# Network effects on stock market participation

Olga Balakina[§], Anastasiya Parakhonyak[¥]

[§]Lund University, Knut Wicksell Centre for Financial Studies
[¥]Toulouse School of Economics

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# Introduction

- *Individual Stock Market Participation*
  - Limited stock market participation
  - Herding, financial instability, asset-price bubbles, investment mistakes
- from *Individual level decision* to *Social Finance*
  - Empirical evidence of the effect of social interactions on stock market participation
- In this paper:
  - *Theoretical Model of Stock Market Participation with a Social Network*

# Content

- Related Literature
- Model
- Simulation Results
- Conclusion

# Stock Market Participation

- Theory:
  - Mehra and Prescott (1985)

$$\lambda = \frac{E\left[risk\ \ premium\right]}{\gamma\sigma^2}$$

  - $E\left[risk\ \ premium\right] > 0$ implies $\lambda > 0$
  - $\gamma$ - coefficient of relative risk aversion
  - $\sigma^2$ - stock market volatility
- Stylized Facts:
  - 50% of U.S. households invest in the stock market
  - 20% hold stocks outside of retirement plans
  - Stock market participation dropped from 30% in 2001 to 18% in 2011

# Existing Literature

- `Fixed costs of stock market participation`
  (Vissing-Jørgensen, 2003; Mankiw and Zeldes, 1991; Heaton and Lucas, 2000)
- `Lack of stock market awareness`
  (Hong, Kubic, and Stein, 2004; Guiso and Jappelli, 2005; Brown et al, 2008)
- `Education deficits`
  (Campbell, 2006; Calvet, Campbell, and Sodini, 2007; Christiansen, Joensen, and Rangvid, 2008; van Rooij, Lusardi, and Alessie, 2007)
- `Lack of trust`
  (Guiso, Sapienza, and Zingales, 2008)
- `Non-standard preferences like ambiguity aversion`
  (Dow and Werlang, 1992; Ang, Bekaert, and Liu, 2005; Cao, Wang and Zhang, 2005; Epstein and Schneider, 2007)

# Existing Literature cont.

- `Learning from peers' choices`
  Bikhchandani and Sharma (2000), Chari and Kehoe (2004)

- `Peer Effects and Social Interactions`
  (Kaustia and Knupfer, 2012; Changwony, Campbell, and Tabner, 2015; Bursztyn et. al. 2014)

# Model: General Setting

- One period model with closed economy
- All agents are risk-averse with initial wealth $w_i \sim \mathcal{F}(\cdot)$ and

$$U(W) = \frac{W^{1-\gamma}}{1-\gamma}, \ \gamma > 0$$

- 2 investment opportunities: Risk-free asset $\left(R^f = 1\right)$ and Risky Asset:

$$R = \begin{cases} 1 + r_u, & \text{with probability } \pi \\ 1 + r_d & \text{with probability } (1-\pi) \end{cases}$$

such that $r_d < 0 < r_u$ and $\pi r_u + (1-\pi) r_d > 0$

# Heterogeneous Agents

- 2 types of agents: Financially Educated and Financially Non-Educated
- Types differ by their fixed participation costs $F(k_i)$:

$$F(k_i) = \begin{cases} \frac{\theta}{k_i} & \text{for Financially Non-Educated investors} \\ \theta_{FinEd} & \text{for Financially Educated investors} \end{cases},$$

  where $k_i$ is a number of peers of investor $i$ who invest in risky asset and share information about stock market.
- Fixed Participation Costs: the time/money spent understanding basic investment principles as well as aquiring enough information about risks and returns, the cost of time spent setting up an account, brokerage commission, and the time spent implementing the trade (Vissing-Jørgensen, 2002)

# Stock Market Participation

An investor $i$ participates in stock market if:

$$\frac{\pi(w_i(1+\lambda_i^* r_u)-F(k_i))^{1-\gamma}+(1-\pi)(w_i(1+\lambda_i^* r_d)-F(k_i))^{1-\gamma}}{1-\gamma}-\frac{w_i^{1-\gamma}}{1-\gamma}>0$$

where $i$ is either Financially Non-Educated investor or Financially Educated investor

# Network

- All agents are part of one Network
- Connectivity in the network:

$$g(i,j) = \begin{cases} 0 \;\; (disconnected), & \text{if } yc^{-d(w_i,w_j)} < \overline{y} \\ \;\; 1 \;\; (connected) & \text{if } yc^{-d(w_i,w_j)} \geq \overline{y} \end{cases},$$

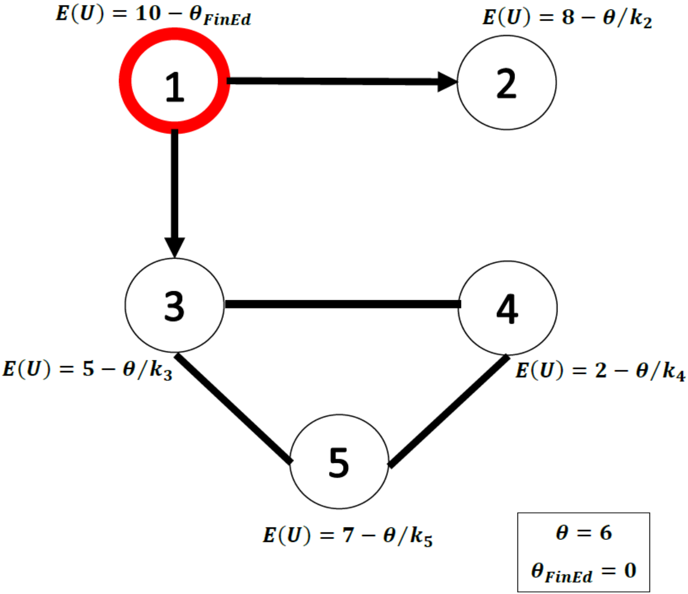
  where $y$ is a random connectivity parameter, $y \sim U[0,1]$, and $d(w_i, w_j)$ is "the distance" between wealth levels of agents $i$ and $j$ (McPherson, Smith-Lovin, and Cook, 2001)
- $c-$ correlation between wealth levels and connectivity
  We assume $c > \dot{1}$, i.e. agents are more likely to set a link with a person who has similar wealth

# Equilibrium: Algorithm 1

- Given a matrix of linked nodes $G = \{g(i,j), \forall i,j \in \boldsymbol{N} \textit{ such that } g(i,j) = 1 \textit{ if } i \textit{ and } j \textit{ are linked}, \textit{ and}$ an array of initial wealth $W = (w_{1,\dots,}w_n)$, $w_i \sim \mathcal{F}(\cdot)$ and a share of financially educated individuals $\mu \in (0,1)$
- 1. We create a stock of financially educated agents = nodes. We assume that $\theta_{FinEd} = 0$. Thus all financially educated agents invest in stocks $\Longrightarrow$ become *Informed*
  2. For the current uninformed node $i$ we solve the stock market participation problem. If node $i$ participates we mark it as an *Informed*
     The total number of informed neighbors for each node $j$ such that $g(i,j) = 1$ increases by one.
  3. Repeat previous steps for the node $(i+1)$

## Theorem (1)

*An equilibrium reached through the algorithm described above is unique and does not depend on order in which we treat all nodes.*


$E(U) = 10 - \theta_{FinEd}$
$E(U) = 8 - \theta/k_2$
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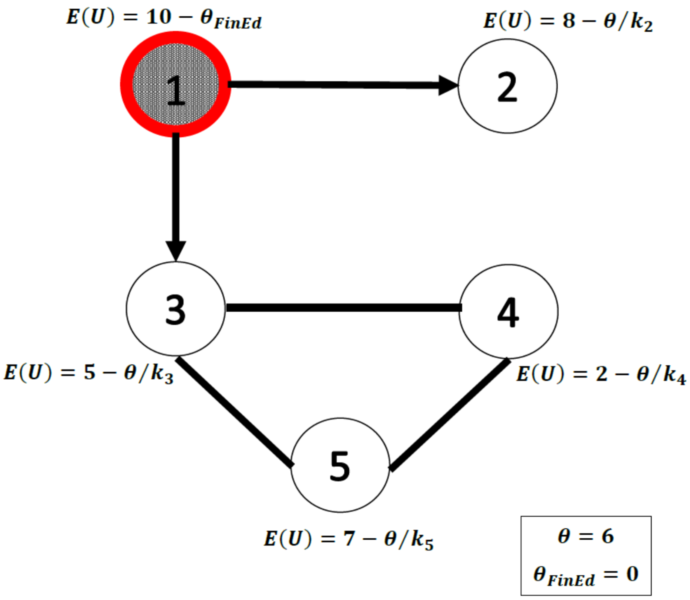
$E(U) = 5 - \theta/k_3$
$E(U) = 2 - \theta/k_4$
$E(U) = 7 - \theta/k_5$
$\theta = 6$
$\theta_{FinEd} = 0$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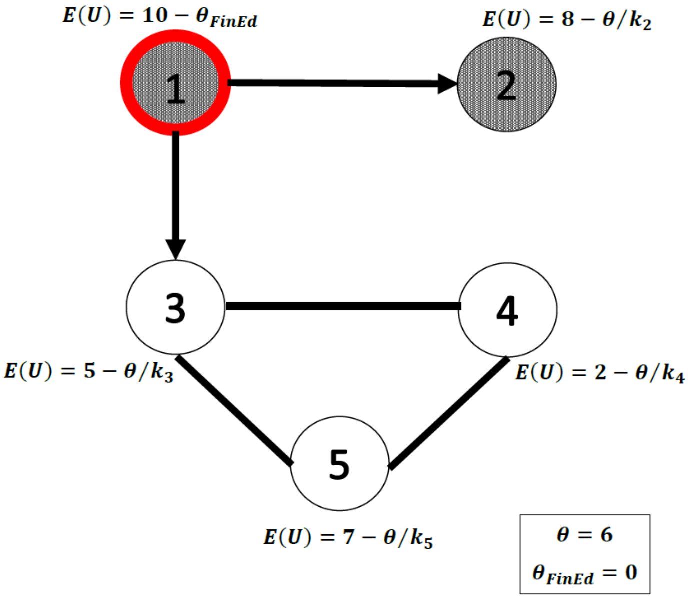

$E(U) = 10 - \theta_{FinEd}$
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$E(U) = 5 - \theta/k_3$
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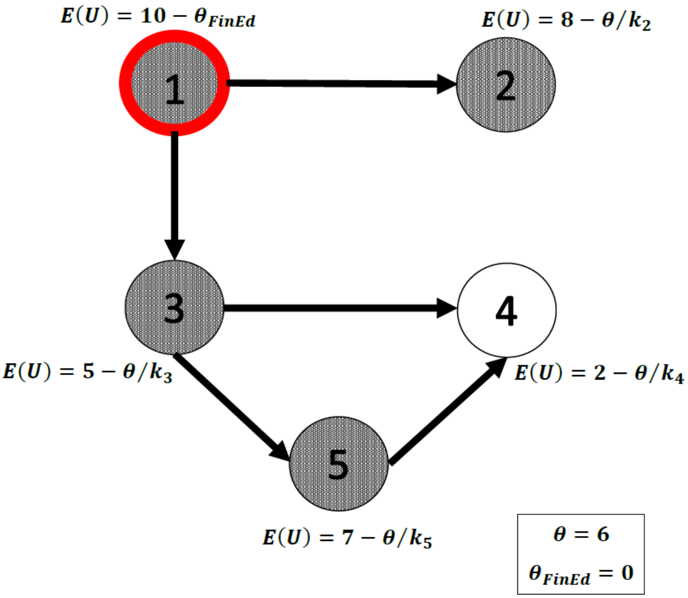
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$\theta = 6$
$\theta_{FinEd} = 0$

# The Upper Limit of SMP: Algorithm 2

1. We start with original graph $G$.
   We create two stacks where for each Uninformed $i$ we add $\widetilde{k_i}$, the minimum number of participating neighbors $i$ need to participate herself, and $k_i$ - total number of $i's$ neighbors.
2. We compare $k_i$ with $\widetilde{k_i}$ for every $i$.
   If $\widetilde{k_i} > k_i$ we exclude $i$ from the graph and we pass from $G_{iter}$ to $G_{iter+1}$ with reduced number of nodes
3. We repeat the procedure while $G_{iter+1} \subseteq G_{iter}$ and $G_{iter} \subsetneq G_{iter}$.

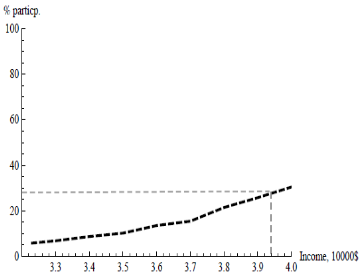
**Theorem (2)**

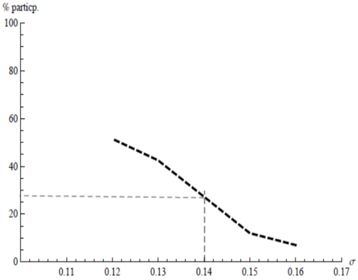
*Algorithm 2 finds the upper limit of stock market participation*

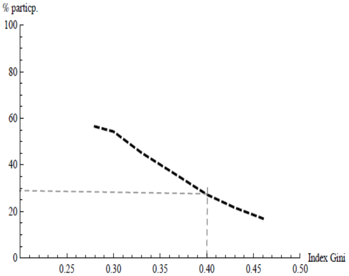
# Simulation Parameters

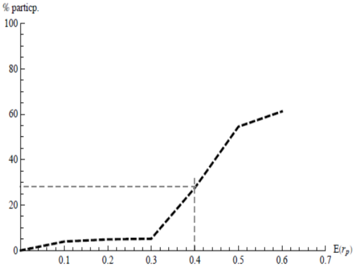
- **Wealth distribution**
  $\mathcal{F}_i(w)$ is a log-logistic distribution
  Gini Index and Average Income
- **Education: Financial Education**
  Share of agents with an education in Economics and/or Finance, and agents employed in Finance and Insurance industry in total labor force
- **Fixed participation costs** - Fixed costs of trading stocks (time/money spent understanding basic investment principles, acquiring enough information about risk and returns, the cost of time spent setting up accounts, brokerage commissions, the value of time spend implementing the trade)

# Simulation Results



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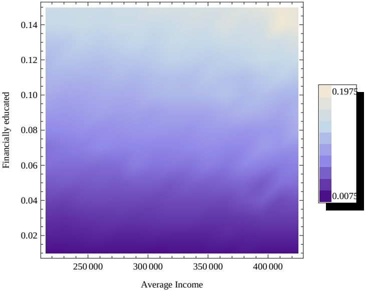
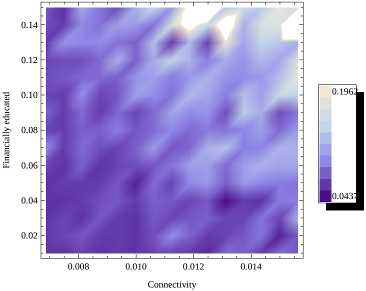
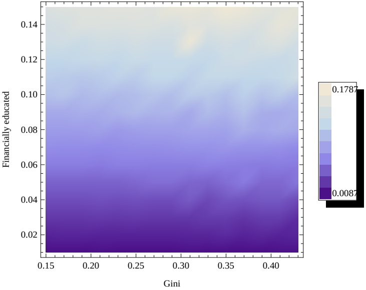
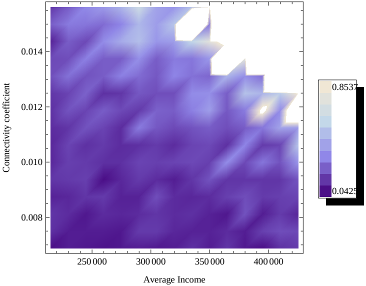


# Bringing the Model to the Data

- Estimate a proxy for connectivity for Danish administrative data for 2010-2013 (municipality-level)
- Estimate parameters of the wealth distribution, education, and the stock market
- Use the estimated parameters in the theoretical model
- Compare results for stock market participation with observable participation in the data

# Connectivity: Social Network

- Co-workers (current place of employment) and Ex-classmates (last educational institution)
- Wealth class: based on income distribution deciles
- Age cohort: closeness in age (5 year cohorts)

# Connectivity

- Colleagues

$$I_{CS_{ij}} = \begin{cases} 1 & \text{if individuals } i \text{ and } j \text{ study at the same school,} \\ 0 & \textit{otherwise} \end{cases}$$

- Ex-Classmates

$$I_{CW_{ij}} = \begin{cases} 1 & \text{if individuals } i \text{ and } j \text{ studied together or work at the same place} \\ 0 & \textit{otherwise} \end{cases}$$

- Age Cohort

$$I_{ageCohortWP_{ij}} = \begin{cases} 1 & \text{if} \quad |age_i - age_j| < 4 \\ 0 & \textit{otherwise} \end{cases}$$

# Connectivity

Connectivity is unobservable, to construct the density of the network we use a proxy for every municipality $m$

$$Density_m = 1 - \left(1 - \frac{\sum_{j=1}^{N_m} ConnectivityWorkplace_{ij}}{N_m}\right) * \\ * \left(1 - \frac{\sum_{j=1}^{N_m} ConnectivityUniversity_{ij}}{N_m}\right)$$

where

$$ConnectivityWorkplace_{ij} = \left\{ \; I_{CW_{ij}} * I_{AgeCohort_{ij}} \; \right\}$$

$$ConnectivityUniversity_{ij} = \left\{ \; I_{CS_{ij}} * I_{AgeCohort_{ij}} \; \right\}$$

and $N_m$ is the size of the municipality

# Stock Market Participation Forecast

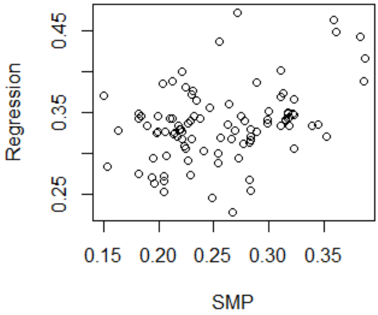



Figure: (a) Without Network

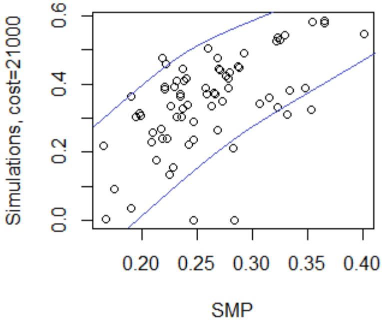
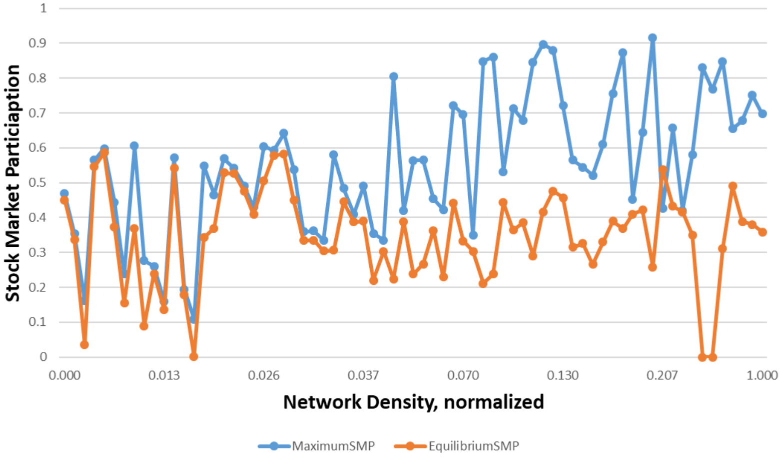
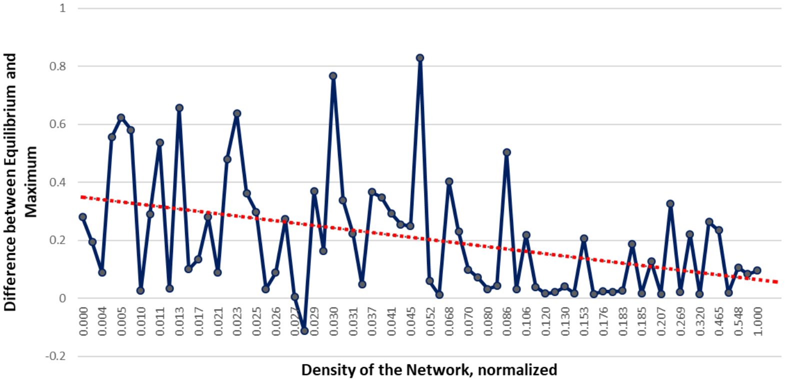



Figure: (b) With Network

# Maximum SMP and Equilibrium SMP



# Difference between Equilibria and Density of the Network



# Conclusion

- We propose a theoretical model with a social network structure.
  - In the model agents can exchange information about the stock market, as a result lowering their stock market participation costs
- We define a Unique Static Equilibrium and The Upper Limit of Stock Market Participation
- With simulations of the model we show that the model with a social network structure predicts equilibrium stock market participation better than a model without the social network

Thank you for your attention!