the number of assignments left in the course, $V_i$ is the weight of each assignment in the overall grade, $Y$ is the EC payout (“output”) of the stock, and $r$ is the real
interest rate. Since EC does not lose value throughout the course of the semester (and as shown in the microeconomic theory section above), the Nash equilibrium real interest rate is zero in equilibrium. Simplifying the above formula, the real price of the stock can be expressed as the expected payout multiplied by the total weight of the remaining assignments:

\[ p = E[Y] \sum_{i=1}^{n} V_i \]

The second step is to calculate the nominal price of the stock by multiplying \( p \) by the weighted price of EC (\( \rho \)) in the issue period. For example, if 50 percent of the overall grade is yet to be determined and the weighted price of EC is 20 Gronks, then one unit of the safe stock (with the expected payout of 1.5 EC points before each remaining assignment) is 15 Gronks as long as students are risk-neutral.

**Discussion 4:** Risk-averse students should be willing to pay less for a stock than the risk-neutral price given by equation (4). This risk discount should be smaller for the safe relative to the risky stock.

**Discussion 5:** Holding one unit of the hedge stock along with one unit each of the safe and risky stocks creates riskless portfolio that pays four points of EC. Notice that if the same number of each of the three stocks is issued, aggregate risk is completely eliminated from the stock market.
REFERENCES


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1 See, for example, Emerson and Taylor (2004), Ball et al. (2006), Dickie (2006), Durham et al. (2007), and Staveley-O’Carroll (2015).

2 Bergstrom and Miller (2000) provide many examples of in-class demonstrations.
3 For example, Socrative.com, a platform that allows students to use their smartphones as clickers, is available for all smartphones.

4 The author is currently developing a web-based application to help instructors easily implement this experiment in their courses. More specifically, it will automate most aspects of the EC market (keeping track of student purchases, EC prices, EC awarded, etc.). Once finished, the application will be free to use by any interested instructor. Until it is completed, instructors can obtain a pre-set Excel spreadsheet from the author that can be used as a template for this experiment.

5 Notice that the price calculated in this section is a market clearing price rather than an equilibrium price. This is because students do not get to observe the price of EC before submitting their desired expenditure levels and thus do not get to create a demand schedule for EC. Once the market-clearing price is revealed after the assignment is returned, it is probable that many students will wish to have spent more (if the price was low) or fewer (if the price was high) Gronks on the assignment. Although the true equilibrium price cannot be determined in this section, a Nash equilibrium for the experiment can be found as described in the Macroeconomic Theory subsection.

6 This implies that a student who spends 25 Gronks on the homework assignment raises his or her course grade by one point; likewise, a student who spends 8 Gronks on the midterm raises their course grade by one point.

7 The description of the experiment in the body of the paper references its original setup. Having previously run it in seven of my classes, I recently made slight modifications to relative weights of homework assignments and to the dice that determine stock payouts—changes do not affect the experiment’s structure or mechanisms but address students’ concerns about the relative
importance of homework grades and reduce the number of EC points awarded due to random
dice rolls, respectively. The instructions in the appendices reflect these modifications and thus
are slightly different from the numbers referenced in the body of the paper.

8 Note that none of the students who participated in any of these courses were exposed to the
experiment in previous classes.

9 It is interesting to note that students arrive at this outcome in the microeconomic principles
class without ever having calculated the Nash equilibrium price of EC.

10 The EC market has not yet been used in a macroeconomic principles course.

11 Second-price sealed-bid auctions have the same theoretical outcome as live auctions, but are
faster, which saves class time. Additionally, this type of auction can easily be run as a Socratic
question.

12 The prices are calculated as \( P_i = \rho \times E[Y] \times \sum V \) for \( i \in \{S, R\} \), where \( \rho \) is the weighted price
of EC at the time the stock is sold, \( E[Y] \) is expected output of the stock for each assignment, and
\( \sum V \) is the total value of assignments that will be affected by the stock payouts. The results are
\( P_S = 14.44 \times 1.5 \times 0.6 = 13 \) and \( P_R = 40 \times 2.5 \times 0.55 = 55 \).

13 Discounting from risk-aversion is calculated by using the percent difference between the
market price of the stock and the expected value of the stock payouts: \( \beta = \frac{P - E[D]}{E[D]} \). For example,
the expected value of the safe stock was 13 Gronks, and the market price of the stock was 6
Gronks; this results in a discounting of 54 percent.

14 Of the positive comments made by students on the teaching evaluations, 52% mention the
Gronks experiment specifically. Additionally, students are asked on the final homework
assignment to describe their most and least favorite parts of the course (on this question, students
receive the same number of points regardless of the answer they give). For the most recent
course, for example, 67 percent of students reported that the Gronks experiment was the best part
of the course. No students reported the experiment as being their least favorite part of the course.

15 Since the bank’s balance sheet in Excel is dynamically linked to students’ currency holdings,
the information in it changes after each lecture. Interested instructors can save the values from
the balance sheet after each lecture so that they can show the in class the effects of student
choices on the bank’s finances.