Team Exercise 6

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Conducting Genetic Algorithm Learning Experiments with the Trade Network Game (TNG) Laboratory

References for Team Exercise 6:

[**1**] ** Leigh Tesfatsion, **Notes on Learning**, Section 5 (GA Learning), ON-LINE at

http://www.econ.iastate.edu/tesfatsi/learning.pdf (pdf,157K)

[**2**] ** **Trade Network Game Home Page** (including a link to automatic installation software for the TNG Laboratory), ON-LINE at

http://www.econ.iastate.edu/tesfatsi/tnghome.htm

[**3**] ** David McFadzean, Deron Stewart, and Leigh Tesfatsion, **"A Computational Laboratory for Evolutionary Trade Networks"**, *IEEE Transactions on Evolutionary Computation*, Volume 5, Number 5, October 2001, special stress on Section VIII: Labor Market Application. ON-LINE at

http://www.econ.iastate.edu/tesfatsi/tngieee.pdf (pdf,244K)

NOTE: This paper constitutes the "manual" for the TNG Laboratory.

[**4**] ** Leigh Tesfatsion, **TNG Lab Parameter List**, ON-LINE at

http://www.econ.iastate.edu/tesfatsi/parlist.pdf (pdf,19K)

NOTE: This TNG Lab guide gives explanations and illustrative settings for the parameter values entered by the user on the Settings Screen for the TNG Lab Graphical User Interface (GUI). The entire range of feasible settings for each of these parameter values is also indicated.

Preliminary Comments on the TNG Lab:

The following comments briefly summarize key features of the TNG Lab important for carrying out Parts A through C of Exercise 6 (see below). Before you attempt to carry out these exercise parts, you should first study carefully Refs.[3]-[4] so that you understand the logical progression of the TNG and the meaning of all of the parameters the user can specify on the TNG Graphical user Interface (GUI).

As carefully explained in Ref.[3], the **Trade Network Game (TNG)** is a framework for studying the formation and evolution of trade networks among strategically interacting traders (buyers, sellers, and dealers) operating under variously specified market protocols. Successive generations of resource-constrained traders choose and refuse trade partners on the basis of continually updated expected utility and engage in bilateral trade interactions modeled as symmetric 2-person games.

Each trader in a bilateral trade can either play C (cooperate) or D (defect). The TNG GUI Settings Screen permits the user to specify arbitrary payoffs for the four situations a trader could find himself in as a result of a bilateral trade: CC (Both Cooperate); DD (Both Defect); DC (Temptation, i.e. the trader defects against a cooperating rival); and CD (Sucker, i.e. the trader is cooperating but his rival defects against him). Consequently, a variety of symmetric 2-person games can be explored, including prisoner's dilemma, the Chicken game, and the Stag Hunt game.

At the start of each TNG experiment, each trader is assigned a totally random strategy for engaging in iterated bilateral trades an indefinite number of times. The trader types then separately evolve their trade strategies over time using genetic algorithm (GA) learning (see Ref.[1], Section 5). In particular, Buyer strategies are updated via a GA applied to the population of Buyers, Seller strategies are updated via a second GA applied to the population of Sellers, and Dealer strategies are updated via a third GA applied to the population of Dealers.

The TNG framework has been implemented in C++ with the support of SimBioSys, a C++ class framework for general evolutionary simulations. TNG/SimBioSys has further been incorporated into a modular extensible computational laboratory, referred to as the **TNG Lab**, which is targeted for the Microsoft Windows desktop. The TNG Lab has an easily operated GUI that can be used to run TNG experiments for research and teaching purposes.

A description of all of the parameters whose values can be set by users via the TNG Lab GUI Settings Screen is given in Ref.[4]. The outcomes of TNG experiments are visualized by means of run-time network animations and run-time chart and data table displays available through Result, Chart, and Animation Screens at the TNG GUI. Detailed output for each TNG run is automatically recorded and saved in a file called tng.out. This file should be in the TNGLab directory automatically created during installation, with default location under "Program Files." Everything you are asked to report below for Exercise 6 will either be reported in this output file or visualized in one of the TNG Lab GUI screens (Results,

Chart, or Animation). One thing you have to be careful about is that the output file tng.out is overwritten with each new run. Consequently, if you want to save the output in tng.out from particular runs, you have to copy tng.out over into a differently named file.

The TNG is divided into a total of GMax **generations**, and each generation G is subdivided into a total of IMax **trade cycles**. The total payoff TP earned by a trader during any generation G includes the sum of all of his trade payoffs (positive and negative) plus the sum of all of his (non-positive) refusal payoffs. A trader suffers a refusal payoff R any time one of his trade offers is refused by another trader; the non-positive level of the refusal payoff R is set by the user in the TNG Lab GUI Settings Screen. The **utility (or fitness)** of each TNG trader in any generation G is measured by his average payoff per trade cycle, i.e., by his total payoff TP divided by IMax.

EXERCISE DETAILS:

As clarified below, each team is asked to use the TNG Lab to develop and implement an experimental design for exploring the type of expressed behaviors that evolve over time under GA learning in game contexts differing from the standard IPD game.

Three restrictions are imposed on your experimental design as follows – please make absolutely sure you satisfy all three restrictions so different team findings can be compared in an interesting way:

Restriction 1: USE A TWO-SIDED MARKET SPECIFICATION FOR YOUR EXPERIMENTAL DESIGN. That is, in each of your experimental runs, be sure you have a **positive number of Buyers**, a **positive number of Sellers**, and **a 0 number of Dealers**. If you wish, for concreteness, you can adopt the basic setting of a two-sided "labor market" as outlined in Section VIII of Ref.[3] in which the Buyers are interpreted as Workers (buyers of job openings) and the Sellers are interpreted as Employers (sellers of job openings).

Restriction 2: USE EITHER CHICKEN OR STAG HUNT GAME PAYOFFS. At the end of this exercise are two tables containing two payoff matrices with specific numerical payoffs, the first for a specific CHICKEN GAME and the second for a specific STAG HUNT GAME. *Even-numbered* teams are asked to set the specific numerical Chicken Game payoffs in Table 1 for the possible payoffs resulting from each bilateral trade in the TNG . *Odd-numbered* teams are asked to set the specific numerical Stag Hunt Game payoffs in Table 2 for the possible payoffs resulting from each bilateral trade in the TNG.

Restriction 3: KEEP THE EXPERIENCE GAIN PARAMETER FIXED AT 0.0 ON THE TNG GUI. The TNG Lab outcomes are currently overly sensitive to non-zero settings for this parameter for technical implementation reasons that I will explain to you if you are interested.

EXERCISE PARTS A THROUGH C:

Part A: Formulate an Interesting Hypothesis

Carefully formulate a conjecture (hypothesis) that your team judges to be interesting and substantial regarding how a systematic change in some chosen TNG treatment factor value might affect the utility (fitness) levels of the TNG buyers and sellers. As your treatment factor, choose one of the parameters that TNG Lab users are permitted to set in the TNG GUI Setting Screen **other** than either the four game payoffs (to be set either as Chicken or Stag Hunt game payoffs), the experience gain parameter (to be set at 0), or the number of dealers (to be set at 0).

Part B: Explore Your Hypothesis within an Experimental Design

Use the TNG Lab to experimentally explore the validity of the hypothesis you proposed in Part A. Specifically:

1. Choose a range of values (at least three) to be tested for your chosen treatment factor in Part A.

2. Set fixed values for all OTHER features of the TNG Lab that are available for user specification in the TNG Lab GUI, to be retained throughout all experimental runs, and report these fixed values along with the type of game (Chicken or Stag Hunt) that you have been assigned.

3. For each value of your treatment factor to be tested, use the TNG Lab to conduct N runs ($N \geq 10$) using N distinct seed values for the pseudo-random number generator.

4. For each value v of your treatment factor to be tested, and for each run $n = 1, ..., N$ conducted for this treatment factor value, report at least the following information:

   (a) the value v of the treatment factor that is being tested;

   (b) the seed value (the identifier for run n);

   (c) the average utility levels $\bar{U}^b(v, n, GMax)$ and $\bar{U}^s(v, n, GMax)$ attained by Buyers and Sellers, respectively, for the treatment value v and run n **in the final generation GMax**.

5. For each tested treatment factor value v, report the mean and standard deviation for the Buyer utility values $\bar{U}^b(v, n, GMax)$ you obtained from the runs $n = 1, ..., N$ you conducted in Step 4. Similarly, for each tested treatment factor value v, report the mean and standard deviation for the Seller utility values $\bar{U}^s(v, n, GMax)$ you obtained from the runs $n = 1, ..., N$ you conducted in Step 4.

6. For each tested treatment factor value v and each run n, be sure to examine the TNG GUI Results, Chart, and Animation Screen data as the run progresses. Report on any interesting phenomena you see displayed in these screens, even if difficult to quantify in precise terms.

Part C: Analysis of Findings

As best you can, provide an explanation and interpretation for your experimental findings. In particular, using data from your runs in Part B as reported in the corresponding tng.out files, and in the Results, Chart, and Animation Screens of the TNG GUI, address the following questions as carefully as you can:

1. Do your findings in Part B provide any support for the hypothesis you proposed in Part A? Or does your hypothesis in Part A appear to be inconsistent with these findings?

2. Based on your findings in Part B, what can you conclude about the relative and absolute utility performance of Buyers and Sellers in your assigned game (Chicken or Stag Hunt)?

3. Do your findings in Part B indicate that the behaviors expressed by the traders in their bilateral trades are varying systematically with changes in your treatment factor value? If so, how?

4. Do your findings in Part B indicate that the trade interaction networks formed by your traders are varying systematically with changes in your treatment factor value? If so, how?

5. Can you make any interesting connections between your findings for this exercise and your findings in Exercise 5, in which you used the same game payoff matrix?

		PLAYER 2	
		C	**D**
PLAYER 1	**C**	**(R=2,R=2)**	**(S=1,T=3)**
	D	**(T=3,S=1)**	**(P=0,P=0)**

Table 1: A Chicken Game ($T > R > S > P$)

		PLAYER 2	
		C	**D**
PLAYER 1	**C**	**(R=3,R=3)**	**(S=0,T=2)**
	D	**(T=2,S=0)**	**(P=1,P=1)**

Table 2: A Stag Hunt Game ($R > T > P > S$)