

Social Networks and Job Matching in an Artificial Economy with Endogenous Network Formation

Melt van Schoor

Department of Economics
University of Stellenbosch

mpvs@sun.ac.za

Economic Society of South Africa Conference, Port Elizabeth,
September 2009

Outline

① Social Networks and Job Search

② Agent Based Modeling Overview

③ Model Description Overview Hex Lattices Social Networks Evolutionary Behaviour

④ Model Results Basic Labour Market - No Networks or skill types Standard Model - Introducing networks Extension - Firms can respond to contact networks

⑤ Conclusions

Social Networks and Job Search

The Issues

- Empirical evidence: Many, probably most, workers found their jobs through social networks
- Under conditions of where jobs are scarce, social networks may explain why some groups are more likely to have high unemployment
- Differential access to and functioning of social networks may explain a large part of social inequality
- Lack of social mobility may likewise be linked to social networks, especially if networks are endogenous.
- Information has economic value and is instrumental in economic outcomes

Social Networks and Job Search

Existing Theoretical Work

- Job referral networks: some worker i hears about job x and his friend j is able to take the job if i does not want it
- e.g. Calvó-Armengol (2004), Calvó-Armengol & Jackson (2004), Calvó-Armengol & Zenou (2005), Ioannides & Soetevent (2006)

Social Networks and Job Search

Existing Theoretical Work

- Job referral networks: some worker i hears about job x and his friend j is able to take the job if i does not want it
- e.g. Calvó-Armengol (2004), Calvó-Armengol & Jackson (2004), Calvó-Armengol & Zenou (2005), Ioannides & Soetevent (2006)
- Limitations:
 - ▶ Onerous assumptions / restrictions, e.g.
 - ★ Homogenous agents
 - ★ Networks very small (e.g. dyads) or with predetermined structure
 - ★ Restrictions on who may form links with whom (common assumption: partners are chosen at random)
 - ★ Fixed number of links
 - ★ Limited modeling of network traversal

Social Networks and Job Search

Existing Theoretical Work

- Job referral networks: some worker i hears about job x and his friend j is able to take the job if i does not want it
- e.g. Calvó-Armengol (2004), Calvó-Armengol & Jackson (2004), Calvó-Armengol & Zenou (2005), Ioannides & Soetevent (2006)
- Limitations:
 - ▶ Onerous assumptions / restrictions, e.g.
 - ★ Homogenous agents
 - ★ Networks very small (e.g. dyads) or with predetermined structure
 - ★ Restrictions on who may form links with whom (common assumption: partners are chosen at random)
 - ★ Fixed number of links
 - ★ Limited modeling of network traversal
 - ▶ Networks not always explicitly modeled
 - ▶ Network functions not explicitly modeled
 - ▶ Network dynamics not modeled

Outline

① Social Networks and Job Search

② Agent Based Modeling Overview

③ Model Description Overview

Hex Lattices

Social Networks

Evolutionary Behaviour

④ Model Results

Basic Labour Market - No Networks or skill types

Standard Model - Introducing networks

Extension - Firms can respond to contact networks

⑤ Conclusions

Agent Based Modeling

Premise

Specifying simple rules for interaction and watching behaviour of the system unfold from the bottom up

Agent Based Modeling

Premise

Specifying simple rules for interaction and watching behaviour of the system unfold from the bottom up

- Individual modeling of agent decisions and interactions in a system
- *Macroscopic* approach: aggregate behaviour is obtained from individual interaction between agents
- No top-down equations specifying aggregate behaviour (and no equilibrium enforced)
- Not tied to the (fully) rational agent behavioural / informational framework

Agent Based Modeling

- Agents

- ▶ have local information only and need not be assumed to fully understand the system in which they operate
- ▶ are fully autonomous with respect to their actions
- ▶ naturally modeled as heterogenous
- ▶ adaptive
- ▶ still have monotonic preferences (assumed or as outcome)

Agent Based Models of Social Networks in Labour Markets

- Tassier & Menczer (2004/5)
- Fagiolo, Dosi & Gabriele (2004)
- Gemkow & Neugart (2008)

Focus

- Role of social networks in transmission of worker information to employers
- Concrete information (requires worker heterogeneity)
- Concrete transmission, including network traversal

Focus

- Role of social networks in transmission of worker information to employers
- Concrete information (requires worker heterogeneity)
- Concrete transmission, including network traversal

Questions

- In what way do social networks capable of transmitting info on worker characteristics to potential employers affect labour market outcomes?
- In what way does employer behaviour affect social network formation?

Actualization

- Networks function *solely* to transmit worker information to employers
- Specifically, generalized skill level (high or low)
- Individuals who work together can form links
- Direct contacts know an individual's skill level and can transmit this information across network
- Firms can make decisions based on information available to *current employees*
- Firms want to hire high-skill workers as they have higher productivity, and may be willing to pay a premium for confirmed high skill workers

A priori expectations

- High skill workers have incentive to make many contacts
- Low skill workers not
- Pooling outcome also possible (e.g. if cost of contacts are too high)

A priori expectations

- High skill workers have incentive to make many contacts
- Low skill workers not
- Pooling outcome also possible (e.g. if cost of contacts are too high)

Complications

- Positive feedback & multiple equilibria
- Network formation frictions
- Firms may be responsive to workers' connectedness
- Network structure

Outline

① Social Networks and Job Search

② Agent Based Modeling Overview

③ Model Description Overview

Hex Lattices

Social Networks

Evolutionary Behaviour

④ Model Results

Basic Labour Market - No Networks or skill types

Standard Model - Introducing networks

Extension - Firms can respond to contact networks

⑤ Conclusions

Model Description

- Job matching model, with endogenous social networks
- Related to Tassier & Menczer (2004/5), who use evolutionary principles to determine agent behaviour
- Related to Epstein & Axtell's (1996) lattice-based *Sugarscape Model*

Model Description

- Job matching model, with endogenous social networks
- Related to Tassier & Menczer (2004/5), who use evolutionary principles to determine agent behaviour
- Related to Epstein & Axtell's (1996) lattice-based *Sugarscape Model*
- Properties:
 - ▶ Discrete time (rounds)
 - ▶ Fixed population of $n = 500$ worker-agents, half low-skill and half high-skill
 - ▶ Fixed number of firms, $m = 100$, each with a fixed number of jobs ($jobsperfirm = 5$)
 - ▶ Firm production is equal to the sum of the skill levels of its employees (1 for low-skill, 2 for high-skill)

Job Matching

- Firms are dispersed on the lattice
- Agents must physically locate jobs in order to know about them
- Agents have a *vision* of $v = 2$ lattice positions away from them
- Each round, and unemployed agent moves to a random location on the lattice
- If there are firms with vacancies in vicinity, unemployed worker applies to all of them
- Firms receiving applications select one of them randomly and makes a wage offer
- Applicants can accept or reject offered wage. The bargaining process ends either way.
- Flows into unemployment:
 - ▶ Each round, small exogenous possibility of contract ending
 - ▶ Each round, small exogenous possibility of job being destroyed

Outline

① Social Networks and Job Search

② Agent Based Modeling Overview

③ Model Description Overview

Hex Lattices

Social Networks

Evolutionary Behaviour

④ Model Results

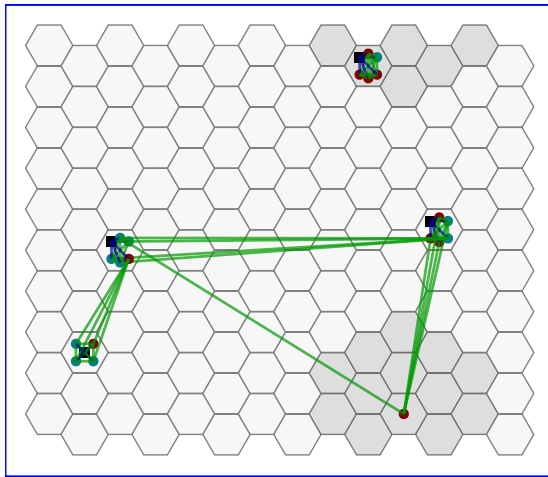
Basic Labour Market - No Networks or skill types

Standard Model - Introducing networks

Extension - Firms can respond to contact networks

⑤ Conclusions

A Toy Version



Outline

① Social Networks and Job Search

② Agent Based Modeling Overview

③ Model Description

Overview

Hex Lattices

Social Networks

Evolutionary Behaviour

④ Model Results

Basic Labour Market - No Networks or skill types

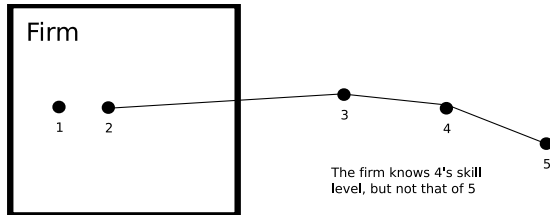
Standard Model - Introducing networks

Extension - Firms can respond to contact networks

⑤ Conclusions

Social Networks

- Maintaining contacts carries a low but positive cost ($fcost = 0.001$)
- Links between agents facilitate flow of information about worker characteristics
- Agents know their direct contacts' skill level
- Rule: Information can traverse $TTL = 2$ links at most



Social Network Formation

- Each worker-agent wants to maintain c_{it} links (determined endogenously, per agent i)
- Links formed between two agents *employed* by same firm by *mutual consent*
- Links endure past working relationship
- Exogenous probability of break-up any time

Outline

① Social Networks and Job Search

② Agent Based Modeling Overview

③ Model Description

Overview

Hex Lattices

Social Networks

Evolutionary Behaviour

④ Model Results

Basic Labour Market - No Networks or skill types

Standard Model - Introducing networks

Extension - Firms can respond to contact networks

⑤ Conclusions

Evolutionary Behaviour

- Agent behaviour dictated by a parameterized equations
- Firms:
 - ▶ $Wageoffer = c + a.knowH + b.knowL$
- Workers:
 - ▶ $WTA = c$
 - ▶ $nfriends = c$

Evolutionary Behaviour

- Agent behaviour dictated by a parameterized equations
- Firms:
 - ▶ $Wageoffer = c + a.knowH + b.knowL$
- Workers:
 - ▶ $WTA = c$
 - ▶ $nfriends = c$
- Parameters evolve according to evolutionary principles
- Inheritance: parameters of some agents are randomly changed to those of other agents from time to time
- Selection: Inheritance is *biased* so that *relatively unsuccessful* agents tend to assume behaviour of *relatively successful* agents
- Mutation: "Accidents of nature" occasionally cause random incremental changes to an agent's c parameters
- Taken as a whole, a population of agents can be regarded as a *Genetic Algorithm (GA)*

Outline

① Social Networks and Job Search

② Agent Based Modeling Overview

③ Model Description Overview

Hex Lattices

Social Networks

Evolutionary Behaviour

④ Model Results

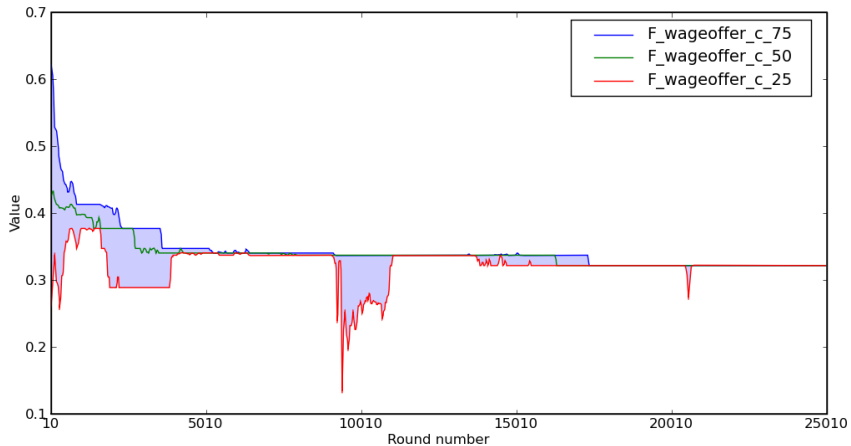
Basic Labour Market - No Networks or skill types

Standard Model - Introducing networks

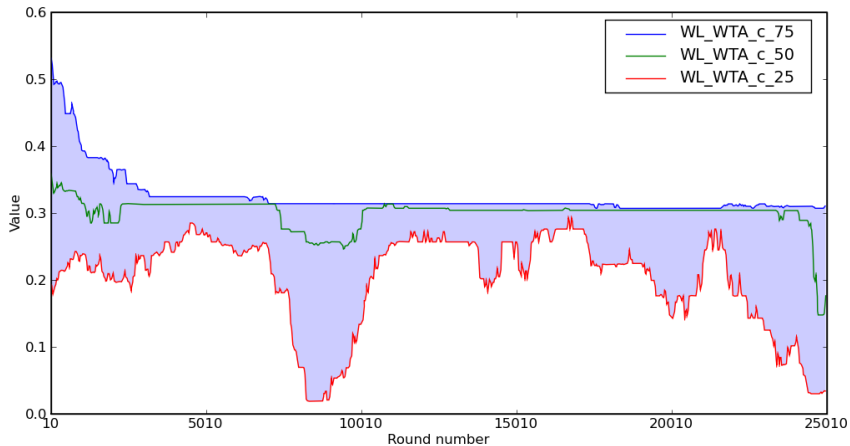
Extension - Firms can respond to contact networks

⑤ Conclusions

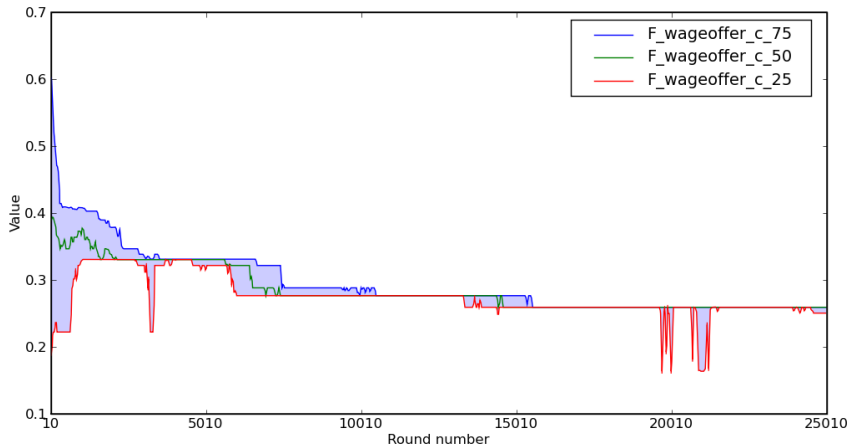
Parameter evolution (run 1)



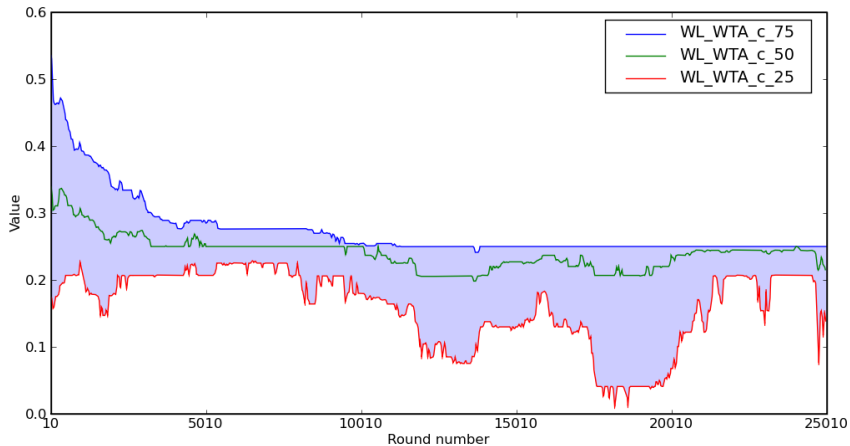
Parameter evolution (run 1)



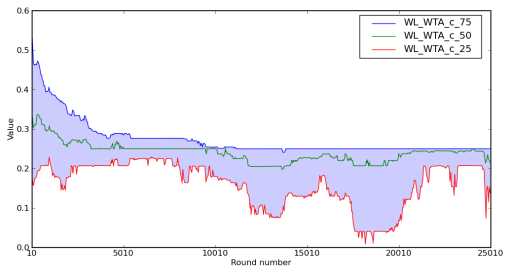
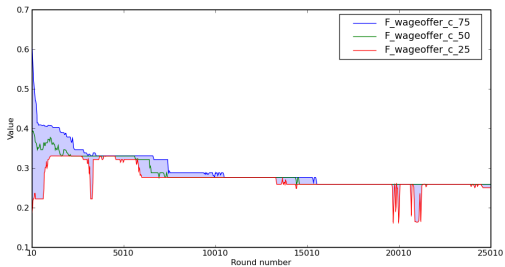
Parameter evolution (run 2)



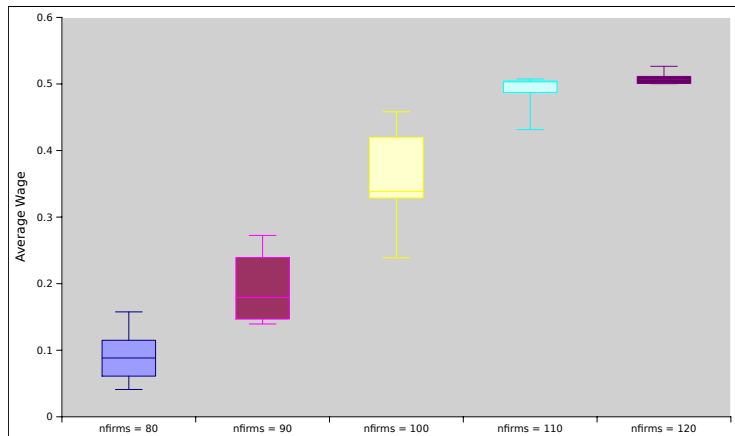
Parameter evolution (run 2)



Evolutionary Steady State (run 2)



Outcomes reflect economic reality



Outline

① Social Networks and Job Search

② Agent Based Modeling Overview

③ Model Description Overview

Hex Lattices

Social Networks

Evolutionary Behaviour

④ Model Results

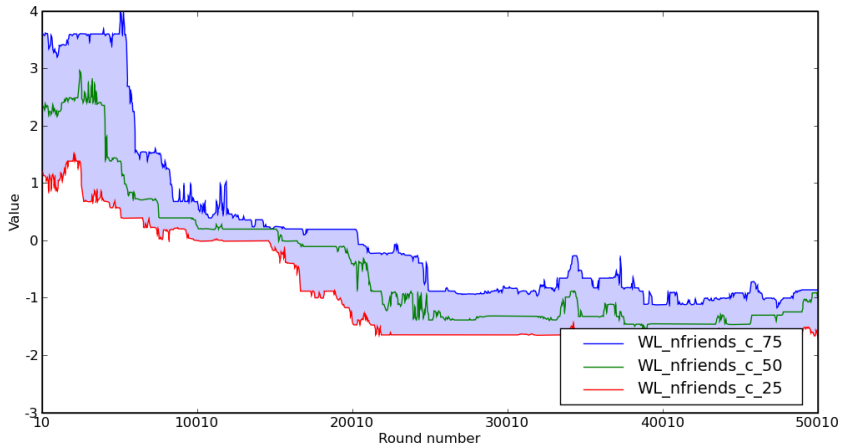
Basic Labour Market - No Networks or skill types

Standard Model - Introducing networks

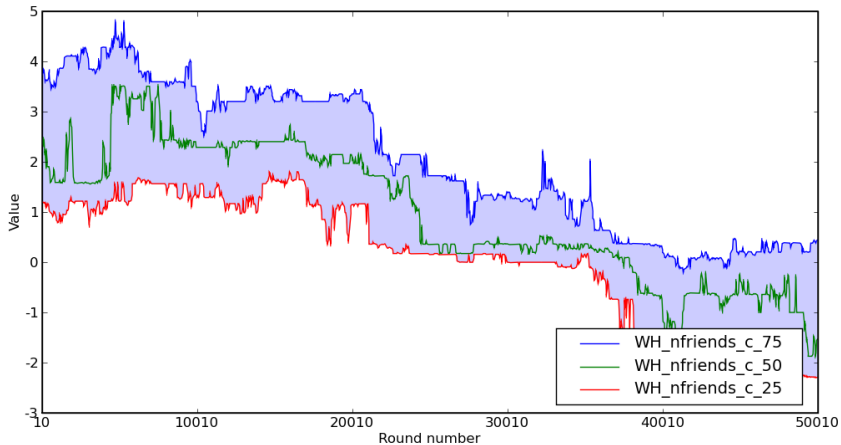
Extension - Firms can respond to contact networks

⑤ Conclusions

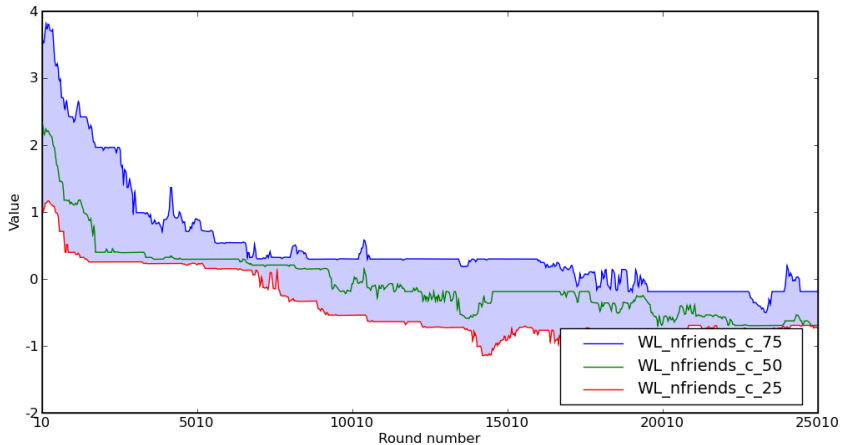
Pooling outcome (run 1)



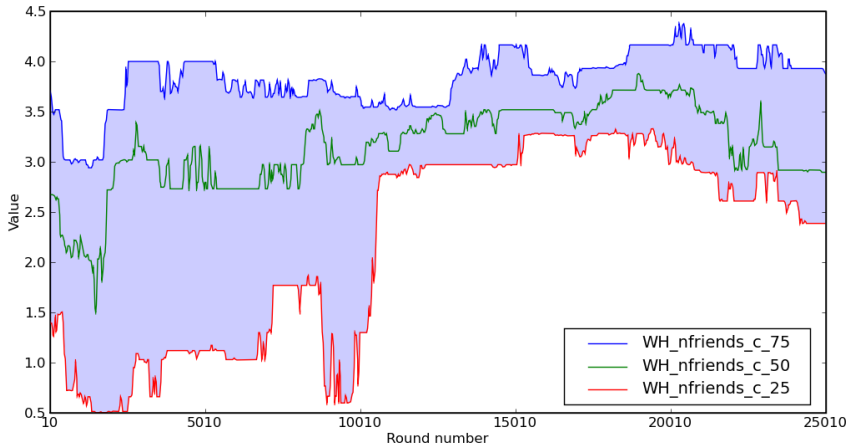
Pooling outcome (run 1)



Separating outcome (run 2)



Separating outcome (run 2)



Outline

① Social Networks and Job Search

② Agent Based Modeling Overview

③ Model Description Overview

Hex Lattices

Social Networks

Evolutionary Behaviour

④ Model Results

Basic Labour Market - No Networks or skill types

Standard Model - Introducing networks

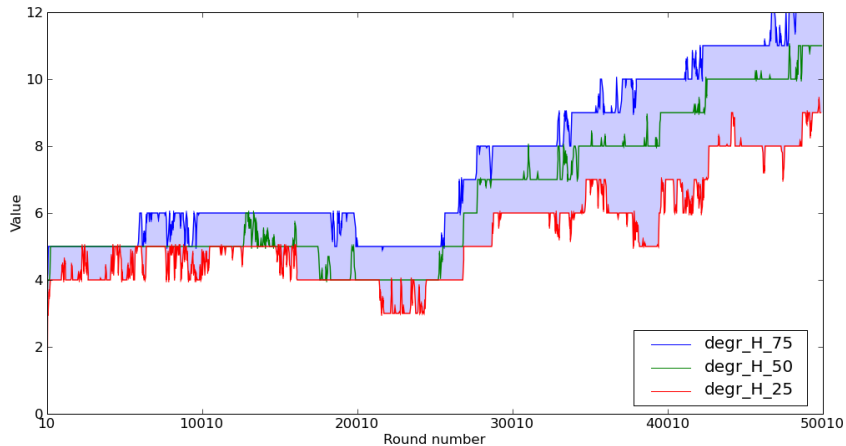
Extension - Firms can respond to contact networks

⑤ Conclusions

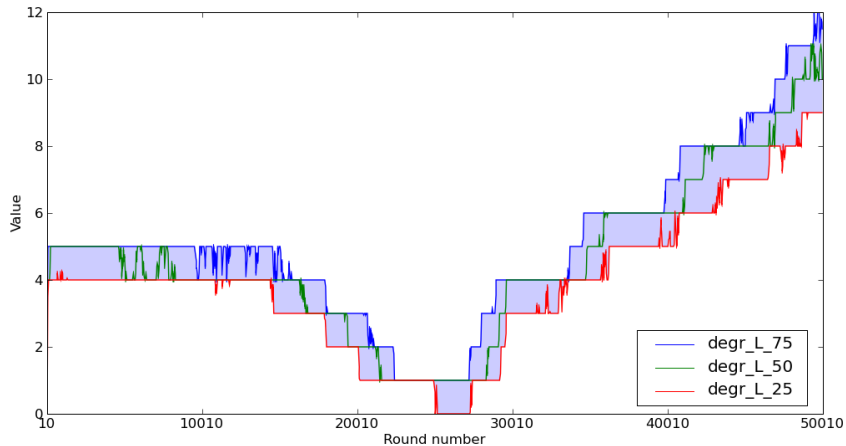
What if firms could observe and respond to applicants' social networks?

- $Wageoffer = c + a.knowH + b.knowL + d.nrworkers + e.nrfriends$
- Value to firms of connected employees?

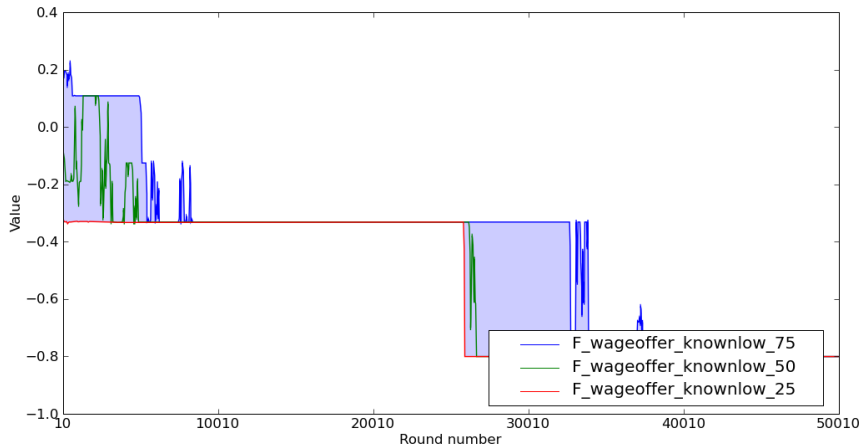
High-skill workers degree



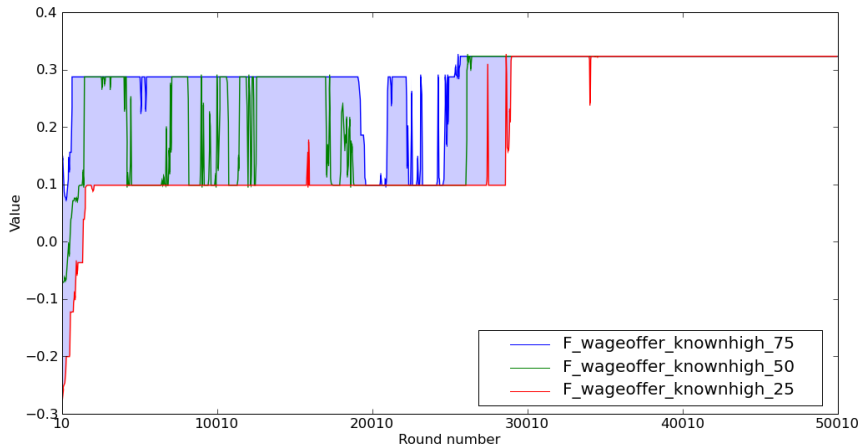
Low-skill workers degree



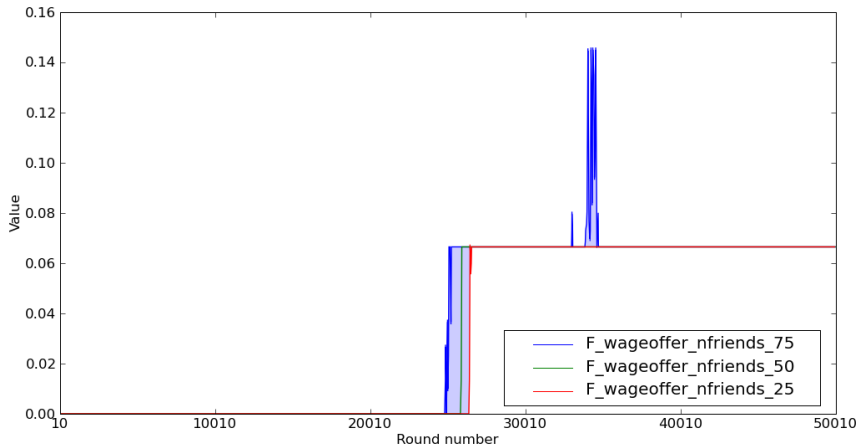
knownhigh



knownhigh



Avg premium per contact



Outline

① Social Networks and Job Search

② Agent Based Modeling Overview

③ Model Description Overview

Hex Lattices

Social Networks

Evolutionary Behaviour

④ Model Results

Basic Labour Market - No Networks or skill types

Standard Model - Introducing networks

Extension - Firms can respond to contact networks

⑤ Conclusions

Conclusions