A Search-Theoretic Classroom Experiment with Money

Denise Hazlett

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Abstract

This classroom experiment promotes discussion of the social origins and characteristics of money. Students take the roles of traders who face a double coincidence of wants problem. As they recognise the benefits of overcoming trading frictions, students spontaneously begin using a consumption good as a medium of exchange. The setting comes from Duffy and Ochs’ (1999) experimental version of the Kiyotaki–Wright (1989) search model of money. In the Kiyotaki–Wright environment, agents specialise in production, consume a good other than their own product, and randomly meet in pairs to trade. Trading in this environment allows students to experience the social conditions that give rise to money, namely specialisation and decentralisation. The experiment also demonstrates how a particular characteristic can make a commodity a good candidate for becoming money. Here, the commodity with the lowest storage cost spontaneously emerges as a generally accepted medium of exchange. The experiment requires approximately 30 minutes to run and can be used as an introductory exercise for students beginning or preparing for an undergraduate course in macroeconomics or money and banking.

JEL Classification: A22

Introduction

Classroom experiments put students in the roles of economic decision-makers. In this experiment, students trade in a decentralised economy. The setting comes from Duffy and Ochs’ (1999) experimental version of the Kiyotaki–Wright (KW) (1989) search-theoretic model of money. Agents specialise in production, yet desire to consume a good other than their product. A series of random pair-wise matchings gives them the opportunity to trade. However, they face the double coincidence of wants problem. In fact, if each person held out for his or her consumption good, no one could ever trade. For trade to occur, at least some people must be willing to accept a good that they do not intend to consume, but
which they hope to trade later for their consumption good. In other words, some people must be willing to accept a medium of exchange. Over the course of the experiment, students come to understand that using a medium of exchange reduces the cost of searching for a trading partner who has what you want and wants what you have. Of course, once a particular consumption good becomes generally accepted as a medium of exchange, then that item has spontaneously become money. Here, the item that emerges as money is the consumption good with the lowest storage cost.

When introducing the experiment, the instructor does not tell students which item they should use as money, or even that they should use money at all. In fact, nothing in the instructions or the title of the experiment ('A Trading Experiment') even uses the word 'money'. I further recommend not making suggestions about trading strategies, and particularly to avoid hinting that students trade for the low-storage-cost good. As Noussair and Walker (1998) note, running an experiment before going over the relevant theory 'allows students to “discover” the theory themselves, and avoids suggesting to them that they follow a particular course of action that the theory specifies’ (p. 67). One of the goals of this experiment is for students to experience first-hand the social conditions that give rise to money: that is, for students to see how money can arise endogenously, without its imposition by some authority. As Holt (1999) notes, 'classroom experiments are effective because students are placed directly into the economic environments being studied. After participating, students bring first-hand experience to the discussion' (p. 1). So, for instance, running the experiment and then discussing Karl Menger’s ‘On the origin of money’ (1892) would give students a foundation to understand Menger’s claim that ‘money has not been generated by law. In its origin it is a social, and not a state, institution’ (p. 82). Similarly, after participating in the experiment, students can bring their experience to bear in analysing W. S. Jevons’ (1875) statement that ‘although many commodities may be capable of performing the function of a medium [of exchange] more or less perfectly, some one article will usually be selected, as money par excellence, by custom or the force of circumstances’ (p. 63). Students see that the force of circumstances in their experimental economy led them to select the commodity that cost the least to store.

I have used this experiment in my undergraduate monetary theory course, with third- and fourth-year economics majors. I run it during the first week of class, before discussing the history of thought on money, and before even introducing a definition of money. Other professors have run the experiment in their money and banking, intermediate macroeconomics, and experimental economics courses. It requires approximately 30 minutes to conduct eight trading periods. Eight periods seem to be enough for most
students to settle on a trading strategy. Instructions and a student record-keeping sheet are presented in the next section.²

### A Trading Experiment: instructions

1. You are about to participate in an experiment that will last several trading periods. Participants are divided into three types, called Type 1, Type 2 and Type 3. There are also three types of goods in the experiment, called Good 1, Good 2 and Good 3. Type 1 people consume only Good 1. Whenever a Type 1 person consumes Good 1, he or she automatically produces Good 2. Similarly, Type 2 people consume Good 1 and produce Good 3. Type 3 people consume Good 3 and produce Good 1. Your ID tag indicates which type of person you are. There are roughly equal numbers of Types 1, 2 and 3.

2. Because you do not produce the good that you wish to consume, you will have to trade with someone else to get your good. Each period you will be randomly matched with someone else in the experiment. You and the person you are matched with will each be holding one unit of a good. You may trade the good you are holding for the good that person is holding, provided both of you are willing to trade. All trades are one for one, so you may not trade any fractions of a good. Note that there are three possible outcomes of a meeting:

   **(i)** You trade for the good you consume. Then you automatically consume your good, and automatically produce the good that your type produces. Then you store your production good until the next period.

   **(ii)** You trade so that you receive some good which is not your consumption good. Then you store that good until the next period.

   **(iii)** You do not trade. Then you store the good you are currently holding until the next period.

3. At the beginning of the next period, you will again be randomly matched with another participant. You will then decide whether you want to offer to trade the good that you have, in exchange for the good that the other person has.

4. Your objective is to get as many points as possible over the course of the experiment. Points represent the satisfaction you get from consuming your good minus the costs of storing goods. Each time you consume your good, you earn 20 points. At the end of every period, you pay a cost in points for whatever good you are storing. The costs of storing
goods are: 1 point for storing Good 1; 4 points for storing Good 2; and 9 points for storing Good 3.

5 Each player begins the experiment with 40 points, plus one unit of the good that he or she produces.

6 Let’s consider how you earn points. Suppose that you just received in trade your consumption good. Then, you earn the net payoff shown in the table below.

<table>
<thead>
<tr>
<th>Type</th>
<th>Points for consuming</th>
<th>Storage cost of good produced</th>
<th>Net points earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gets 20 for consuming Good 1</td>
<td>Pays 4 to store Good 2</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Gets 20 for consuming Good 2</td>
<td>Pays 9 to store Good 3</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>Gets 20 for consuming Good 3</td>
<td>Pays 1 to store Good 1</td>
<td>19</td>
</tr>
</tbody>
</table>

7 Recall that at the end of every period you must pay a storage cost for whatever good you store, whether you consumed that period or not. Please keep track of your points on your record-keeping sheet.

**A Trading Experiment: record-keeping sheet**

Your Type: __________________ Your name: _________________________

<table>
<thead>
<tr>
<th>Type of Person</th>
<th>Consumes</th>
<th>Produces</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Good 1</td>
<td>Good 2</td>
</tr>
<tr>
<td>2</td>
<td>Good 2</td>
<td>Good 3</td>
</tr>
<tr>
<td>3</td>
<td>Good 3</td>
<td>Good 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Good</th>
<th>Storage cost in points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
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</tbody>
</table>
You start Period 1 with one unit of the good that you produce, and 40 points.

<table>
<thead>
<tr>
<th>Period</th>
<th>Good you start with</th>
<th>Type of person matched with</th>
<th>Good that person is holding</th>
<th>Did you trade?</th>
<th>Did you consume? If yes, mark 20 points</th>
<th>Storage cost at end of period</th>
<th>Total points</th>
</tr>
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Randomly matching traders

The instructor randomly matches pairs of traders each period. Thus, in a class with an odd number of students, one student will sit out each period. The instructor labels separate locations in the classroom with letters ‘A’, ‘B’, ‘C’, etc. Using an Excel spreadsheet, the instructor randomly assigns two traders to each of these locations in each trading period. Projecting the spreadsheet values on a screen allows the whole class immediately to view the results of each random match. Otherwise, the instructor must announce the matches. As soon as a trader learns the letter assigned to her name for that period, she goes to the designated location for that letter, and waits for her new trading partner to show up. When a pair of trading partners meet, they tell each other what good they are each holding. Then, they decide whether or not to trade.

The random-matching Excel spreadsheet, with instructions on how to use it, can be downloaded from the same website that provides the instructions and record-keeping sheets. This spreadsheet works particularly well with class sizes of up to 52 students. With these size classes, the list of all of the matches fits on one screen. With larger classes, scrolling down the list becomes necessary in order to see all of the matches. The spreadsheet is set up to accommodate classes as large as 100 students and can be easily extended for even larger classes. Then, the limiting factors become the students’ ability to read the screen listing the matches, and the number of distinct trading locations that the instructor can create within the classroom.

Items the instructor brings to class for the experiment

1. One instruction sheet and one record-keeping sheet per student.

2. One ID tag per student, identifying the student as a Type 1, 2 or 3. There should be equal numbers of each type, or as close to this as possible while still including all students in the experiment.

3. Signs labelled ‘A’, ‘B’, ‘C’, etc. to identify the various sections of the classroom, plus tape for posting the signs. Bring one sign for every pair of students in the class.
A computer (with optional projector) running the Excel spreadsheet, which randomly assigns pairs of students to each section of the room, in each period.

**Equilibrium predictions for this classroom experiment**

As Duffy and Ochs show, for the utility function and storage costs in this classroom experiment, theory predicts a unique pure strategy Nash equilibrium. In this equilibrium, everyone always trades for their own consumption good. Moreover, if offered a good other than their consumption good, everyone’s best response is always to trade for a good that is less costly to store than the good they are currently holding. Thus, theory predicts that Good 1, as the cheapest to store, will emerge as a generally accepted medium of exchange. The experiment therefore demonstrates how money arises endogenously in an economy with specialisation and decentralisation, and what characteristics can make an item a good candidate for becoming money.

**A comment on payoffs**

Some instructors use sweets or chocolates to represent the payoffs in this experiment, whereas others keep the payoffs hypothetical. The experimental point system is set up so that instructors could offer, say, a chocolate for every 10 points. However, instructors contemplating using chocolate should keep in mind that students will earn radically different amounts of points, depending mainly on luck. For instance, in one session, one of my Type 2 students consumed only once in eight periods, due to the bad luck of being matched only once with someone holding Good 2. This unlucky Type 2 student paid the heavy storage costs for holding Good 3 for most of the experiment. She ended the experiment with a mere 3 points, i.e. she started with 40 points, earned another 20, and paid storage costs of 57. In contrast, a Type 3 student in that same class consumed five times and stored Good 1 at the end of every period, thus paying the lowest storage cost possible. He ended the experiment with 131 points. With chocolate payoffs, the first student would have received a third of a chocolate, and the second would have received 13 chocolates.

**Follow-up discussion and writing assignment**

The questions below can organise a post-experiment discussion that lasts about 15 minutes. Typical student responses appear below the questions.

1. **What trades were you willing to make and why? Did you have a particular trading strategy, and if so, what was it? Was your strategy effective at maximising your total points?**
Students described their willingness to accept Good 1 in trade, even if it was not their consumption good, because of Good 1’s low storage cost. In contrast, they noted the illiquidity of the costly-to-store Good 3. In particular, Type 2 people reported that they found it impossible to unload the Good 3s that they produced, unless they met a Type 3 person. Thus, Type 2s without the good luck to be matched often with a Type 3 ended up with very few or even negative points, after several periods of storing Good 3. In contrast, a typical student had 60 or 70 points at the end of eight periods.

2 Did any item serve as a generally accepted medium of exchange in the experiment? If so, what item was it, why were people willing to accept it, and how was the pattern of trades affected by the existence of a medium of exchange? What were the advantages of having a generally accepted medium of exchange in this economy? If not, why was there no generally accepted medium of exchange?

The first goal of question 2 is to have students recognise that their willingness to accept Good 1 means that this good is serving as a medium of exchange, the defining function of money. In fact, I use this occasion to introduce the definition of money as a generally accepted medium of exchange. As students talk about how the experimental setting influenced their trading decisions, they begin articulating (in their own words) what caused the double coincidence of wants problem. They see the critical roles that specialisation in production and bilateral trading played in creating trading frictions. They note that using a medium of exchange overcame these trading frictions: that is, accepting Good 1 reduced the amount of time spent searching for someone who held the good you wanted and wanted the good you held. With consumption and production occurring more frequently as a result, everyone in the economy was potentially better off.

3 What would the effect on trading strategies have been if the storage costs of all the goods had been equal?

Students decide that without a difference in storage costs, no item would have emerged as more liquid than the others. Basically, all of the goods in this economy would have served as media of exchange. I use this opportunity to define a monetary economy as an economy in which one item, or a relatively small number of items, circulates as a generally accepted medium of exchange. Thus, students conclude that, given equal storage costs, their economy would have had too many media of exchange to have been a monetary economy.

4 What other characteristics, besides low storage cost, could make an item a good candidate for becoming generally accepted as a medium of exchange?
Students list many characteristics, typically including portability, durability and a distinctive appearance that makes it difficult to counterfeit.

**Further readings**

An instructor could follow the experiment with first-hand readings from the history of thought on money. For instance, students could use their insights from participating in the experiment to understand Jevons’ and Menger’s essays on the origins of money, as described in the introduction to this paper.

**A writing assignment**

Some instructors use an outside writing assignment rather than an in-class discussion to debrief students. A sample writing assignment follows.3

1 Explain the trading strategy you used in the in-class exercise ‘A Trading Experiment’. How successful was your strategy? If you had to do it over again, what would you do differently?

2 Make up a table showing for each type of person all the possible trading situations they could have found themselves in. Assuming everyone was a point-maximiser, what would you expect to happen in each of those cases? Does one of the goods play a special role in the trades you describe? What particular characteristic causes this special role? What do we call goods that play this special role?

3 Make up a fable explaining the origins of money.

**A different equilibrium under different parameters**

Students sometimes suggest that Good 3 should be less costly to store, in order to make the payoffs more equal between participants. However, the relatively high storage cost for Good 3 serves a purpose. As Duffy and Ochs show, a smaller range of storage costs would yield a different unique pure strategy Nash equilibrium. Specifically, given a low enough cost of storing Good 3, Type 1s always accept Good 3 when offered it. They do so despite the fact that it costs more to store than the good they are trading away. They accept Good 3 in the hope of trading it to a Type 3 person who has produced and stored Good 1. (Of course, Type 1s also always accept their own consumption good when offered it.) The strategy of accepting a higher-cost medium of exchange is called a speculative strategy. So, the reason for the relatively high storage costs for Good 3 is to generate an equilibrium in which no type uses a speculative strategy. Equilibrium speculative strategies would make the follow-up discussion too complicated for most undergraduate courses. However, advanced
undergraduates might enjoy following the experiment with a reading of Duffy’s (1998) accessible review of the literature on monetary theory in the experimental laboratory. In his review, Duffy summarises the Kiyotaki-Wright model and the Duffy and Ochs research experiments. This summary is only four pages long and is available online.

**Conclusion**

This experiment has students participate as traders in an economy where no item has been designated as money. Instead, money arises endogenously over the course of their trades. Because students have consistently relied on money for their real-life trades, an economy where no authority figure tells them what to use as money is a pretty abstract concept to them. However, as Noussair and Walker (1998, p. 49) note, classroom experiments serve to ‘bring abstract concepts to life [and] provide powerful demonstrations of the principles of economics at work’. This experiment has students actively demonstrating for themselves how social conditions (specialisation and decentralisation) can give rise to money, and the resulting benefits of using money.

**Contact details**

Denise Hazlett  
Associate Professor of Economics  
Department of Economics  
Whitman College  
345 Boyer Ave  
Walla Walla, WA 99362  
USA  
Email: hazlett@whitman.edu

**References**


**Notes**

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[2] Ready-to-use print-outs of the instructions and record-keeping sheets are available online by going to [http://people.whitman.edu/~hazlett/econ/private](http://people.whitman.edu/~hazlett/econ/private), entering ‘private’ as the username and ‘Modeling!’ as the password. (You will be prompted twice to enter the password.) I recommend that the instructor read the instructions aloud, with students following along on their own copies. Students will then all be at the same point in the instructions if someone stops the instructor to ask for clarification.

[3] These questions are based on a homework assignment that Dr Robert Rycroft of Mary Washington College gave the students in his money and banking course, after running the experiment and before discussing the results.