Labor Institutions and Market Performance

An Agent-Based Computational Economics Approach

Presenter:

Leigh Tesfatsion

Professor of Econ, Math, and Electrical and Comp. Eng.

Department of Economics

Iowa State University

Ames, Iowa 50011-1070

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

tesfatsi@iastate.edu

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Outline

- What is Agent-Based Computational Economics (ACE)?
- Labor Institutions and Market Performance: What does ACE have to offer?
- Illustration: (M. Pingle/L. Tesfatsion, 2003)

  "Evolution of Worker-Employer Networks and Behaviors Under Alternative Non-Employment Benefits"

- Trade Network Game (TNG) Lab Implementation

  www.econ.iastate.edu/tesfatsi/TNGHome.htm

What is Agent-Based Computational Economics (ACE)?

- **Culture-dish approach** to the study of decentralized market processes
- **Computational study** of economic processes modeled as dynamic systems of interacting agents

ACE Resource Site:

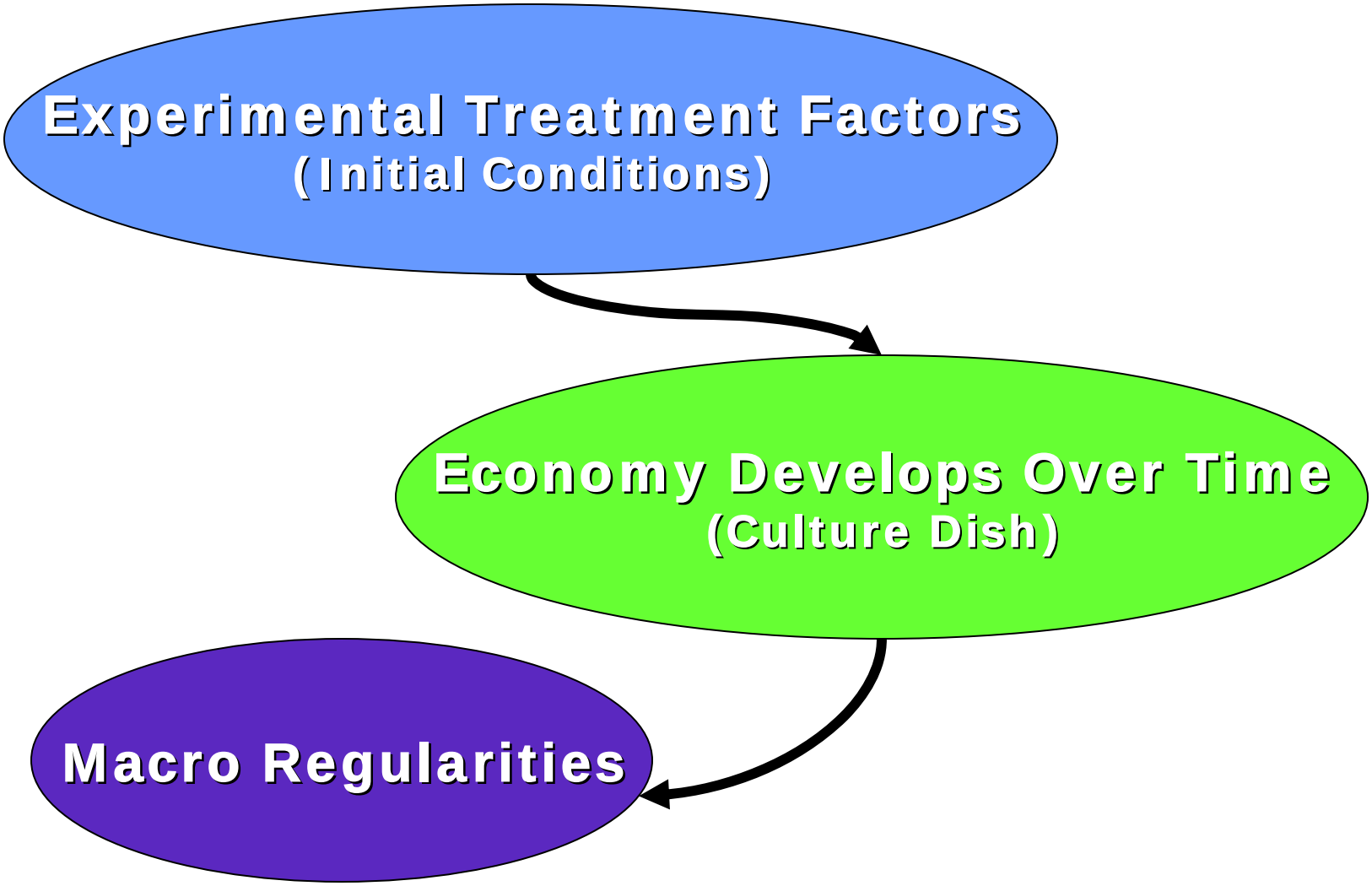
www.econ.iastate.edu/tesfatsi/ace.htm

- **ACE Labor Market Research Site:**
  www.econ.iastate.edu/tesfatsi/alabor.htm

ACE Modeling: Culture Dish Analogy

- Modeler constructs a **computational economic world** populated by various types of agents (economic, social, biological, & physical)
- Modeler sets **initial conditions**
- The world then **develops over time** without further outside intervention
- World driven solely by **agent interactions**

ACE Modeling: Culture Dish Analogy



Key Characteristics of ACE Models

- **Agents** are encapsulated software programs capable of
  - ***Adaptation*** to environmental conditions
  - ***Social communication*** with other agents
  - ***Goal-directed learning***
  - ***Autonomy*** (self-activation and self-determinism based on private internal processes)
- Agents can be situated in realistically rendered problem environments
- Behaviour/interaction patterns can develop endogenously over time

Current ACE Research Areas

(http://www.econ.iastate.edu/tesfatsi/aapplic.htm)

- Embodied cognition
- Network formation
- Financial Economics
- Labor Markets
- Industrial organization
- Macroeconomics
- Technological change and economic growth
- Market design
- Automated markets and software agents
- Parallel experiments (real & computational agents)
- Empirical validation and verification of ACE models
- **Many others...**

Labor Institutions and Market Performance

Some Key Issues:

- Labor contracts typically **incomplete**
- Supplemented by government programs with **numerous eligibility restrictions**
- **Difficult to test program effects** by means of conventional analytical and/or statistical tools

Example: U.S. Programs Providing
Unemployment Benefits (UB)

- UB only paid to “no fault of their own” unemployed
- UB recipients must continue to seek employment
- UB levels based on past earnings
- UB of limited duration
- UB financed by taxes imposed on employers
- Additional UB often granted when unemployment rate is abnormally high for prolonged periods
- ***Example:*** IA Unemployment Insurance Guide (29pp)
  http://www.iowaworkforce.org/ui/guide.htm

Empirical UB Findings

(*Handbook of Labor Economics*, Vols. 1-3, Elsevier, 1999)

- Higher benefit **level** increases duration of unemployment spells.
- Increased benefit **duration** increases unemployment rate (unemployed as percentage of labor force).
- **Evidence of other impacts of UB is considerably more mixed** (endogeneity, small sample bias problems,...)

Common Approach to UB Theoretical Modeling

(*Handbook of Labor Economics*, Vols. 1-3, Elsevier, 1999)

- Dynamic Programming (DP)
- Jobs arise and end randomly
- Unemployed receive UB
- Workers compare DP value of new job vs. current job or unemployment
- Each worker maximizes lifetime expected utility
- **Precise predictions possible, but empirical support unclear.**

Potential Contributions of an ACE Approach to Labor Research

www.econ.iastate.edu/tesfatsi/alabor.htm

- Employers/workers can be modeled as **autonomous interacting agents**
- Matching process can be preferential (**endogenous hires, quits, and firings**)
- **Learning** can be calibrated to data (empirical, human-subject experimental)
- **Evolution** of behaviors/interaction networks
- Relatively easy to incorporate **realistically detailed structural features** (market protocols, policy rules, program eligibility requirements,...)

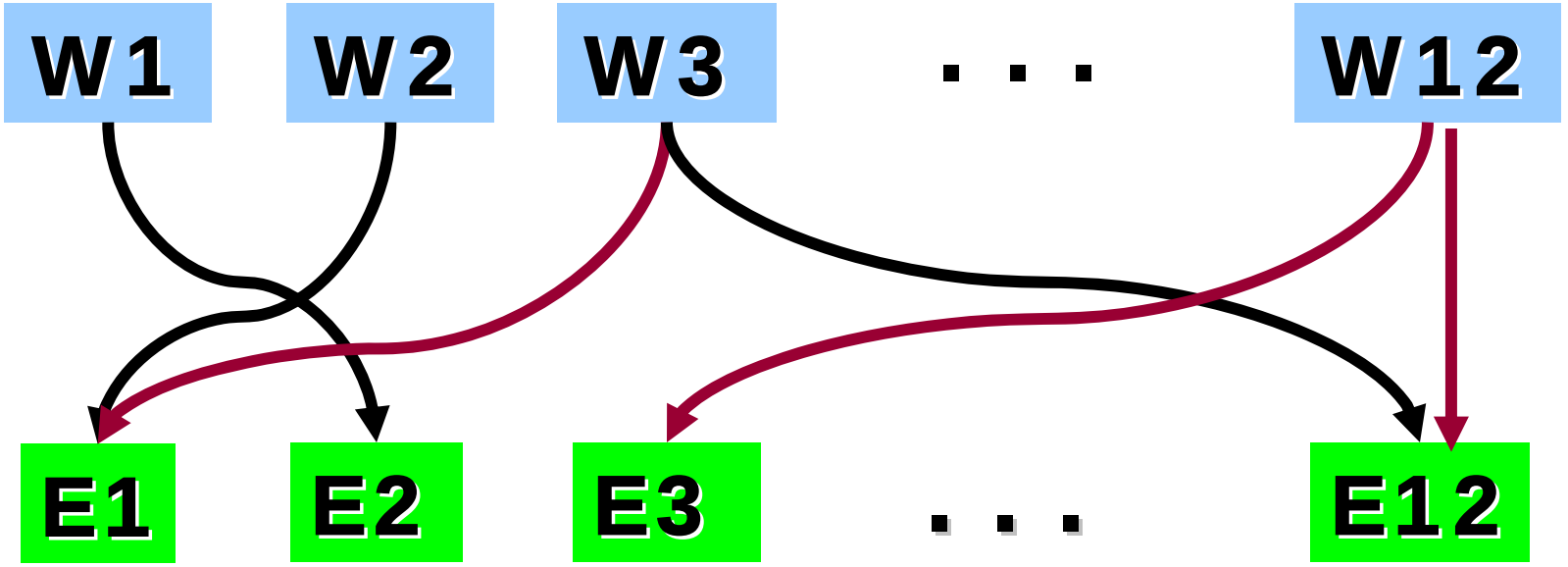
Illustration: An ACE Study of "Non-Employment Payments" (NEP)

- **Joint work with M. Pingle (U of Nevada-Reno)**
- Published in *New Directions in Networks,* 2003, Edward-Elgar volume, edited by A. Nagurney

  M. Pingle and L. Tesfatsion, "Evolution of Worker-Employer Networks and Behaviors under Alternative Non-Employment Benefits: An Agent-Based Computational Economics Study"
- Pre-print available at

  www.econ.iastate.edu/tesfatsi/alabmplt.pdf
- Parallel human-subject experiments conducted

ACE Labor Market Framework



Preferential job search with choice/refusal of partners:
Red directed arrow indicates **refused work offer**.

Focus on Interaction Effects ➔
Endogenous Heterogeneity of Agents

- 12 workers with **same observable attributes** in initial period T=0
- 12 employers with **same observable attributes** in initial period T=0
- Each worker can work for at most one employer in each period T
- Each employer can provide at most one job opening in each period T
- **Worksite strategies** in initial period T=0 are **random and private info**

Each worker and employer has…

- ***Public methods for requesting/receiving info*** about various market and NEP policy protocols
- ***Public communication methods*****–**workers and employers can talk with each other.
- ***Privately stored data*** that can change over time through experiences/communications
- ***Private behavioral methods*** that include expectation formation & learning about preferred worksite partners and worksite strategy choices

A Worker Agent

Public Access:

// **Public Methods**

Protocols governing job search;
Protocols governing negotiations with potential employers;
Protocols governing non-employment payments program;
Methods for communicating with other agents;
Methods for retrieving stored Worker data;

Private Access Only:

// **Private Methods**

Method for calculating own expected utility assessments;
Method for choosing/refusing employers **[learning]** ;
Method for updating own worksite strategy **[learning]**;

// **Private Data**

Data about own self (history, utility fct., current wealth…);
Data recorded about external world (employer behaviors,…);
Addresses for other agents **[permits agent communication]**

An Employer Agent

Public Access:

// **Public Methods**

Protocols governing search for workers;
Protocols governing negotiations with potential workers;
Protocols governing non-employment payments program;
Methods for communicating with other agents;
Methods for retrieving stored Employer data;

Private Access Only:

// **Private Methods**

Method for calculating own expected profit assessments;
Method for choosing/refusing workers **[learning]** ;
Method for updating own worksite strategy **[learning]**;

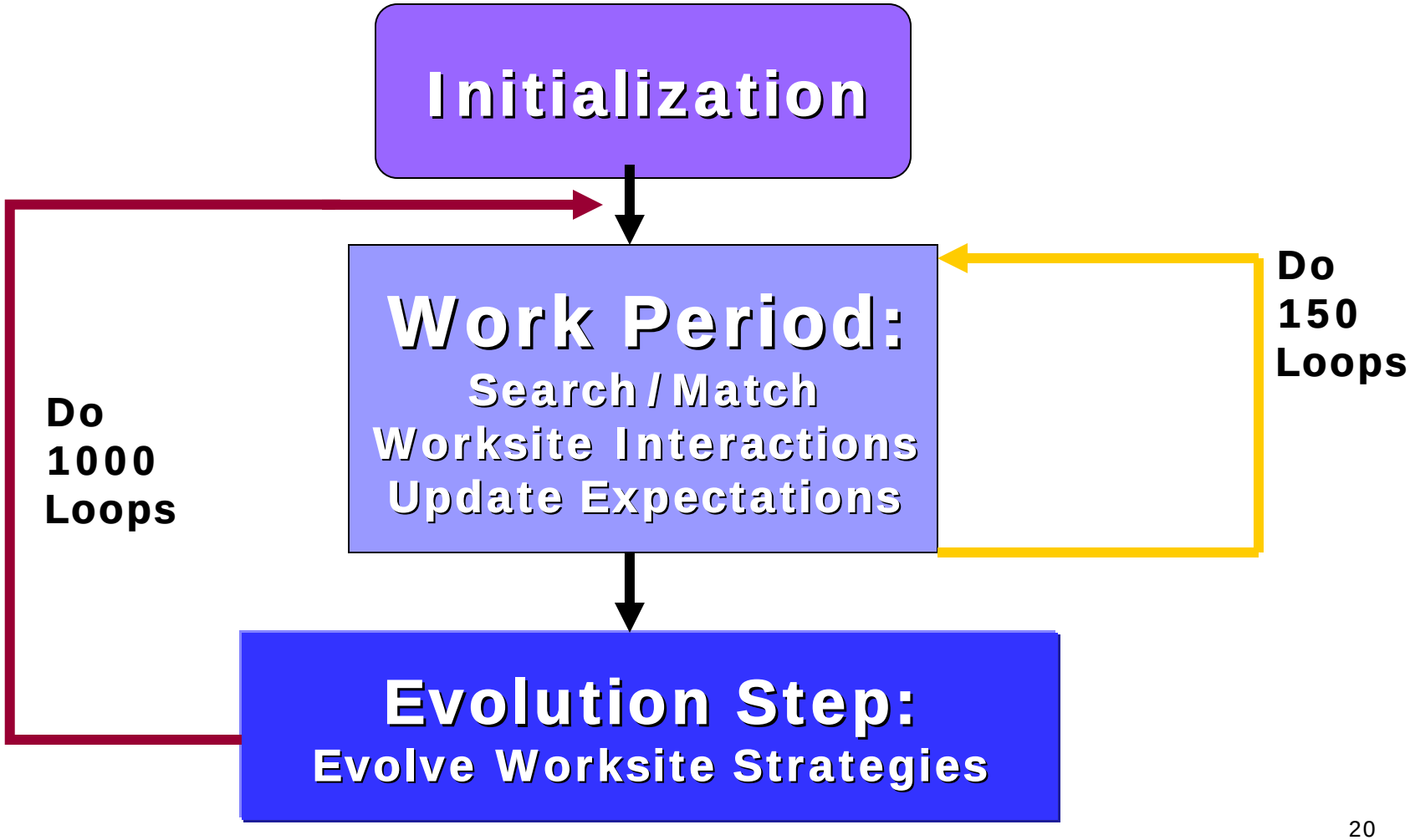
// **Private Data**

Data about own self (history, profit fct., current wealth…);
Data recorded about external world (worker behaviors,…);
Addresses for other agents **[permits agent communication]**

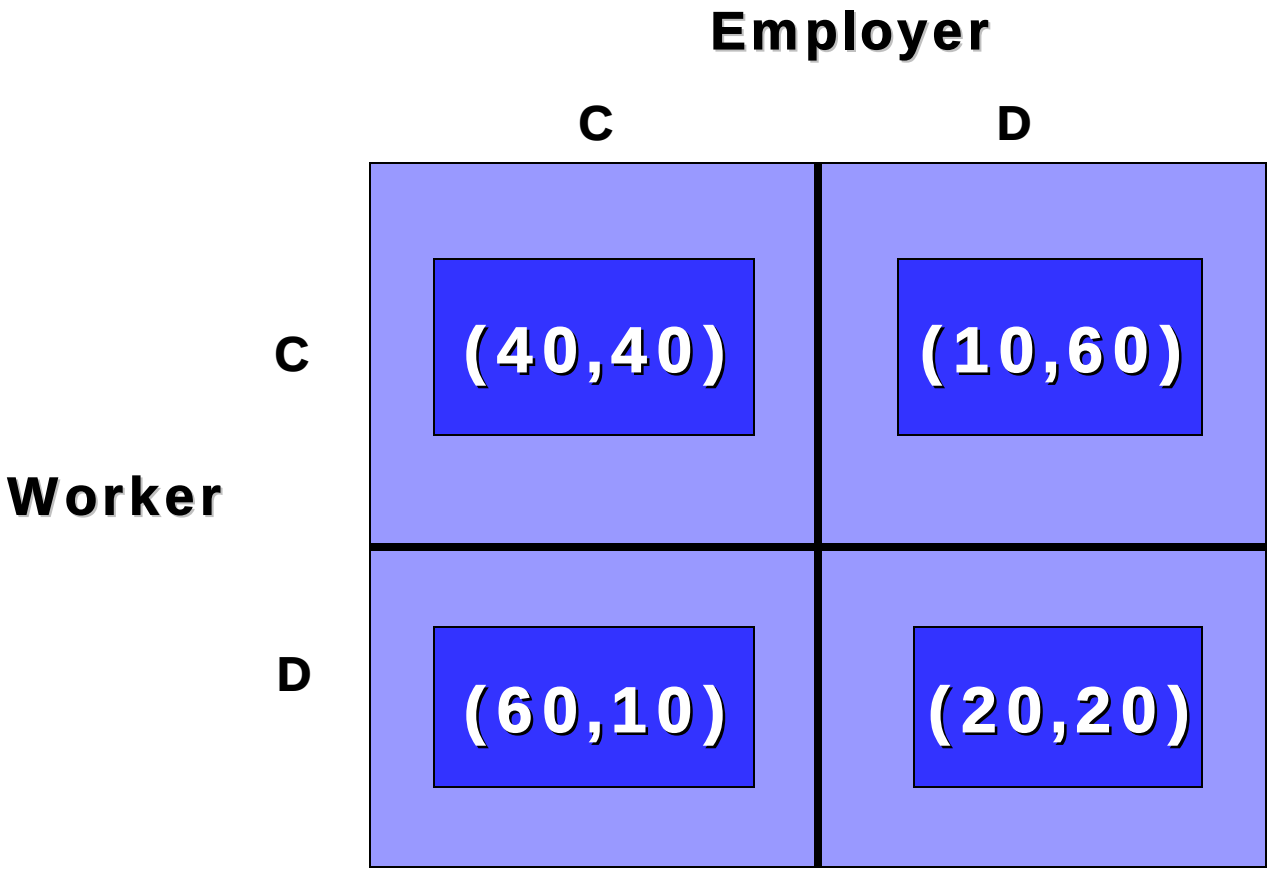
Flow of Activities in the ACE Labor Market

- Workers make offers to preferred employers at a small cost per offer (**quits allowed**)
- After batching work offers, employers accept or refuse these offers (**firings allowed**)
- Each matched pair engages in one worksite interaction (**PD - cooperate or defect**)
- After 150 work periods, each worker (employer) updates its iterated prisoner's dilemma strategy for interactions with each potential employer (worker).

Flow of Activities in the ACE Labor Market



Worksite Interactions as Prisoner's Dilemma (PD) Games



D = Defect (Shirk); C = Cooperate (Fulfill Obligations)

Key Issues Addressed

How do **changes** in the level of the non-employment payment (NEP) affect...

- **Worker-Employer Interaction Networks**
- **Worksite Behaviors:** Degree to which workers/employers shirk (defect) or fulfill obligations (cooperate) on the worksite
- **Market Efficiency** (total surplus net of NEP program costs, unemployment/vacancy rates,...)
- **Market Power** (distribution of total net surplus)

Experimental Design

- **Treatment Factor: NEP**

  Non-Employment Payment (NEP) paid to each unemployed worker and each employee having no workers

- **Three Tested Treatment Levels:**

  NEP=0, NEP=15, NEP=30

- **Runs per Treatment: 20**

  1 Run = 1000 Generations;

  1 Generation = 150 Work Periods Plus Evolutionary Step

- **Data Collected Per Run:** Network patterns, behaviors, and market performance (reported in detail for generations 12, 50, 1000)

Three NEP Treatments in Relation to PD Payoffs

① **NEP=0** < L=10

② L=10 < **NEP=15** < D=20

③ D=20 < **NEP=30** < C=40

NOTE: Work-site PD payoffs given by:

L (Sucker)=10 < D (MutualDef) = 20
< C (MutualCoop) = 40
< H (Temptation) = 60

Market Efficiency Findings

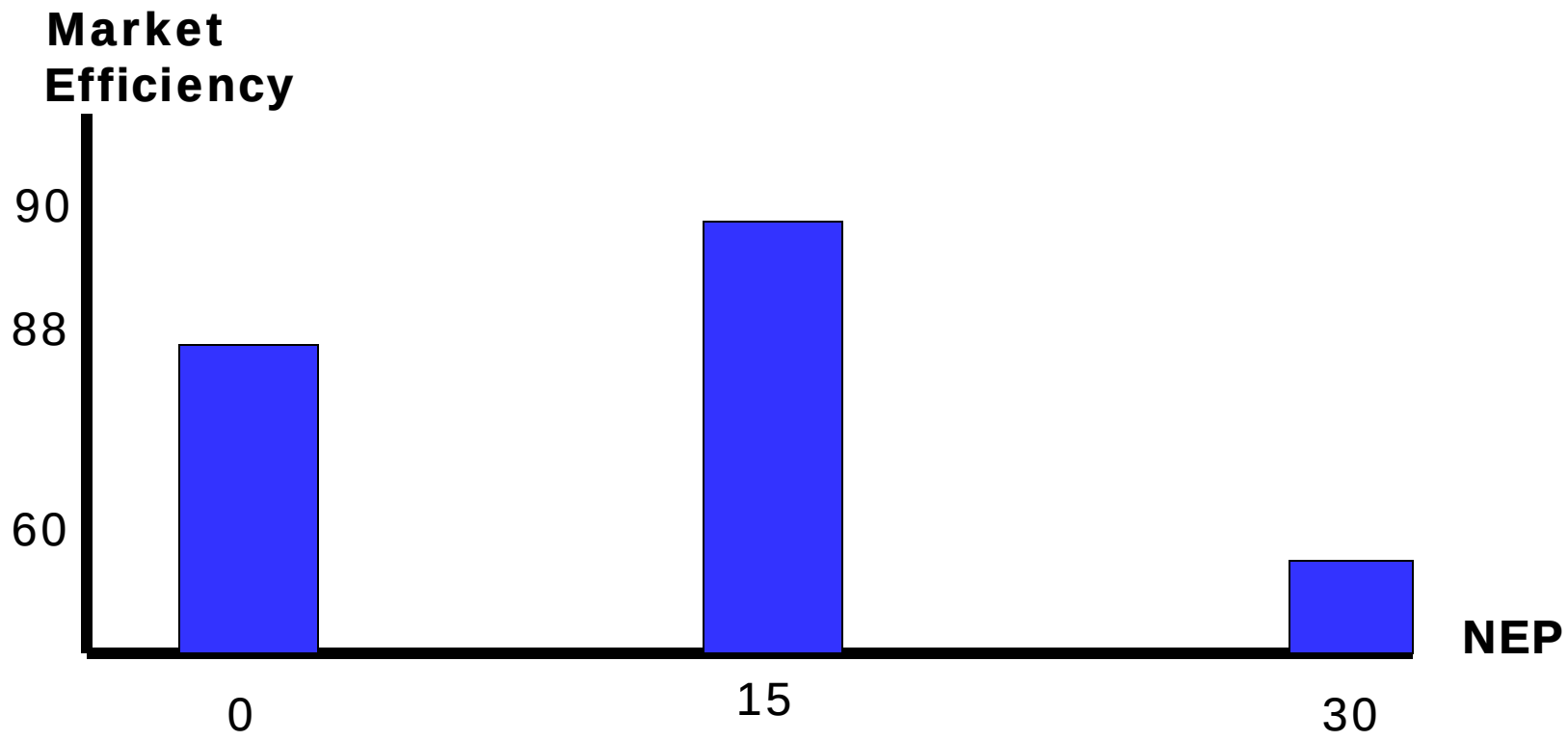
As NEP level **increases** from 0 to 30...

- ***higher*** average unemployment and vacancy rates are observed; ← **KNOWN EFFECT**
- ***more*** work-site cooperation observed on average among workers & employers who match. ← **NEW EX POST EFFECT**

Note: These outcomes have ***potentially offsetting*** effects on market efficiency.

Efficiency Findings...

Market Efficiency *(utility less NEP program costs) averaged across generations 12, 50, and 1000 for three different NEP treatments*



Efficiency Findings...

- NEP=15 yields ***highest efficiency***
- NEP=0 yields ***lower*** efficiency
  (too much shirking)
- NEP=30 yields ***lowest efficiency***
  (program costs too high – everyone too picky!)

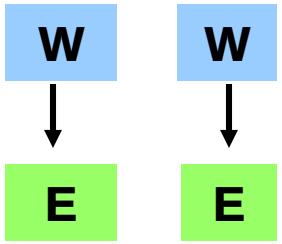
Multiple Attractors

- Two distinct "behavioral attractors" observed for each NEP treatment...
  - **NEP=0 and NEP=15:**
    - First Attractor = Latched network supporting ***mutual cooperation***;
    - Second Attractor = Latched network supporting ***intermittent defection***
  - **NEP=30:**
    - First Attractor = Latched network supporting ***mutual cooperation***
    - Second Attractor = Disconnected network reflecting ***total coordination failure***

The Following Diagrams Report...

① Two-sided (W-E) network distributions

0 = Stochastic fully connected network;

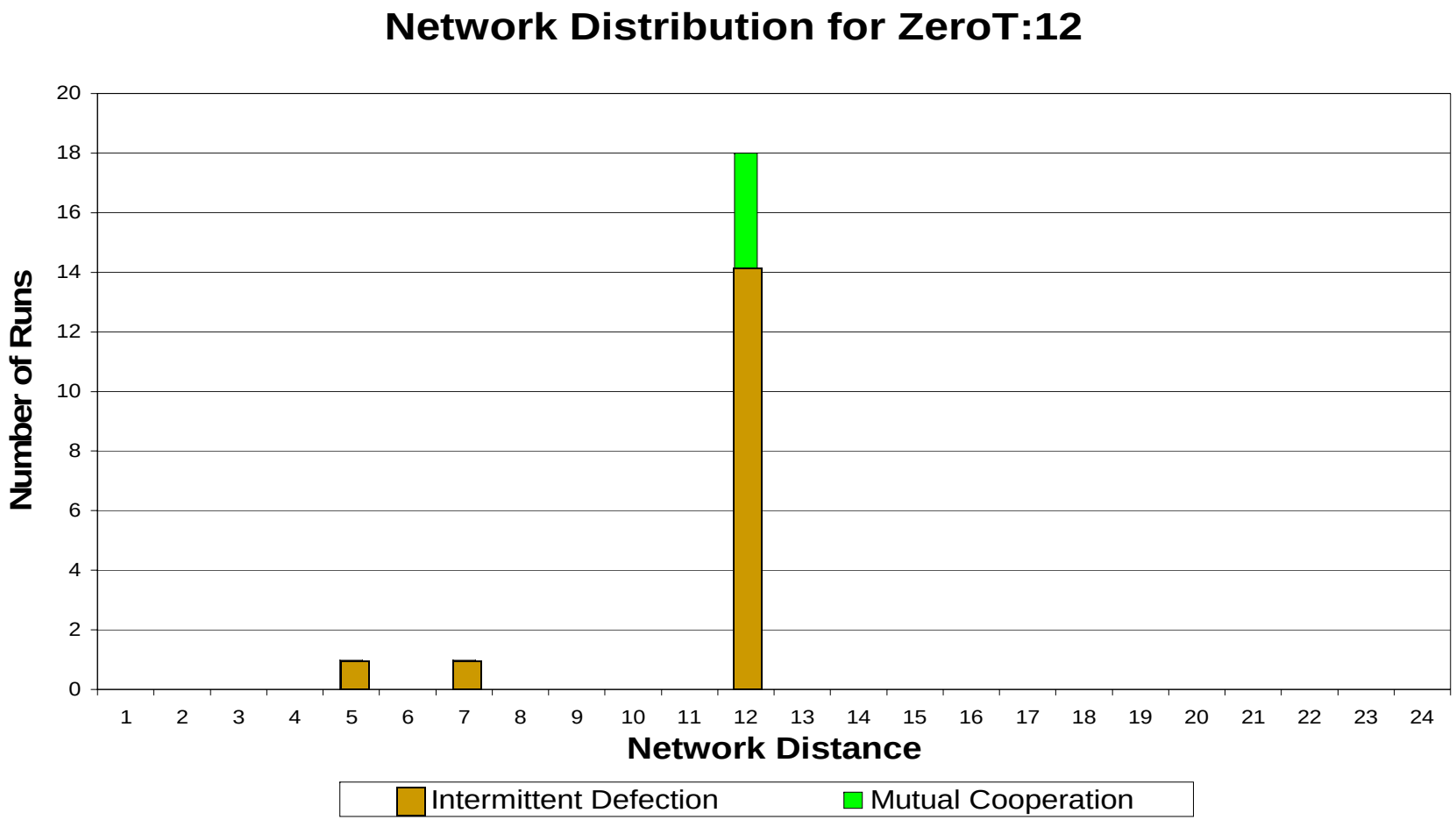
12 = Latched in pairs 

...

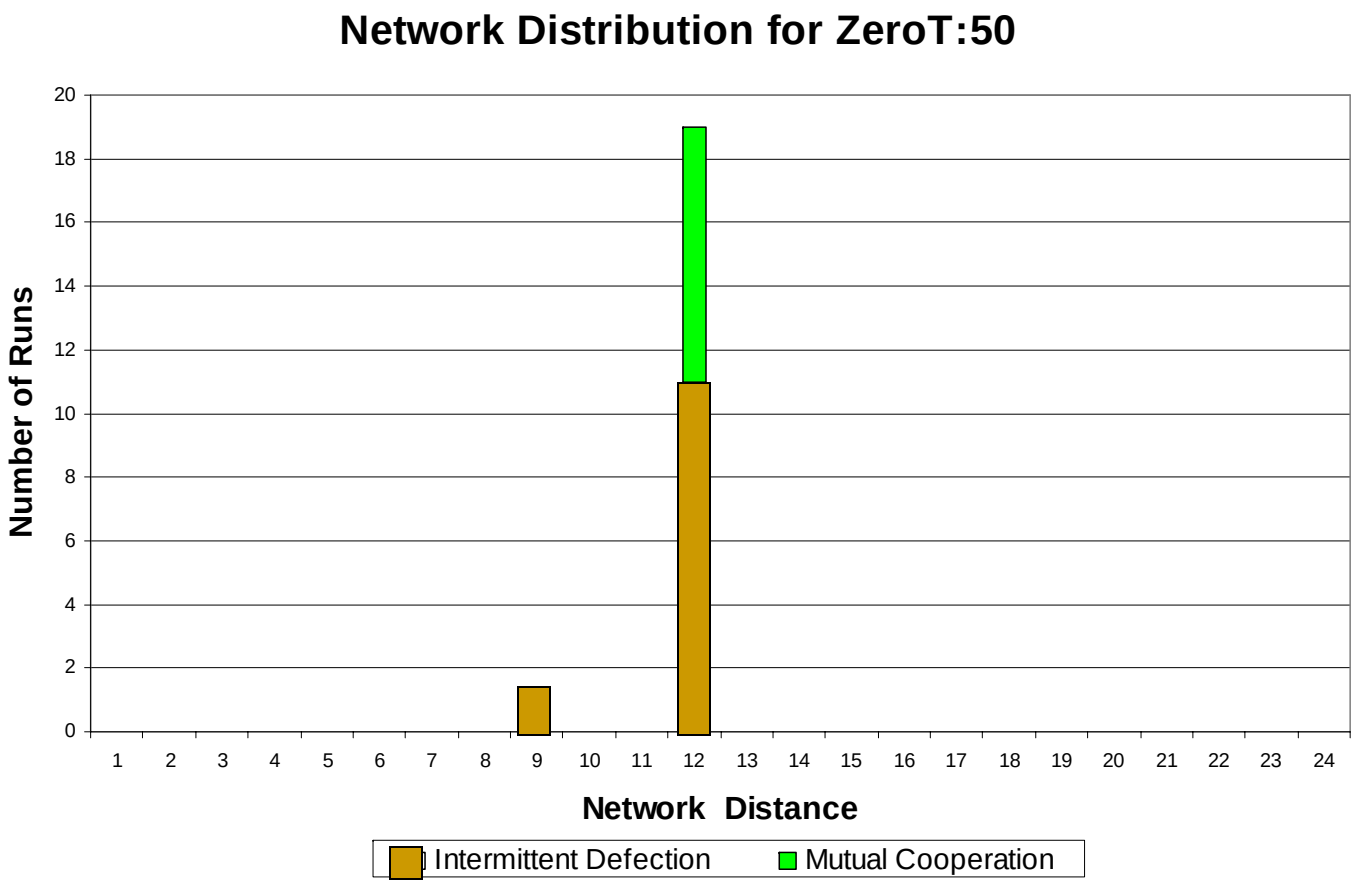
24 = Completely disconnected

② Worksite behaviors that are supported by these network outcomes

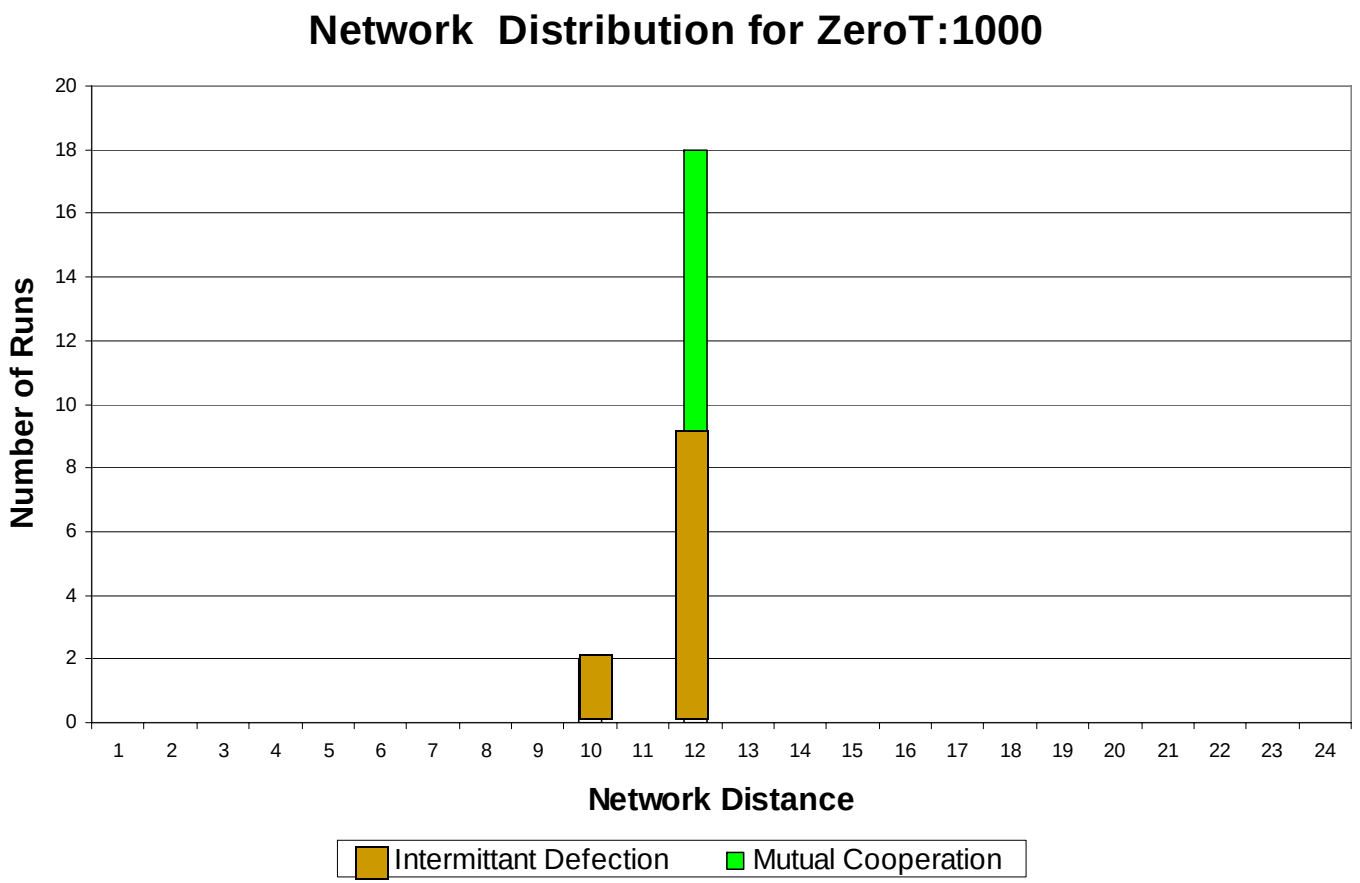
Network Distribution for **NEP=0** Sampled at End of **Generation 12**



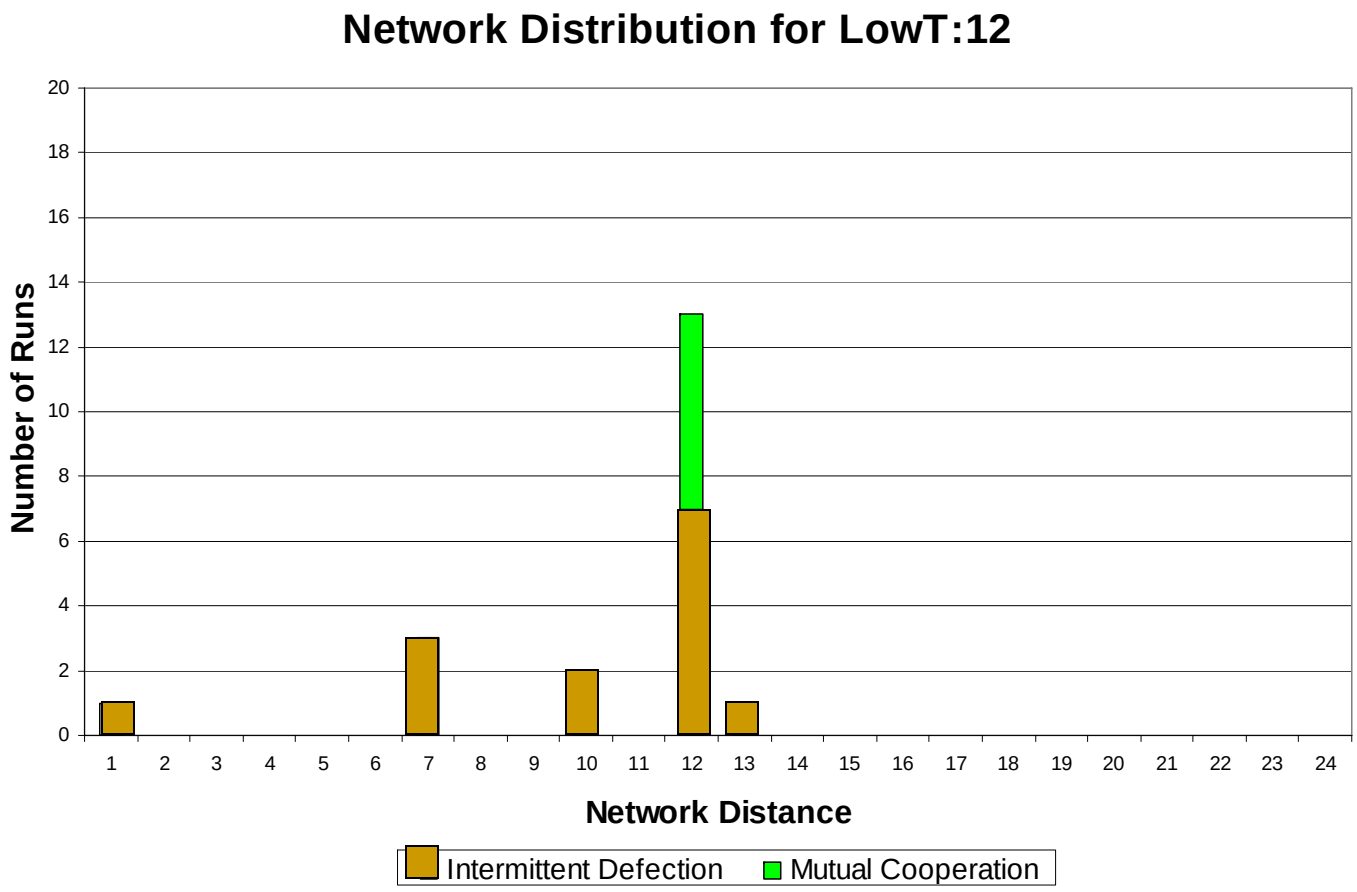
Network Distribution for **NEP=0** Sampled at End of **Generation 50**



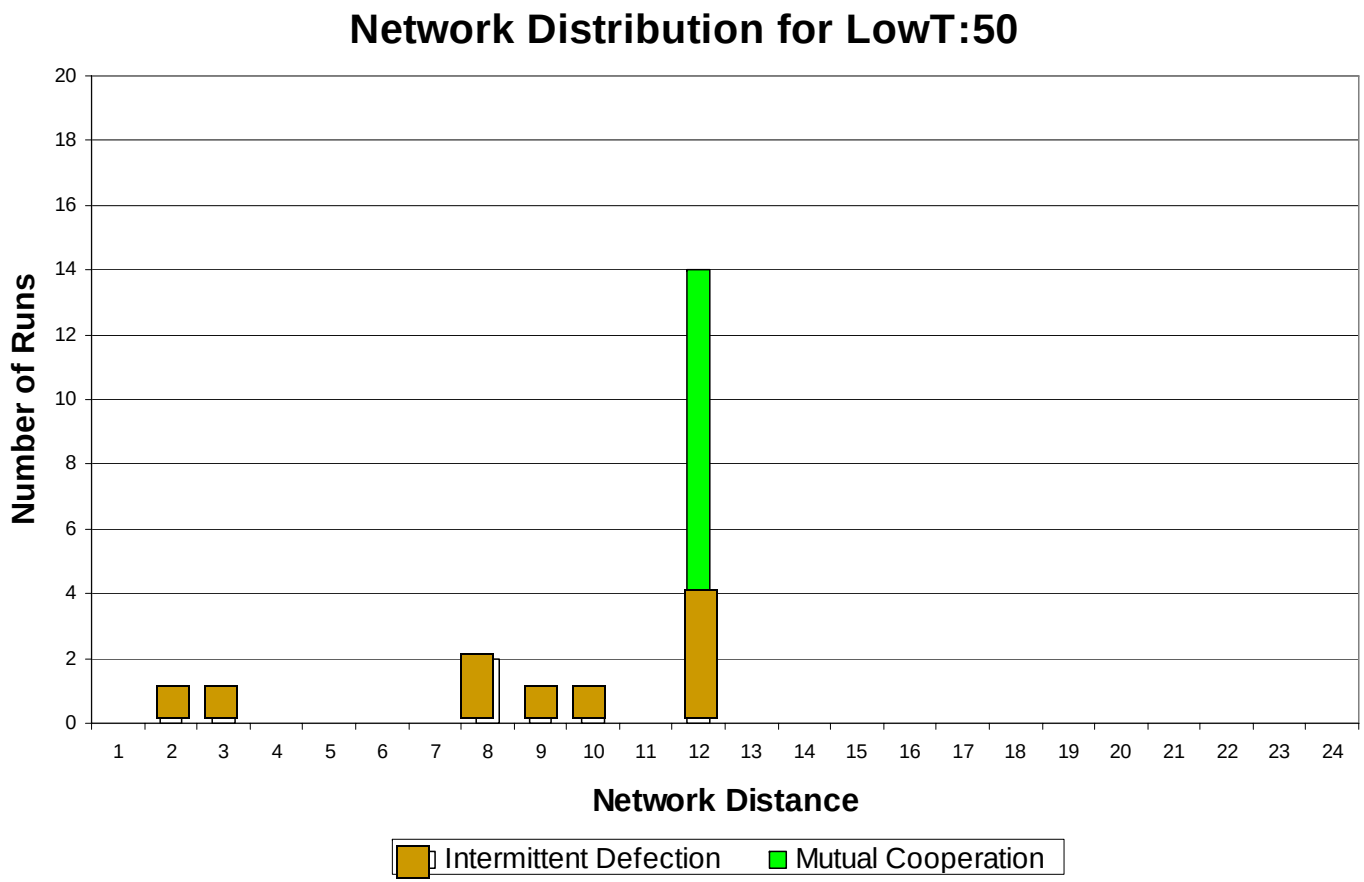
Network Distribution for **NEP=0** Sampled at End of **Generation 1000**



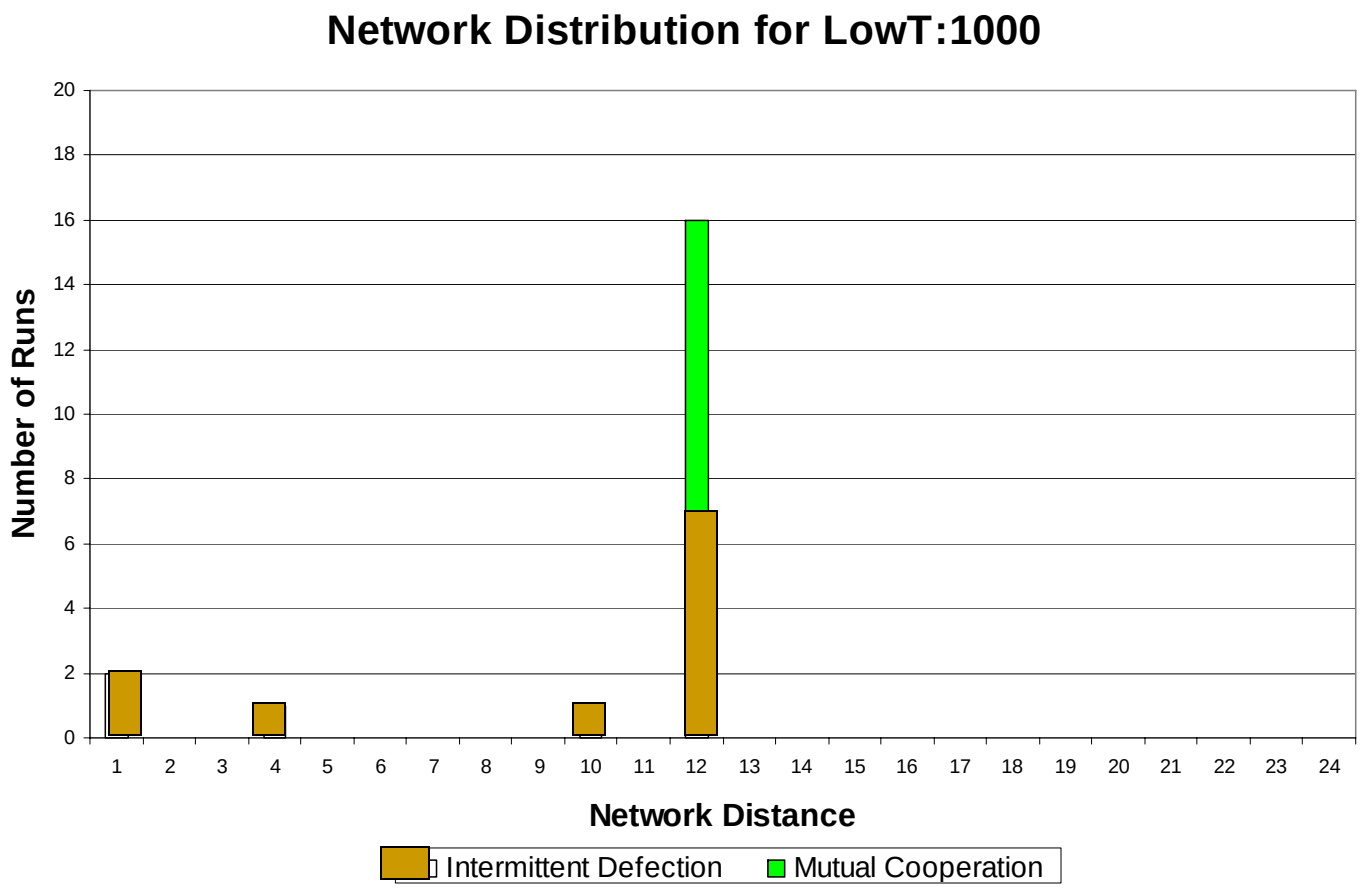
Network Distribution for **NEP=15** Sampled at End of **Generation 12**



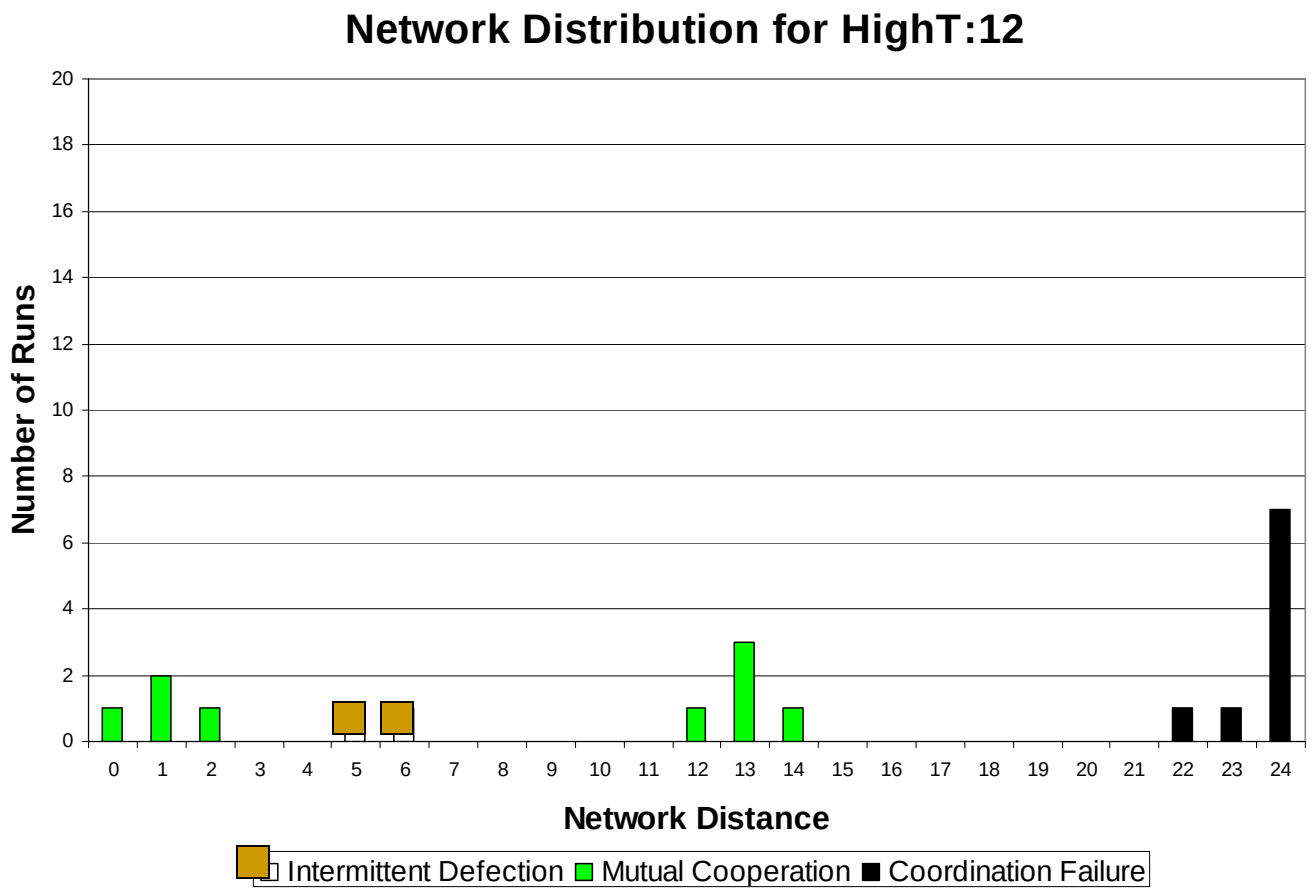
Network Distribution for **NEP=15** Sampled at End of **Generation 50**



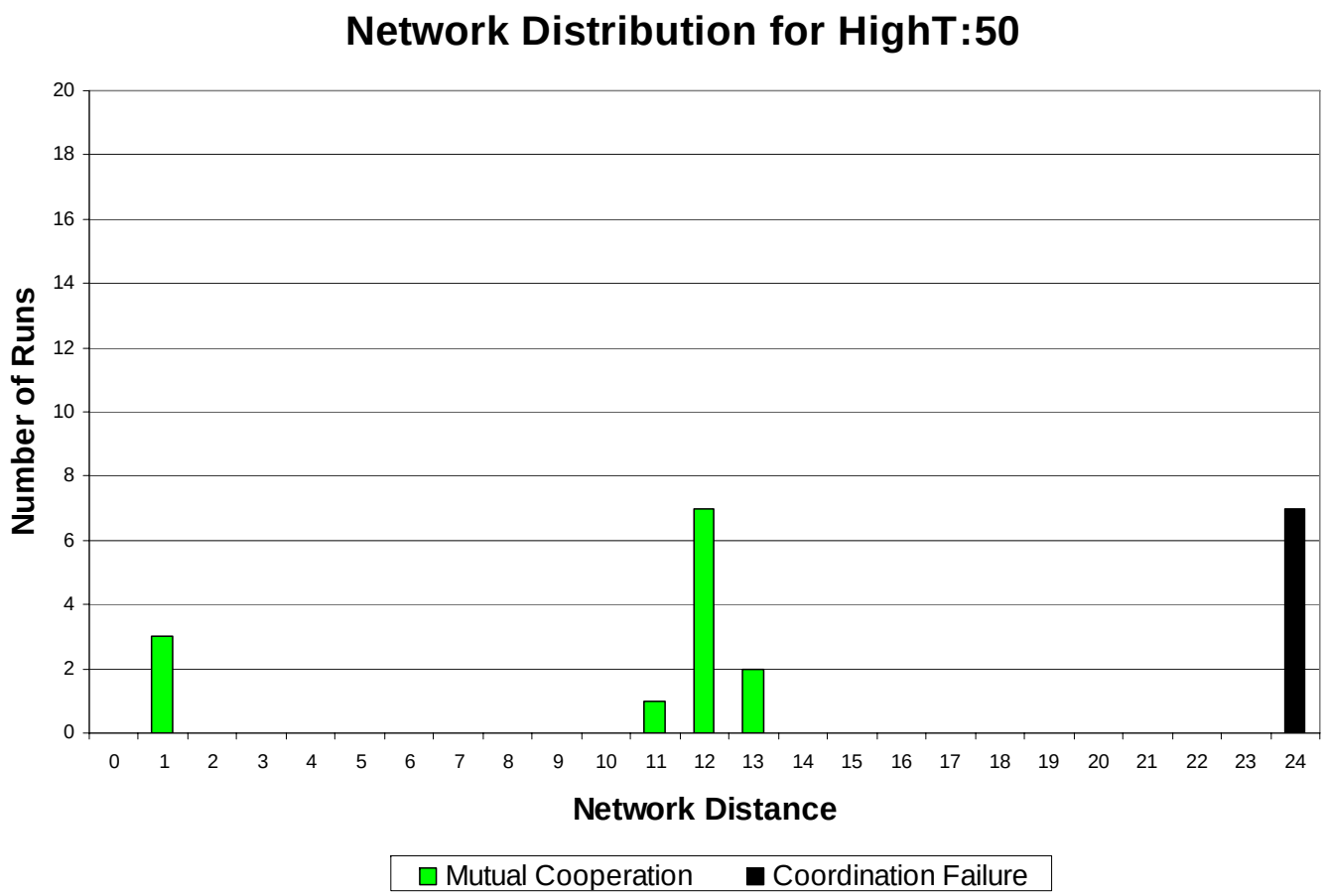
Network Distribution for **NEP=15** Sampled at End of **Generation 1000**



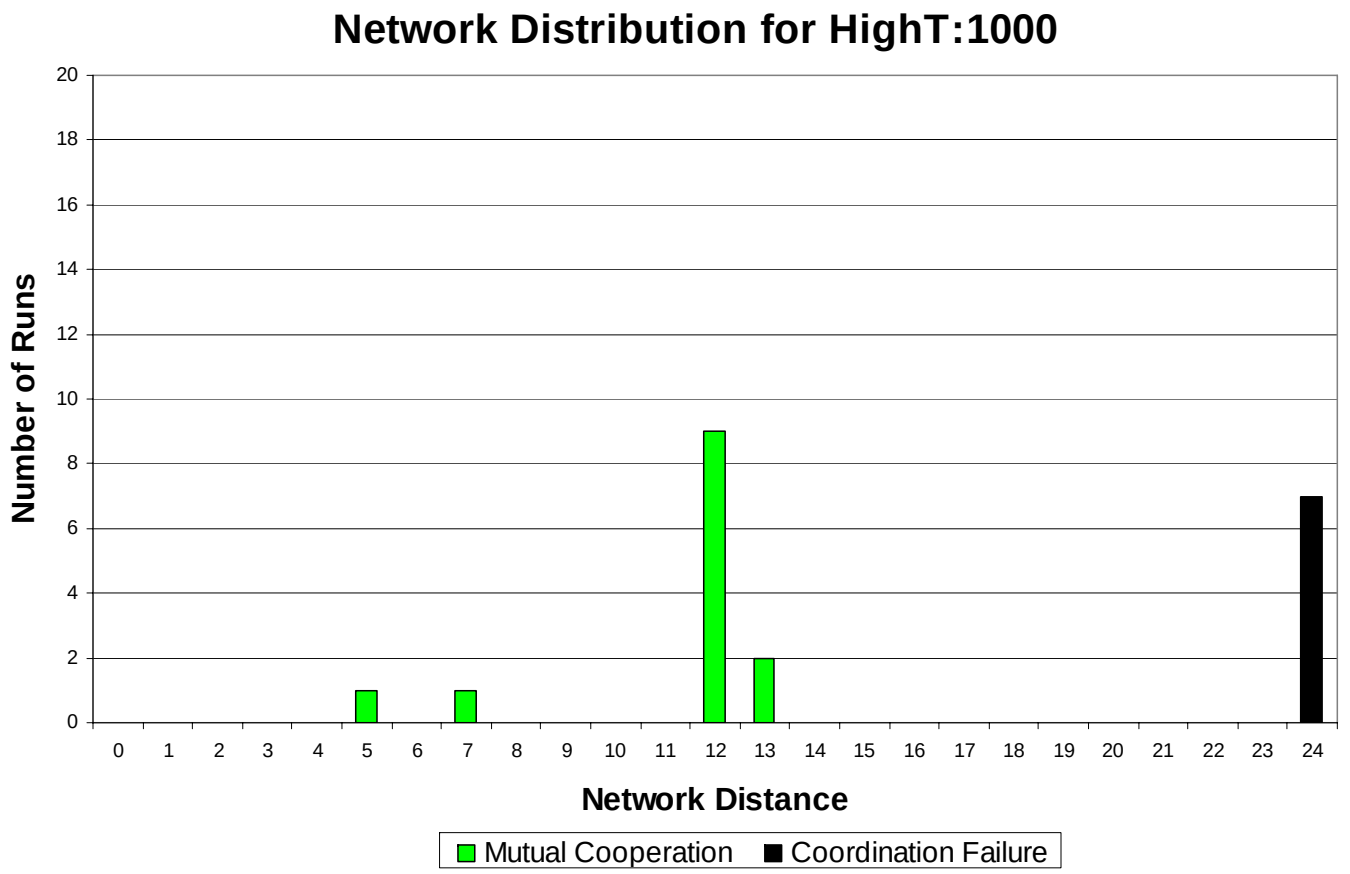
Network Distribution for **NEP=30** Sampled at End of **Generation 12**



Network Distribution for **NEP=30** Sampled at End of **Generation 50**



Network Distribution for **NEP=30** Sampled at End of **Generation 1000**

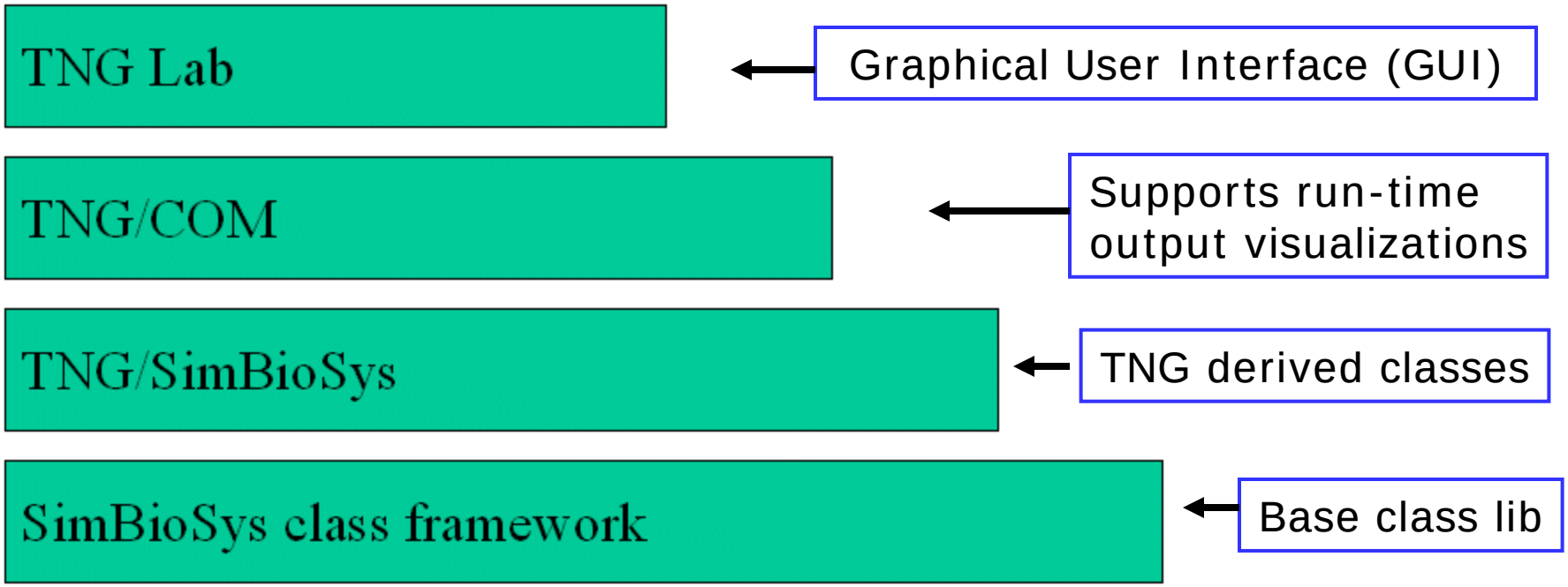


Summary of Findings

- Changes in NEP ***systematically*** affect unemployment, vacancy, worksite behaviors, and welfare outcomes
- Worker-employer networks tend to be either ***fully latched in pairs*** or ***completely disconnected***
- But... even fully latched networks support ***spectral (multiple-peaked)*** behavioral distributions (potential pooling problems)

Implementation via Trade Network Game (TNG) Lab:

Architecture of the TNG Lab



TNG Homepage:

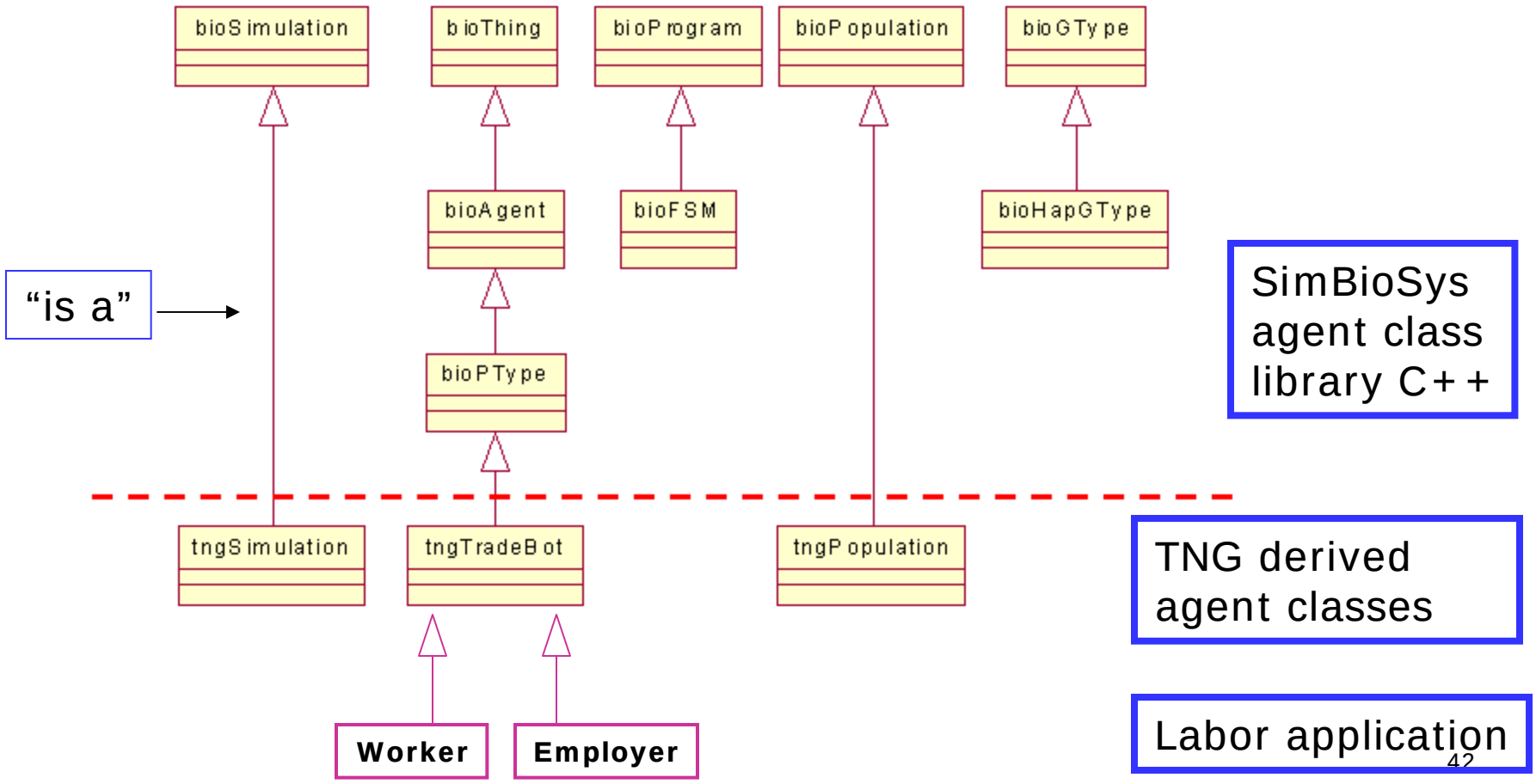
http://www.econ.iastate.edu/tesfatsi/tnghome.htm

SimBioSys Class Framework

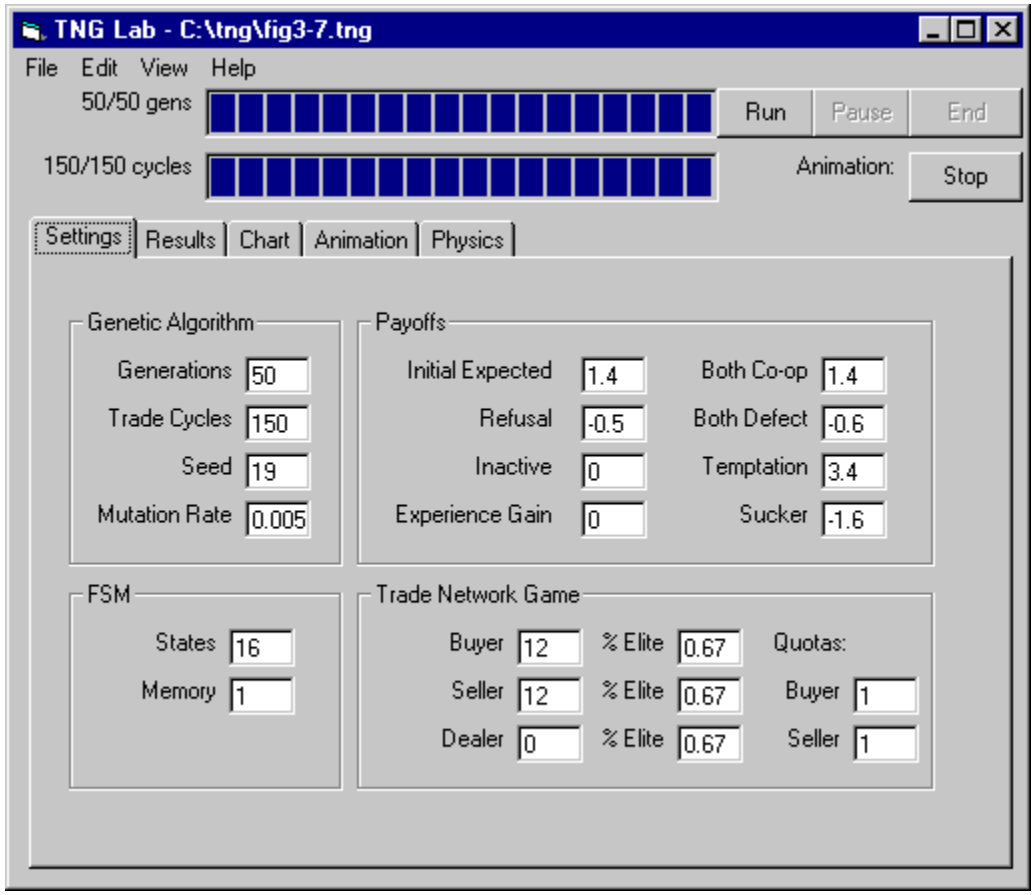
(David McFadzean, M.S. Thesis, 1995)

- Simulation toolkit
- C++ class library
- Designed for artificial life simulations (populations of autonomous interacting agents evolving in a virtual spatial world)

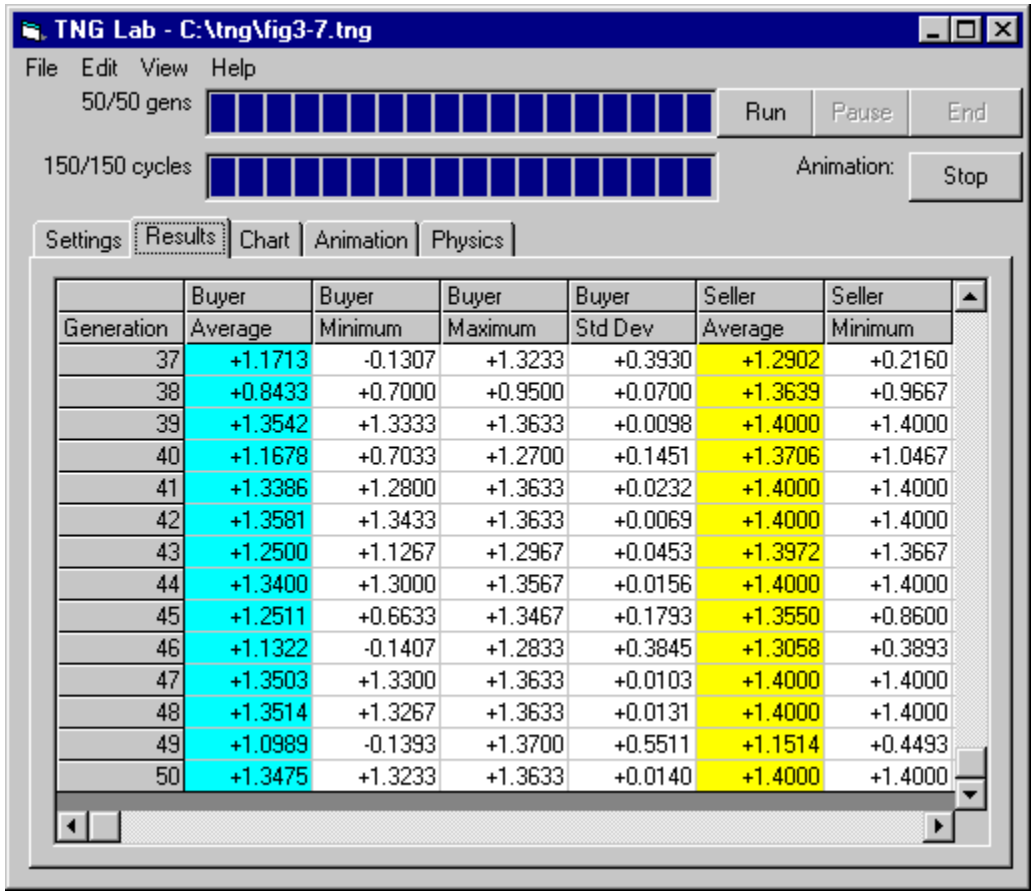
TNG Lab: Agent Hierarchy in *Unified Modeling Language (UML)*



TNG Lab Graphical User Interface (GUI)
Settings Screen

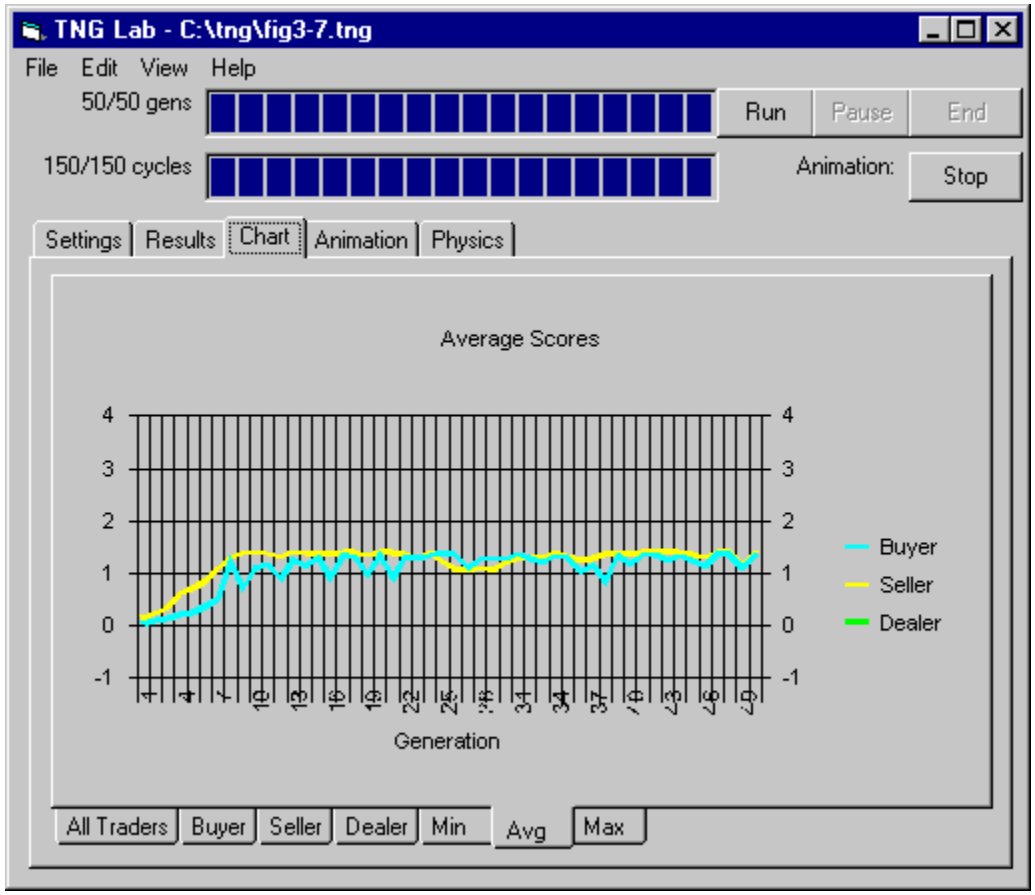


TNG Lab GUI:
Results Screen

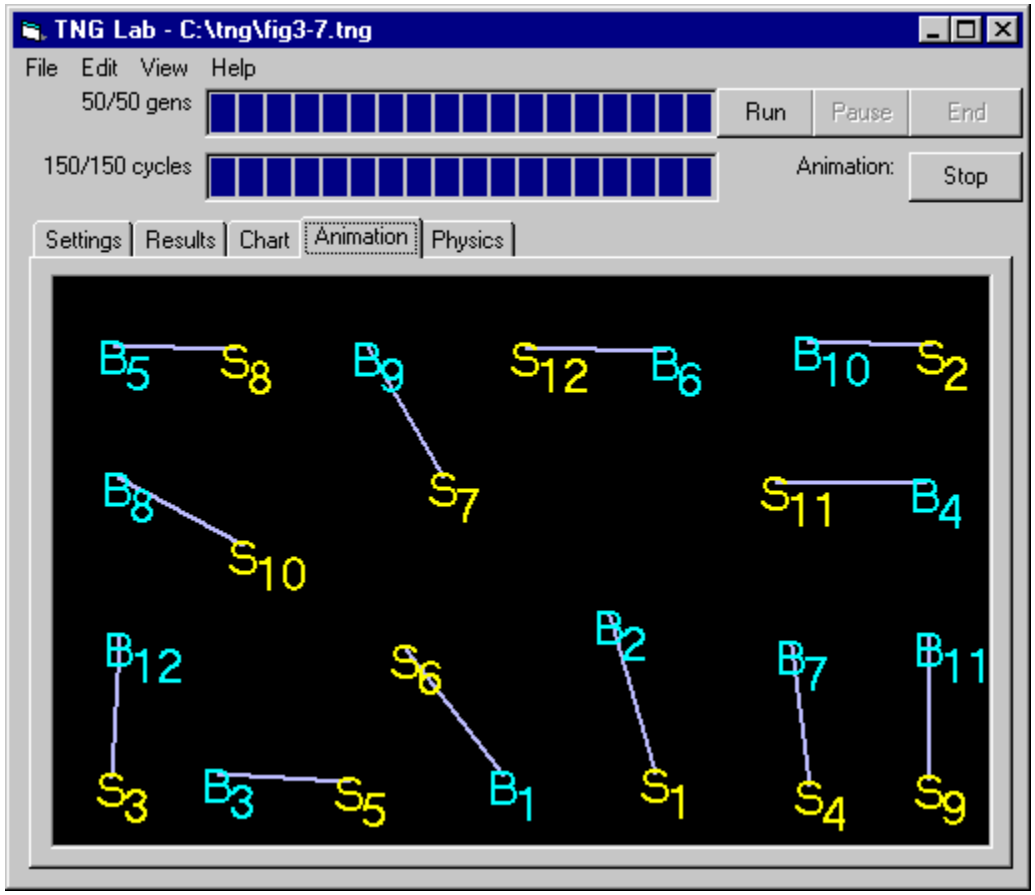


Generation	Buyer Average	Buyer Minimum	Buyer Maximum	Buyer Std Dev	Seller Average	Seller Minimum
37	+1.1713	-0.1307	+1.3233	+0.3930	+1.2902	+0.2160
38	+0.8433	+0.7000	+0.9500	+0.0700	+1.3639	+0.9667
39	+1.3542	+1.3333	+1.3633	+0.0098	+1.4000	+1.4000
40	+1.1678	+0.7033	+1.2700	+0.1451	+1.3706	+1.0467
41	+1.3386	+1.2800	+1.3633	+0.0232	+1.4000	+1.4000
42	+1.3581	+1.3433	+1.3633	+0.0069	+1.4000	+1.4000
43	+1.2500	+1.1267	+1.2967	+0.0453	+1.3972	+1.3667
44	+1.3400	+1.3000	+1.3567	+0.0156	+1.4000	+1.4000
45	+1.2511	+0.6633	+1.3467	+0.1793	+1.3550	+0.8600
46	+1.1322	-0.1407	+1.2833	+0.3845	+1.3058	+0.3893
47	+1.3503	+1.3300	+1.3633	+0.0103	+1.4000	+1.4000
48	+1.3514	+1.3267	+1.3633	+0.0131	+1.4000	+1.4000
49	+1.0989	-0.1393	+1.3700	+0.5511	+1.1514	+0.4493
50	+1.3475	+1.3233	+1.3633	+0.0140	+1.4000	+1.4000

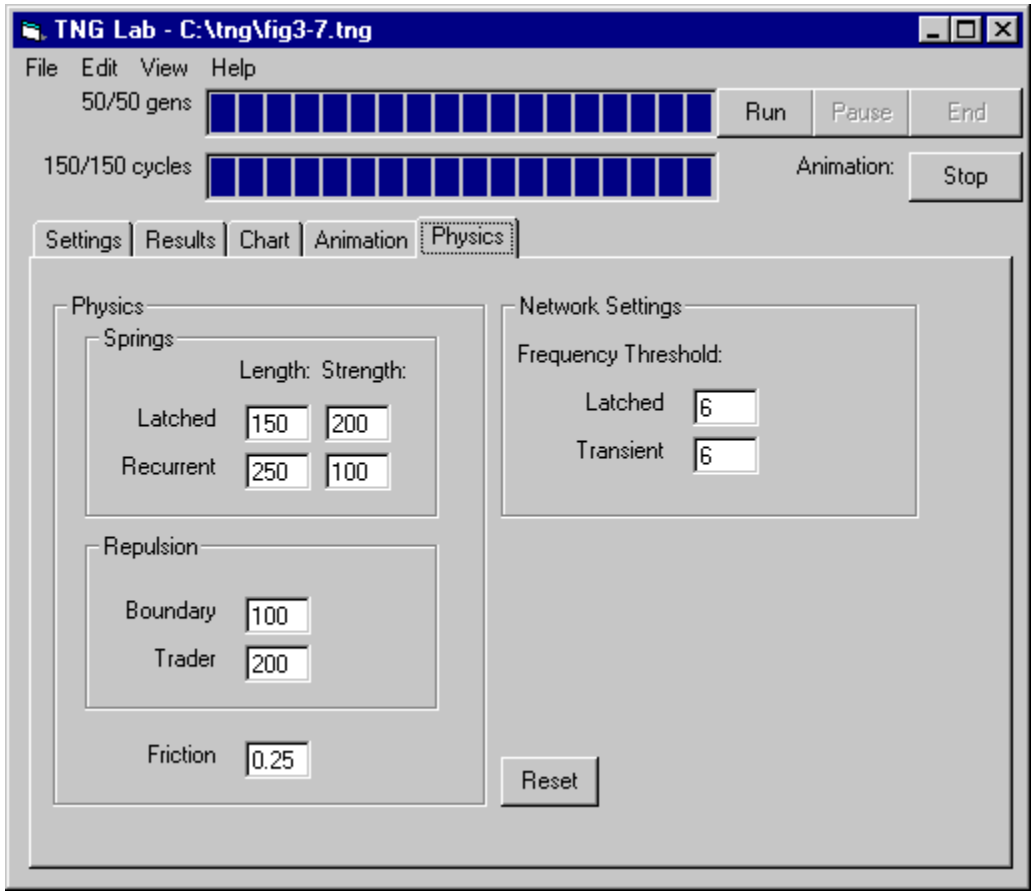
TNG Lab GUI:
Chart Screen



TNG Lab GUI:
Network Animation Screen



TNG Lab GUI:
Physics Screen



Online Software Resources

- **ACE General Software and Toolkits**

  www.econ.iastate.edu/tesfatsi/acecode.htm

- **ACE Computational Laboratories**

  www.econ.iastate.edu/tesfatsi/acedemos.htm

- **Research Area: Development and Use of Computational Laboratories**

  www.econ.iastate.edu/tesfatsi/acomplab.htm

- **TNG Lab Homepage**

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