Exercise 6 (Team/Individual Exercise, 30 Points Total)   Leigh Tesfatsion
DUE: Tuesday, April 14, 11:00am   Econ 308, Spring 2009

** LATE ASSIGNMENTS WILL NOT BE ACCEPTED - NO EXCEPTIONS!

**Learning Vs. Zero-Intelligence Trading in Double-Auction Markets
(NETLOGO VERSION - CONTINUATION OF EX 5)**

Basic References:

1 ** Mark McBride, **Zero-Intelligence (ZI) Trading Demo (Java Applet/NetLogo Model)**
http://mcbridme.sba.muohio.edu/ace/labs/zitrazde/zitradenetlogo.html

2 ** L. Tesfatsion, **"Learning Algorithms: Illustrative Examples"** (Syllabus III.B)
http://www.econ.iastate.edu/classes/econ308/tesfatsion/LearnAlgorithms.LT.pdf

3 ** L. Tesfatsion, **"Notes on Learning"** (Syllabus III.B)
http://www.econ.iastate.edu/classes/econ308/tesfatsion/LEARNING.Econ308.pdf

4 * S. Railsback, S. Lytinen, and S. Jackson, **StupidModel: A Template Model for ABM Platforms**, http://condor.depaul.edu/∼slytinen/abm/StupidModel/

5 ** L. Tesfatsion, **"Market Basics for Price-Setting Agents** (Syllbus II)
http://www.econ.iastate.edu/classes/econ308/tesfatsion/MBasics.SlidesIncluded.pdf

6 ** L. Tesfatsion, **"Experimental Design: Basic Concepts and Terminology"** (Syllabus I.A) http://www.econ.iastate.edu/classes/econ308/tesfatsion/expdesign.pdf

EXERCISE OVERVIEW:

In the previously assigned Exercise 5, you used the McBride NetLogo ZI Trading Demo (Ref. [1]) to conduct specific types of ZI trader experiments. Building on this prior work, Exercise 6 asks you to explore whether the introduction of learning capabilities for some or all of the traders in this NetLogo ZI Trading Demo has any substantial effects on market efficiency and market advantage (as defined in Ref. [5]).

Updated team/individal assignments for Exercise 6 are posted at the Exercise Information Site linked to the course homepage. Here is the direct link:

www.econ.iastate.edu/classes/econ308/tesfatsion/ExTeams.Econ308.2009.htm

EXERCISE DETAILS:

Part A (4 Points): Constructive Understanding of Individual Trader Learning Capabilities

For the purposes of this exercise, assume that any trader with learning capabilities uses reactive reinforcement learning in the form of **Modified Roth-Erev (MRE) Reinforcement Learning** (see Refs.[2-3]).

Using simple flow diagrams, mathematical equations, and careful verbal explanations (NOT CODE), describe carefully – step by step – how any trader (either a buyer or a seller) in the NetLogo ZI Trading demo [1] used in Exercise 5 could instead be modeled as a trader that LEARNS OVER TIME how to choose its bid price (if a buyer) or its ask price (if a seller) by means of MRE reinforcement learning.

Part B (8 Points): Incorporate Learning Traders Into the NetLogo ZI Trading Demo Code

- Let NS and NB denote, respectively, the total number of seller traders and the total number of buyer traders in the NetLogo ZI Trading Demo (Ref. [1]).

- MODIFY the code of the NetLogo ZI Trading Demo [1] so that the user can designate any number of seller traders (from 0 to NS) and buyer traders (from 0 to NB) to be "learning traders."

- Using your analysis in Part A, MODIFY the code of the NetLogo ZI Trading Demo [1] so that any trader designated to be a "learning trader" choses its bid prices (if a buyer) or ask prices (if a seller) over time in accordance with MRE reinforcement learning.

- Be sure to include in your modified code a "stopping rule" that stops a simulation run after a certain number M of time steps (or "ticks"). Call your resulting modified demo the **NetLogo Learner Trading Demo**.

- After debugging your modified code for your NetLogo Learner Trading Demo, and ensuring it runs and compiles properly, **print out a copy of this modified code and turn it in as your answer for Part B of Exercise 6.**

    IMPORTANT NOTE FOR PART B: For parts of this code modification, you might want to refer to the sample code in Ref.[2] for MRE reinforcement learning and in NetLogo Versions 1 through 16 for the StupidModel (Ref. [4]). Additional help materials (demos, tutorials, etc.) are provided at the NetLogo homepage (http://ccl.northwestern.edu/netlogo/).

Part C (4 Points): Develop an Experimental Design

Part C asks you to specify numerical parameter values for an experimental design to be conducted with your NetLogo Learner Trading Demo from Part B.

As clarified in Part D, below, the purpose of this experimental design will be to experimentally test the effects of learning capabilities on Market Efficiency and Market Advantage. For Part C you are only asked to DEVELOP the experimental design, not to run any actual experiments.

The treatment factors to be considered in this experimental design are the exact numbers of seller traders and buyer traders who have learning capabilities. More precisely, the following four *Learning Treatments)* will be considered:

Treatment 1: ALL TRADERS are ZI-C traders as defined in Ref.[1] (i.e., zero-intelligent traders constrained only by budget considerations).

Treatment 2: Only ONE SELLER has learning capabilities and ALL OTHER TRADERS are ZI-C traders.

Treatment 3: ALL SELLER TRADERS have learning capabilities while ALL BUYER TRADERS are ZI-C traders.

Treatment 4: ALL TRADERS (BOTH BUYERS AND SELLERS) have learning capabilities.

Complete this experimental design by specifying and reporting specific numerical values for all maintained parameter values, as follows:

- Select and report specific numerical values for the number NS of seller traders and the number NB of buyer traders to be maintained across all experimental runs.

- Select and report specific numerical values for all other required parameter settings in your NetLogo Learner Trading Demo to be maintained across all experimental runs. Be sure to include among your specified parameter values an integer value $M \geq 1000$ for the maximum number of time steps (or "ticks") permitted for each simulation run. (The ideal is to have each run reach a point where all trade ceases.)

- Specify and report specific numerical values for all required parameter settings for the MRE reinforcement learning algorithm(s) used in Treatments 1 through 4. (You might want to have every learning trader have the same MRE parameter values, or you might want to permit different learning traders to learn using different MRE parameter values.)

- These specific numerical values should be selected to give you an economically interesting (non-trivial) trading environment.

Part D (8 Points): Carry out your experimental design.

Using your NetLogo Learner Trading Demo from Part B, implement your experimental design in Part C as follows:

1. For each of the four treatments of your experimental design in Part C, conduct N experimental runs ($N \geq 10$) of your NetLogo Learning Trading Demo using N distinct initial seed values for the pseudo-random number generator.

2. For each of the four treatments of your experimental design in Part C, and for each run $n = 1, ..., N$ conducted for this treatment, report:

   (a) the specific treatment number;
   (b) the pseudo-random number seed value (the identifier for the run);
   (c) the Market Efficiency attained by the Mth time step for this run;
   (d) the Market Advantage (positive or negative) attained by each buyer and seller by the Mth time step for this run.

3. For each of the four treatments of your experimental design in Part C, display the histogram for the Market Efficiency outcomes attained across the N runs in the Mth time step.

4. For each of the four treatments of your experimental design in Part C, report the sample mean and sample standard deviation ("N definition") for the Market Efficiency outcomes attained across the N runs in the Mth time step.

5. For each of the four treatments of your experimental design in Part C, report and display the Market Advantage outcomes attained by buyers and sellers across the N runs in the Mth time step in some interesting and informative manner of your own choosing.

> **Important Note for Part D:** Be sure to use the precise measures for "Market efficiency" and "Market Advantage" introduced and explained in Ref. [5]. Also, be sure to use the precise measures for "sample mean," "sample standard deviation" (N definition), and "histogram" as provided in Ref. [6].

Part E (6 Points): Analyze Your Findings

As best you can, provide an explanation and interpretation for the experimental findings you reported in Part D. In particular, in what sense (if any) do these findings support the conjecture that the degree of Market Efficiency and Market Advantage attained for the double-auction market modeled in your demo does NOT depend on the learning capabilities specified for the participant traders? Explain carefully.