

# Endogenous Trade Network Formation

## Example – A Labor Market Study

---

**Presenter:**

**Leigh Tesfatsion**

Professor of Economics

Courtesy Professor of Mathematics

Department of Economics

Iowa State University

Ames, Iowa 50011-1070

[https://www2.econ.iastate.edu/tesfatsi/  
tesfatsi@iastate.edu](https://www2.econ.iastate.edu/tesfatsi/tesfatsi@iastate.edu)

# Outline

---

- ★ Labor Institutions and market performance: What does **Agent-based Computational Economics (ACE)** have to offer?

ACE Research Area: Agent-Based Labor Economic Research

<https://www2.econ.iastate.edu/tesfatsi/alabor.htm>

## Illustration:

M. Pingle, L. Tesfatsion (2003), “Evolution of Worker-Employer Networks and Behaviors Under Alternative Non-Employment Benefits,” pp. 256-285 in A. Nagurney (ed.), *New Directions in Networks*, Edward-Elgar, 2003.

ACE worker-employer network formation experiments implemented via the

Trade Network Game (TNG) Laboratory

<https://www2.econ.iastate.edu/tesfatsi/tnghome.htm>

# 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

# Empirical Findings

(Handbook of Labor Economics, 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** (small sample bias problems, confounding effects,...)

# Common Approach to UB Modeling

---

- ◆ Dynamic Programming (DP)
- ◆ Representative worker uses DP to maximize lifetime expected utility
- ◆ Jobs arise and end randomly, and unemployment benefit received if unemployed
- ◆ At each time  $t$  that a job arises, worker compares DP value of new job vs. DP value of staying in current situation (old job or unemployment)
- ◆ **Precise predictions, but empirical support unclear.**

# Potential Contributions of an ACE Approach

---

- ◆ Both workers & employers can be modeled as **utility-seeking 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,...)

# An ACE Study of Unemployment Benefits

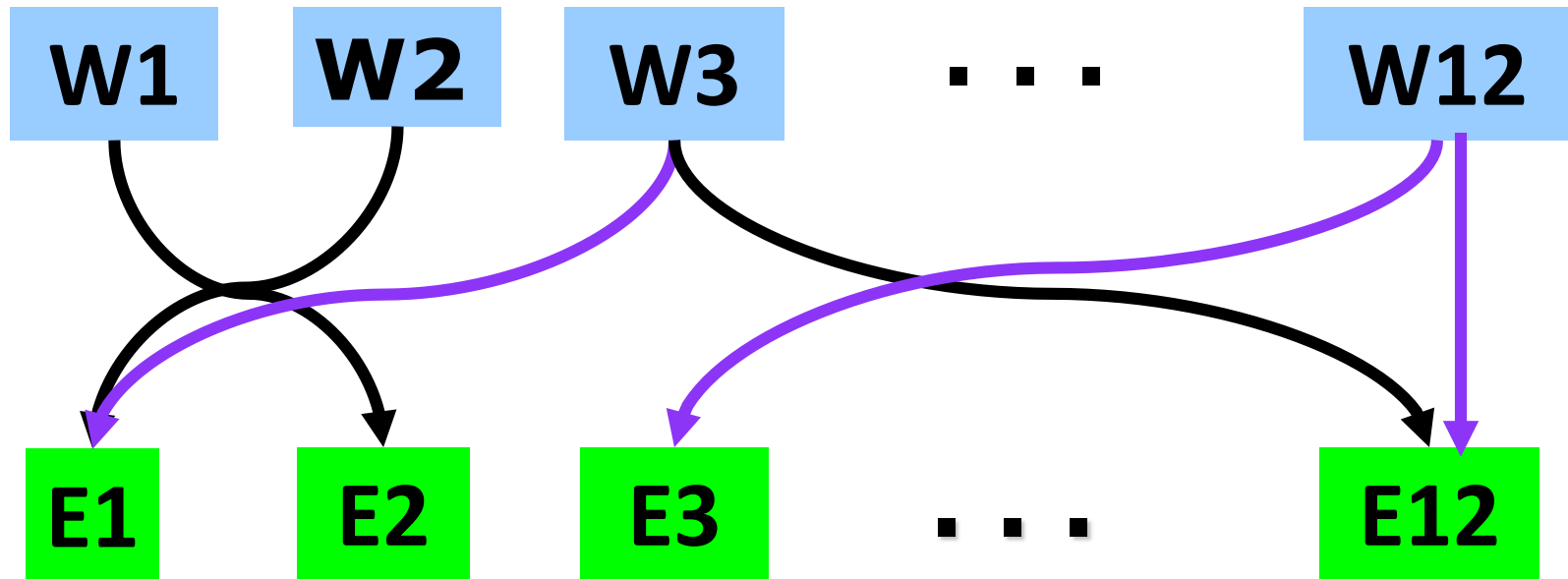
---

- “Evolution of Worker-Employer Networks and Behaviors under Alternative Non-Employment Benefits: An ACE Study”
- **Joint work with M. Pingle (U of Nevada-Reno)**
- Published in *New Directions in Networks*, Edward Elgar, 2003, edited by Anna Nagurney
- Pre-print available at:  
<https://www2.econ.iastate.edu/tesfatsi/alabmplt.pdf>
- Parallel human-subject experiment conducted



# ACE Labor Market Framework

---



Preferential job search with choice/refusal of partners:

Purple directed arrow indicates refused work offer;  
Black directed arrow indicated accepted work offer.

# ACE Labor Market Framework ...

---

- ⊗ 12 workers with same **observable** structural attributes in initial period  $T=0$
- ⊗ 12 employers with same **observable** structural attributes in initial period  $T=0$
- ⊗ Only **observable** source of heterogeneity among workers and among employers is their expressed behaviors on the work-site

# ACE Labor Market Framework ...

---

- ⊗ 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  $T$
- ⊗ Work-site strategies in initial period  $T=0$  are **randomly determined and private information**

# Each worker and employer has ...

---

- ⊗ *Publicly available information* about various market and policy protocols (e.g., UB eligibility rules)
- ⊗ *Private behavioral methods* that can evolve over time
- ⊗ *Privately stored data* that can change over time

# A Computational Worker

## Public Access:

### // **Public Methods**

Protocols governing job search

Protocols governing negotiations with potential employers

Protocols governing unemployment benefits program

Methods for receiving data

Methods for retrieving Worker data

## Private Access:

### // **Private Methods**

Method for calculating my expected utility assessments

Method for calculating my actual utility outcomes

Method for updating my worksite strategy (**GA learning**)

### // **Private Data**

Data about myself (my history, utility fct., current wealth...)

Data recorded about external world (employer behaviors,...)

Addresses for potential employers (permits communication)

# A Computational Employer

## Public Access:

### // **Public Methods**

Protocols governing search for workers

Protocols governing negotiations with potential workers

Protocols governing unemployment benefits program

Methods for receiving data

Methods for retrieving Employer data

## Private Access:

### // **Private Methods**

Method for calculating my expected profit assessments

Method for calculating my actual profit outcomes

Method for updating my work-site strategy (**GA Learning**)

### // **Private Data**

Data about myself (my history, profit fct., current wealth...)

Data recorded about external world (worker behaviors,...)

Addresses for potential workers (permits communication)

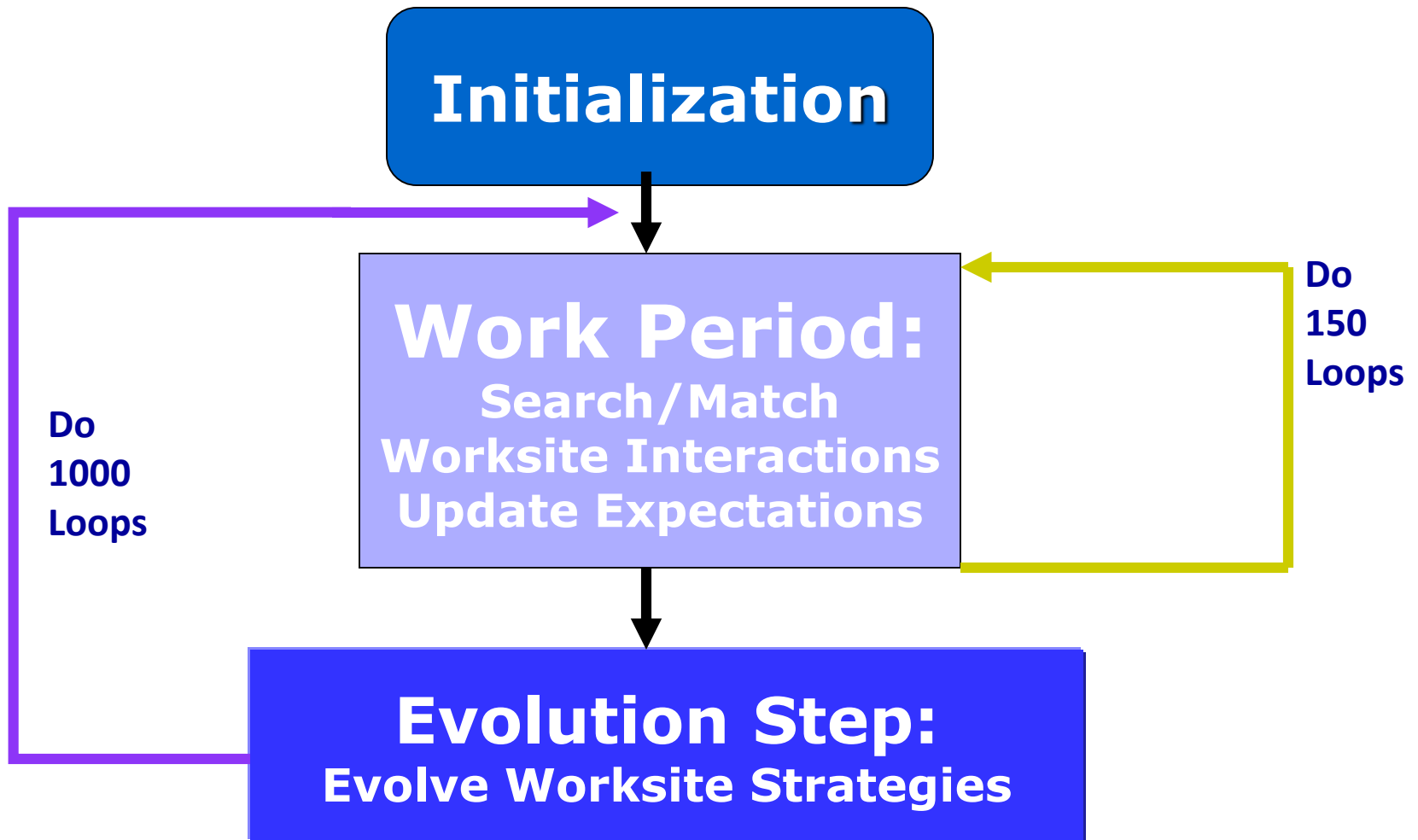
# Flow of Activities in the ACE Labor Market

---

- ⊗ Workers make offers to preferred employers at a small cost per offer (quits allowed)
- ⊗ Employers accept or refuse received work offers (firings allowed)
- ⊗ Each matched pair engages in one work-site interaction (PD game - cooperate or defect)
- ⊗ After 150 work periods, each worker and employer updates its work-site IPD strategy

# Flow of Activities in the ACE Labor Market ...

---





# Worksite Interactions as Prisoner's Dilemma (PD) Games

---

		Employer	
		C	D
Worker	C	(40,40)	(10,60)
	D	(60,10)	(20,20)

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

# Key Issues Addressed in Experiments

---

- How do **changes** in the level of a “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 UB program costs, unemployment/vacancy rates,...)
- ***Market Power*** (distribution of surplus)

# Experimental Design

---

- ⊗ **Treatment Factor:**

  - Non-Employment Payment (NEP)

- ⊗ **Three Tested Treatment Levels:**

  - NEP=0, NEP=15, NEP=30

- ⊗ **Runs per Treatment:**

  - 20 (1 Run = 1000 Generations; 1 Gen.=150 Work Periods)

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

# Three Tested Treatments: NEP =0, NEP=15, and NEP=30

---

**Treatment 1:** NEP=0 < L=10

**Treatment 2:** L=10 < NEP=15 < D=20

**Treatment 3:** D=20 < NEP=30 < C=40

❖ **NOTE:** Work-site PD payoffs satisfy

L (Sucker) = 10 < D (MutualD) = 20

< C (MutualC) = 40 < H (Temptation) = 60

# Market Efficiency Findings

---

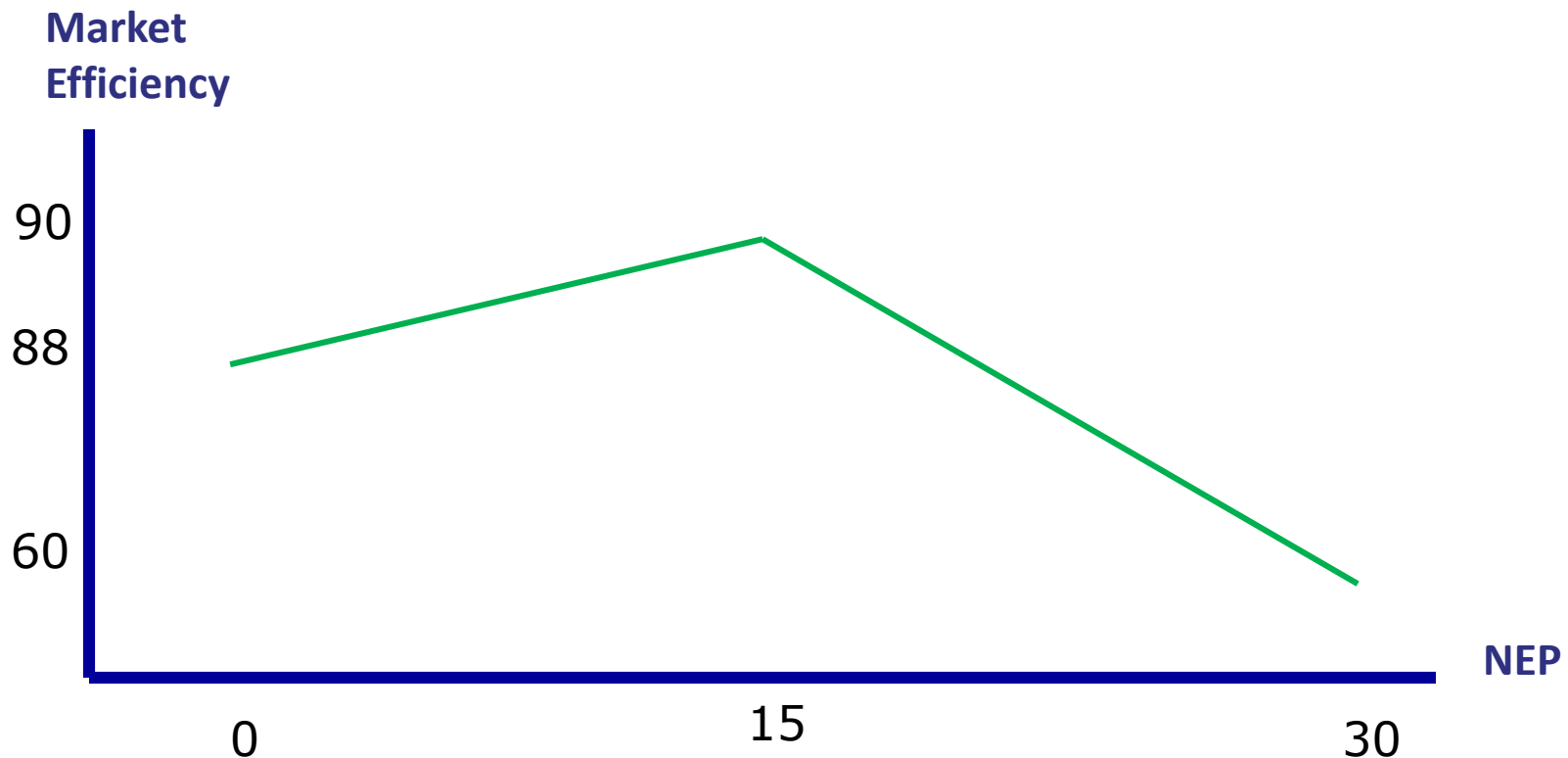
As NEP level **increases** from 0 to 30...

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

**Note:** The above two effects together 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*  
(NEP program costs too high)

# Multiple Attractors Findings

---

## \* Two distinct “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* = Completely disconnected network (*no coordination*)



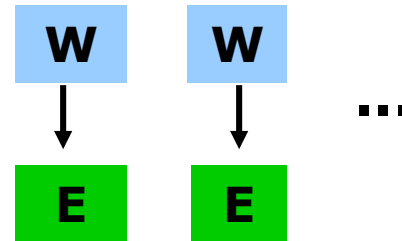
# The Following Diagrams Report ...

---

## ① Two-sided (W-E) network distributions

**0**=Stochastic fully connected network

**12**=Latched in pairs

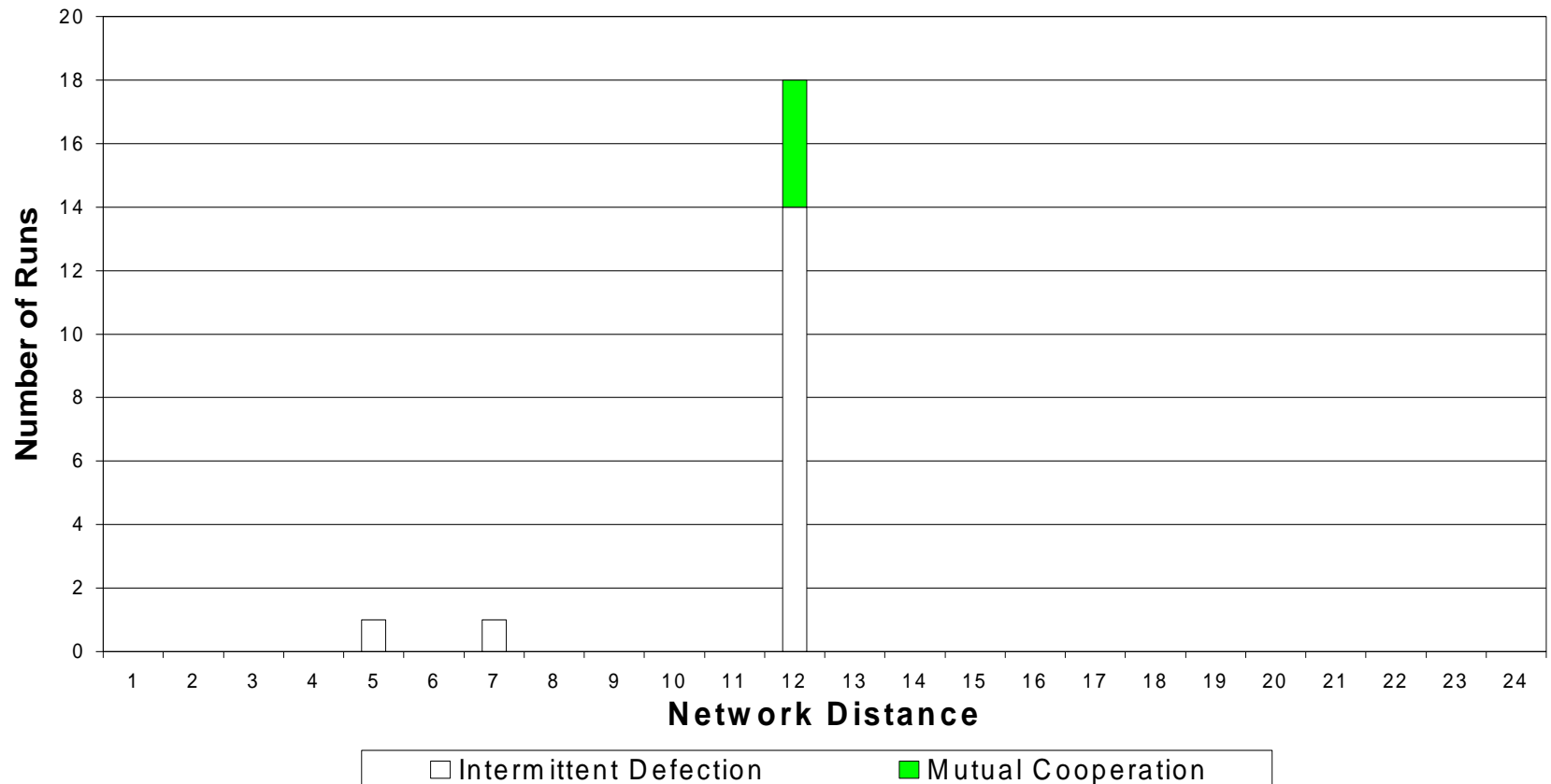


**24**=Completely disconnected

## ② Worksite behaviors supported by network outcomes

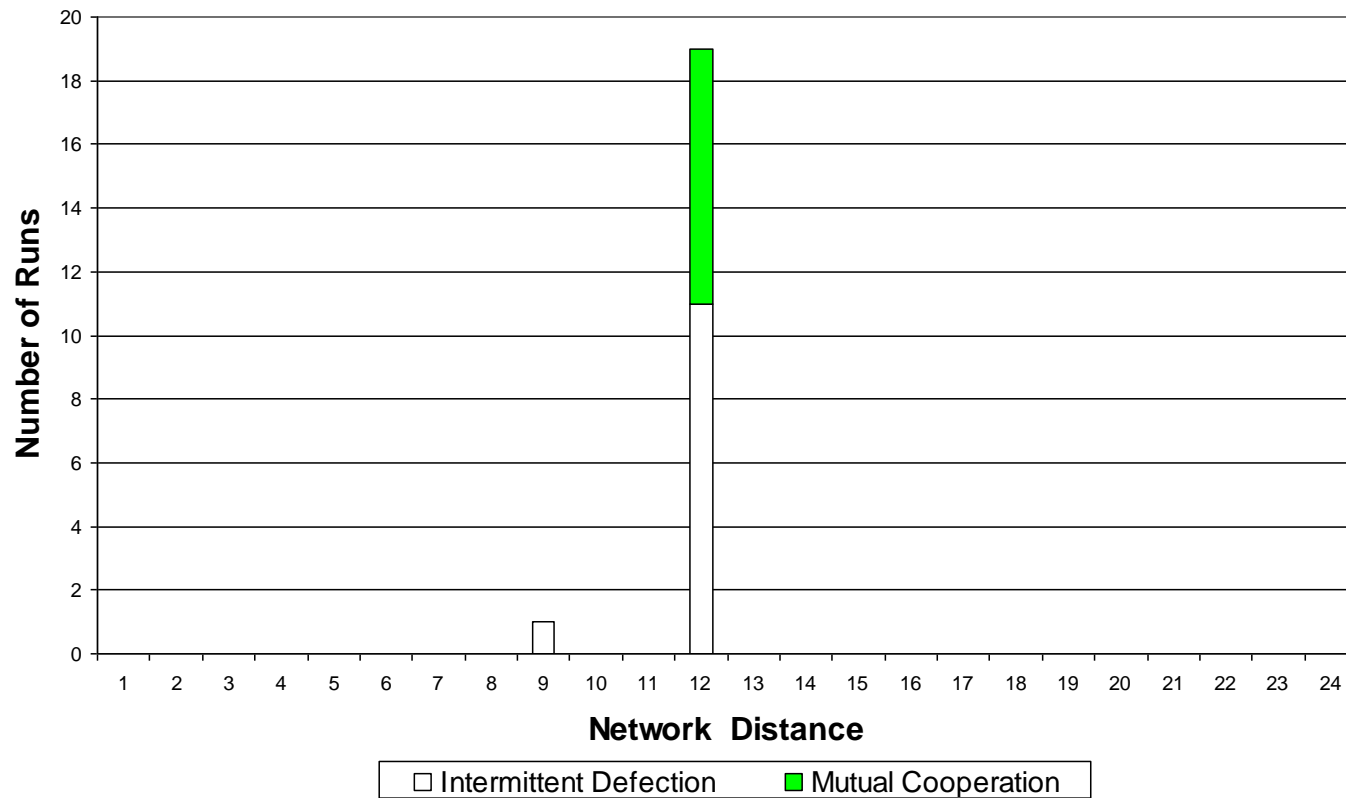
# Network Distribution for NEP=0 Sampled at End of Generation 12

## Network Distribution for ZeroT:12



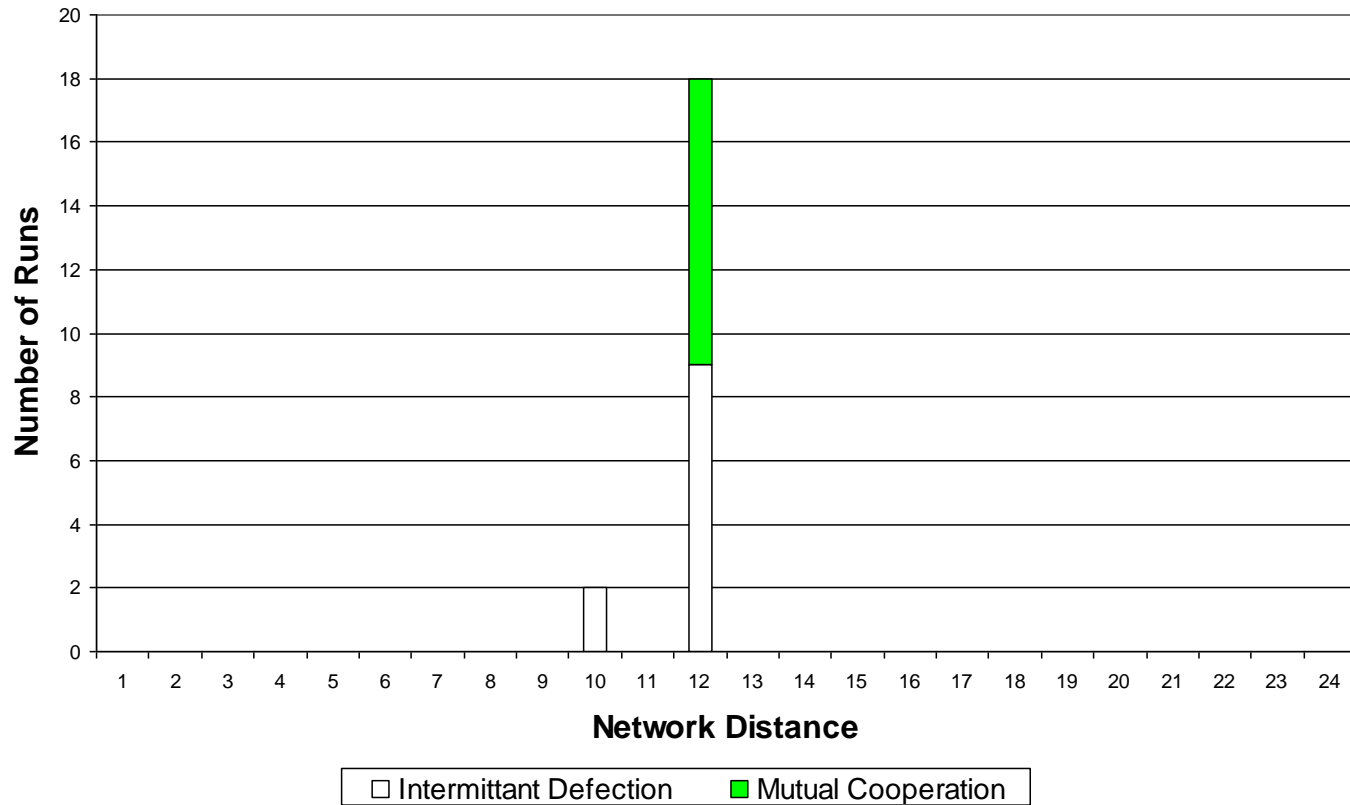
# Network Distribution for NEP=0 Sampled at End of Generation 50

Network Distribution for ZeroT:50



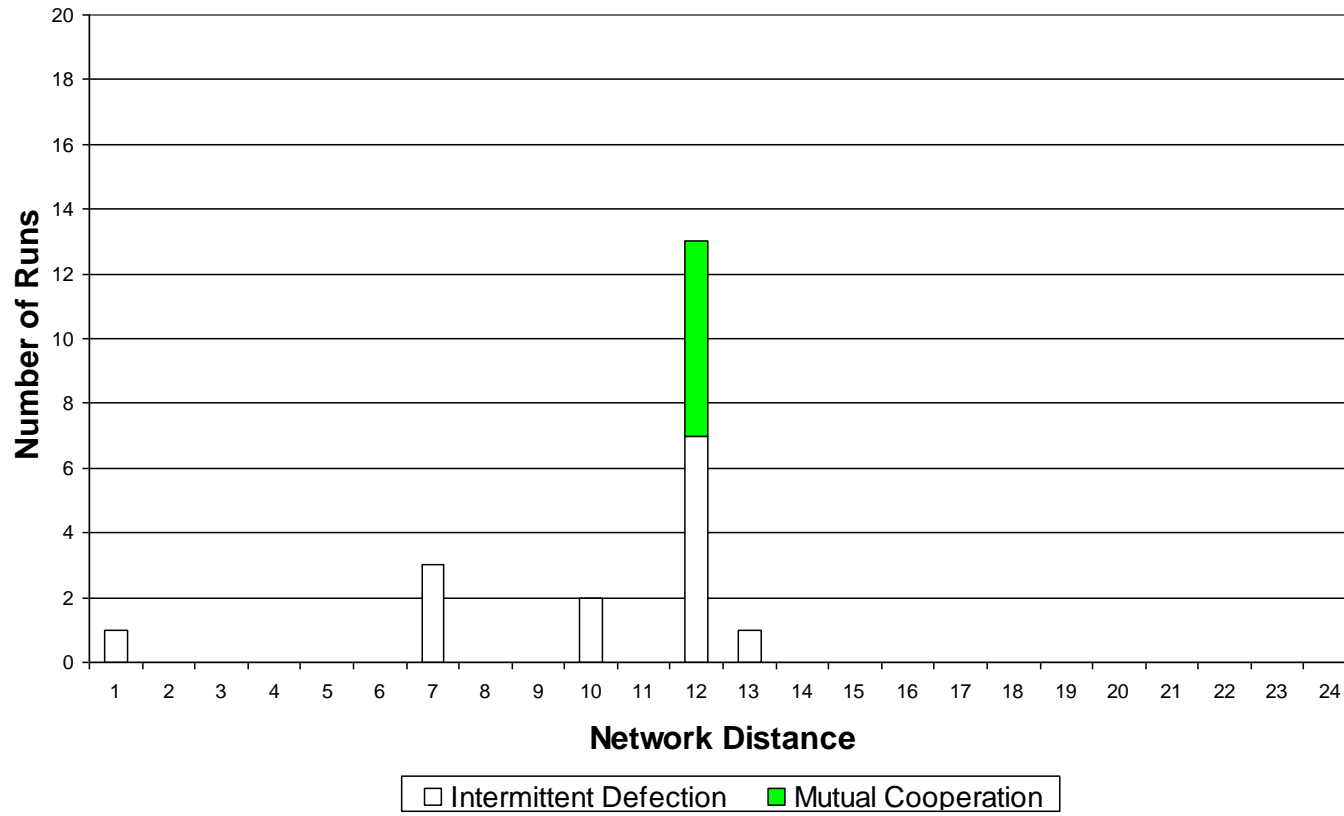
# Network Distribution for NEP=0 Sampled at End of Generation 1000

Network Distribution for ZeroT:1000



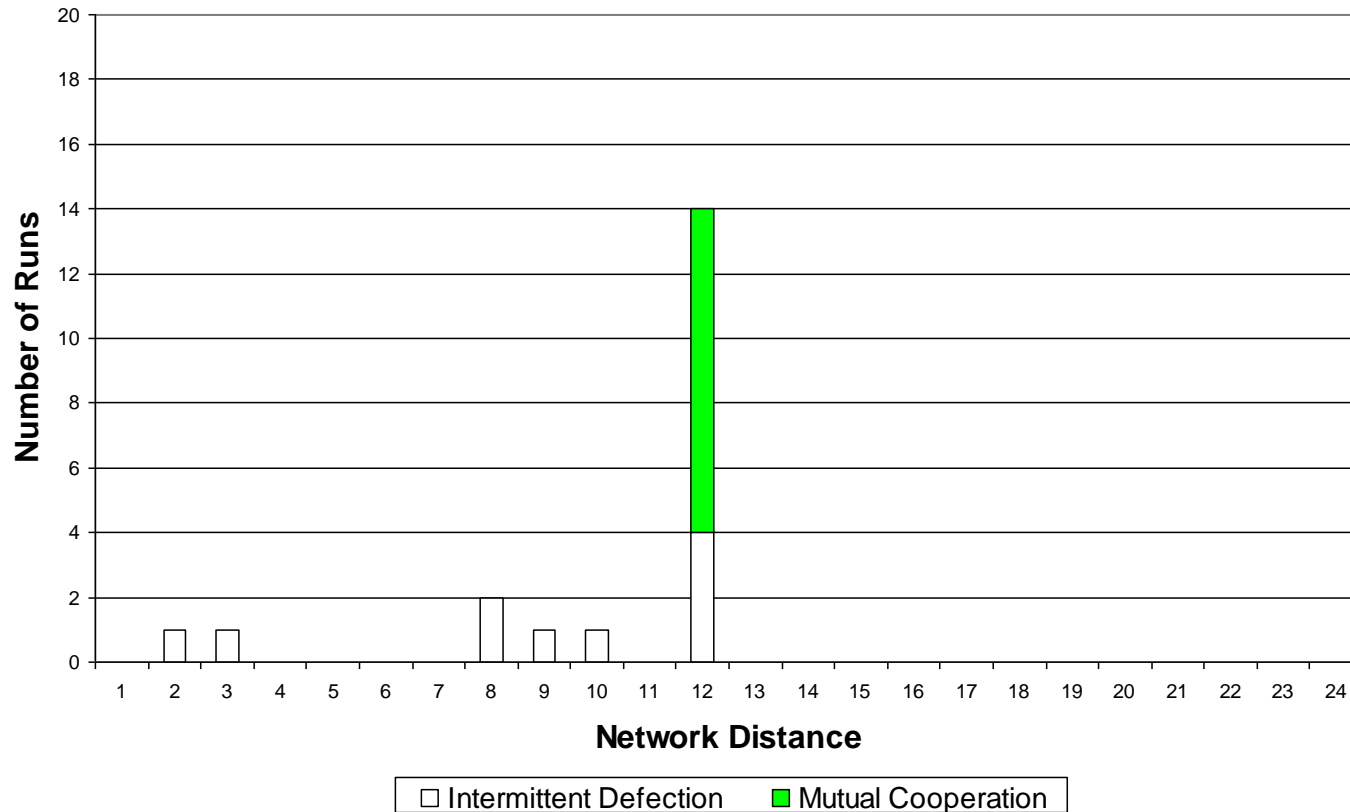
# Network Distribution for NEP=15 Sampled at End of Generation 12

## Network Distribution for LowT:12



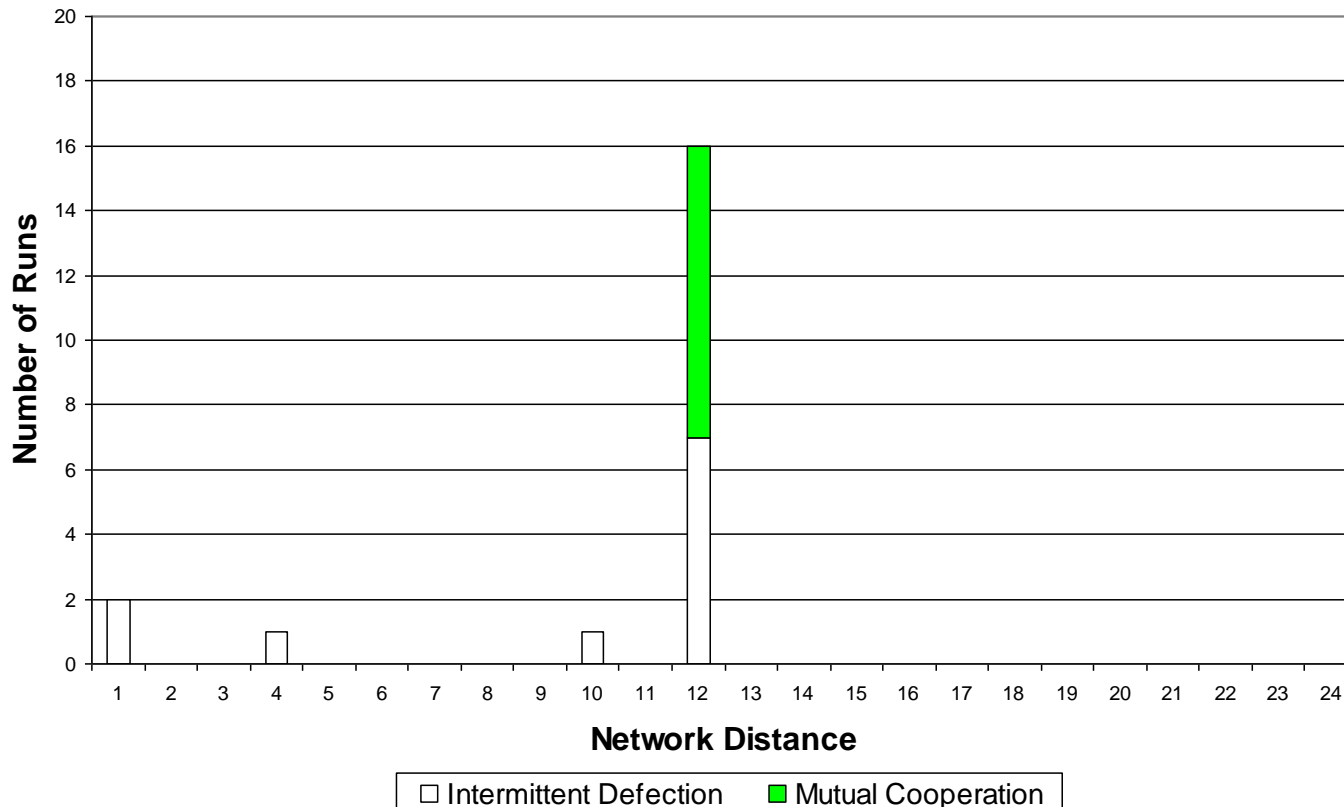
# Network Distribution for NEP=15 Sampled at End of Generation 50

Network Distribution for LowT:50



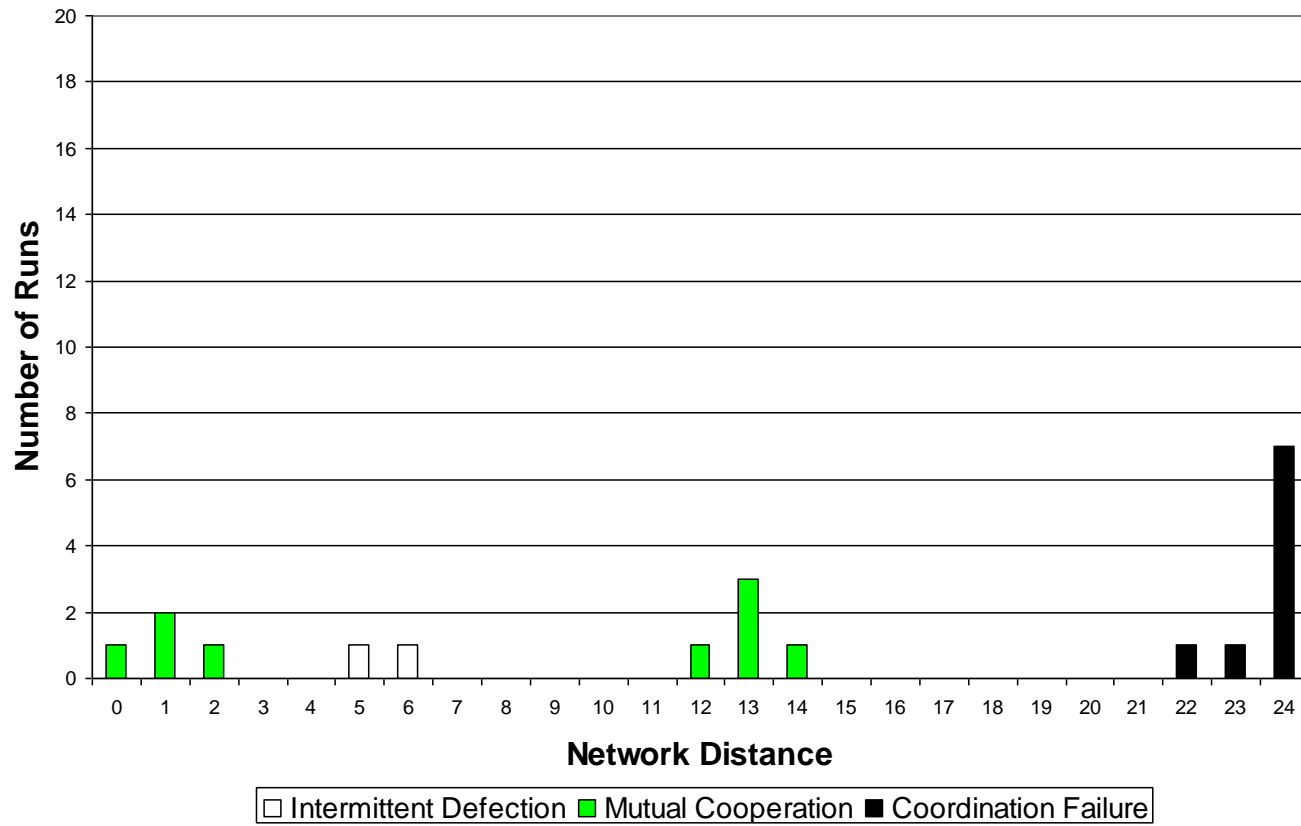
# Network Distribution for NEP=15 Sampled at End of Generation 1000

## Network Distribution for LowT:1000



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

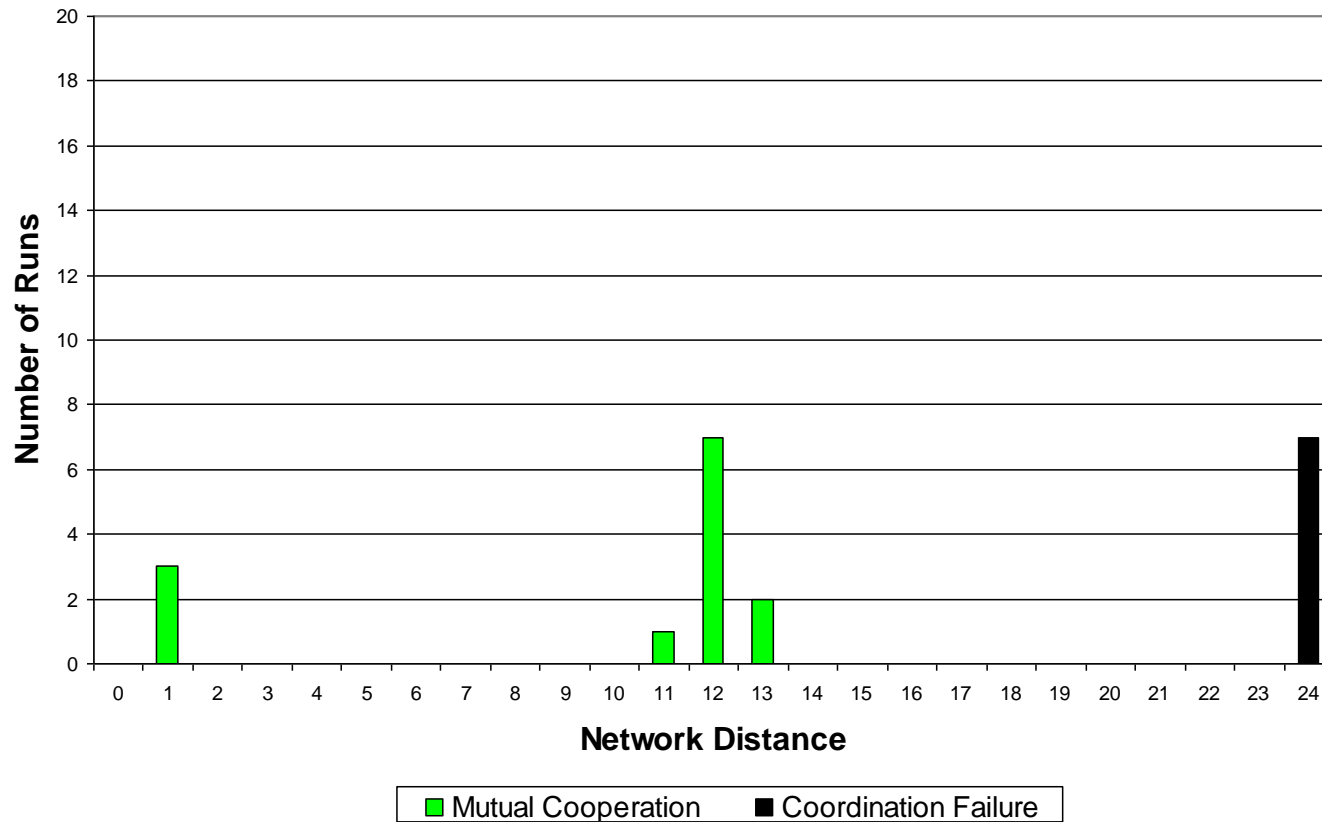
## Network Distribution for HighT:12





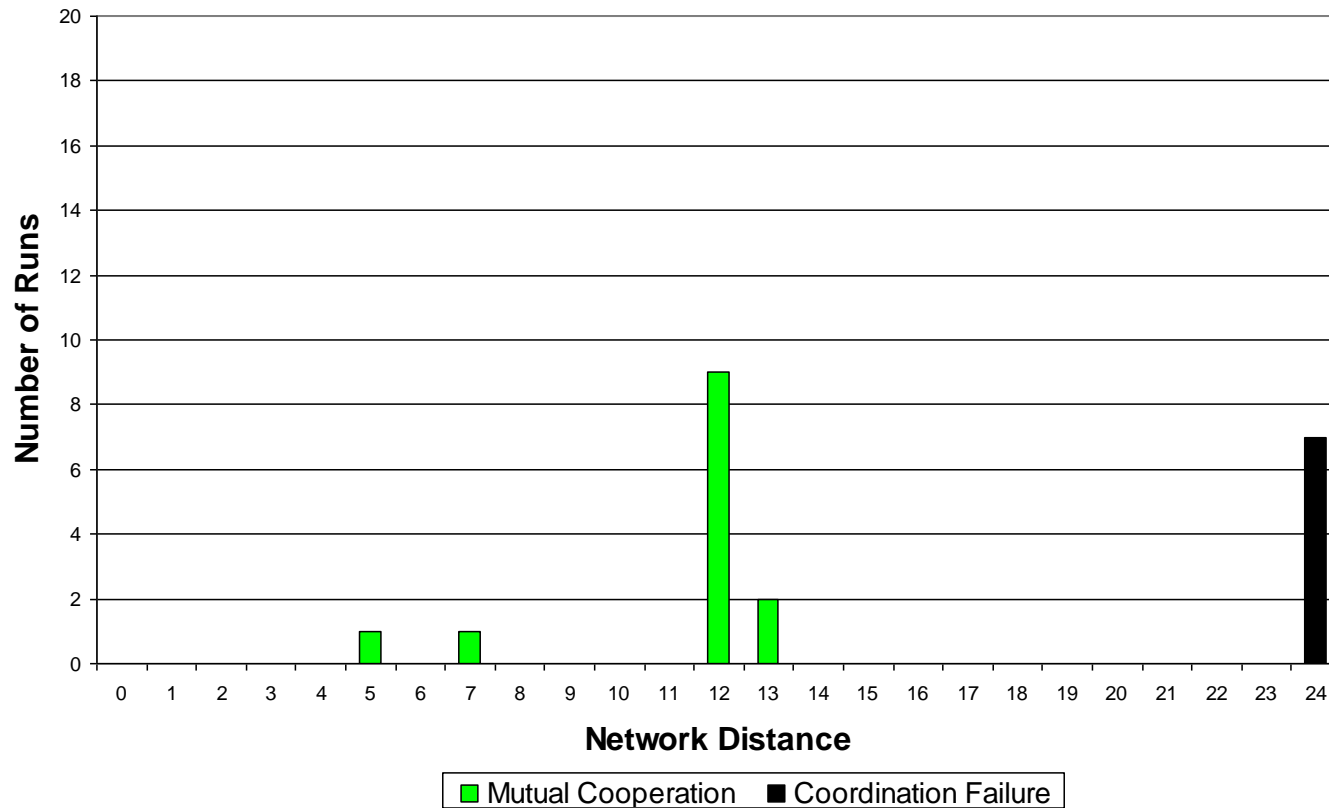
# Network Distribution for NEP=30 Sampled at End of Generation 50

Network Distribution for HighT:50



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

## Network Distribution for HighT:1000



# Summary of Experimental 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 *multiple peaked* behavioral distributions, indicating potential pooling problems.