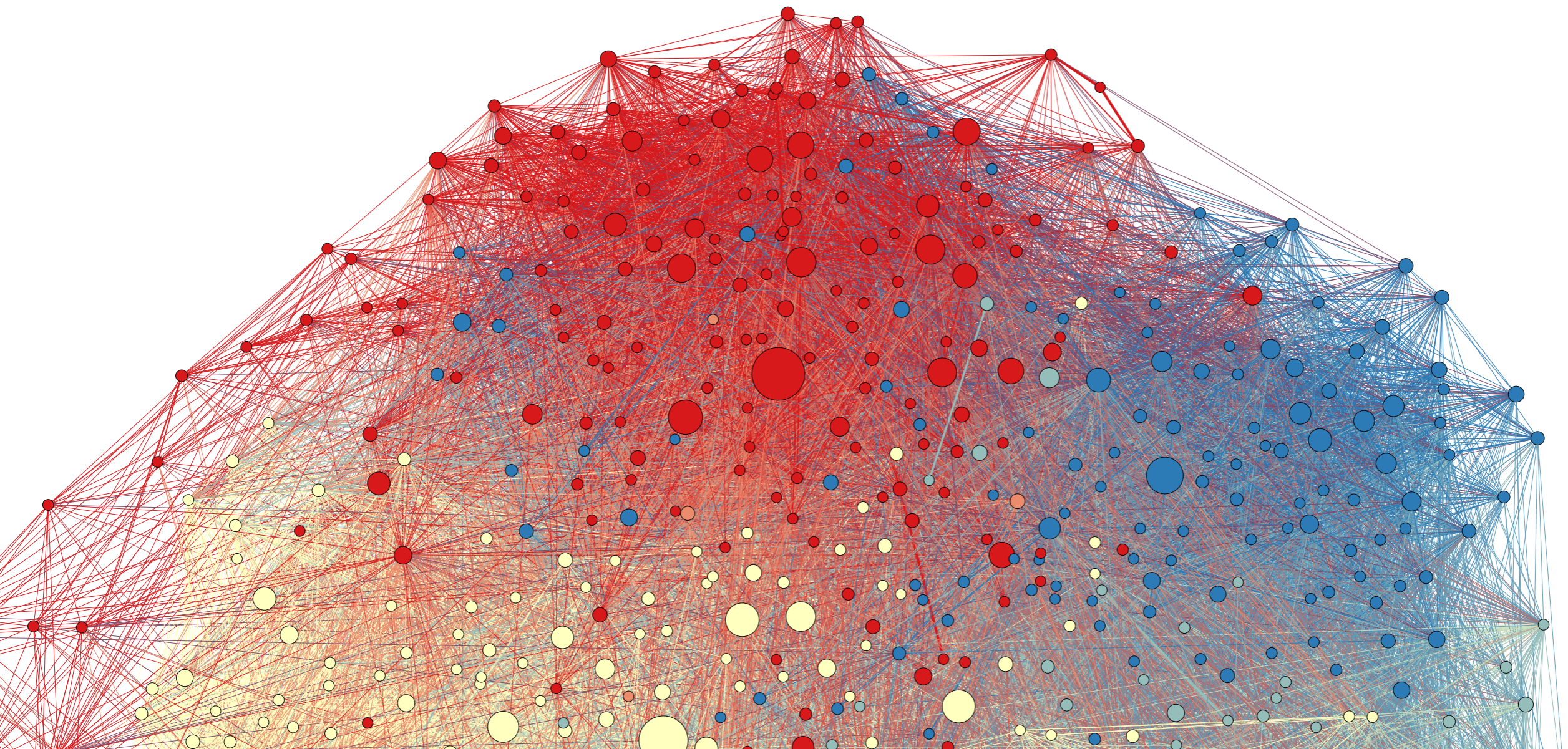


A Wonderful Mess: Local Behavior and Global Outcomes

Kate A. Anderson



A bit about my background...

- In college, I majored in math
 - Math is beautiful and very simple
- After college, I worked at the Chicago Fed
I learned:
 - Six different programming languages
 - Predicting what the economy will do is not at all simple
- Graduate degree in economics and complex systems

Social Science is Hard

- People are complicated
- *Groups* of people are impossibly complicated
- People insist on being different from each other
- Different is particularly complicated

"More is Different"

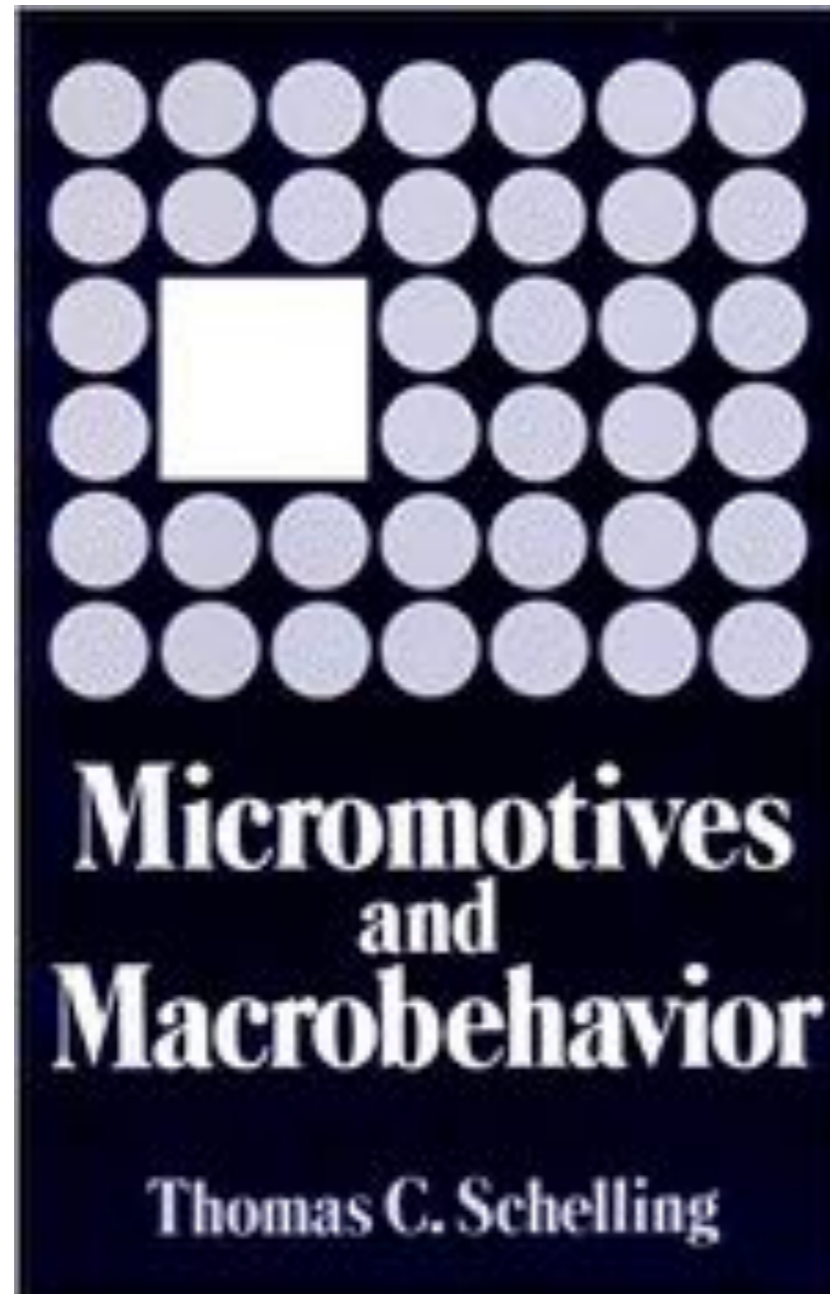
- Philip Warren Anderson



The ability to reduce everything to simple fundamental laws does not imply the ability to start from those laws and reconstruct the universe... The behavior of large and complex aggregates of elementary particles...is not to be understood in terms of the simple extrapolation of the properties of a few particles. Instead, at each level of complexity entirely new properties appear...

Particle Physicist: won the Noble Prize in 1977

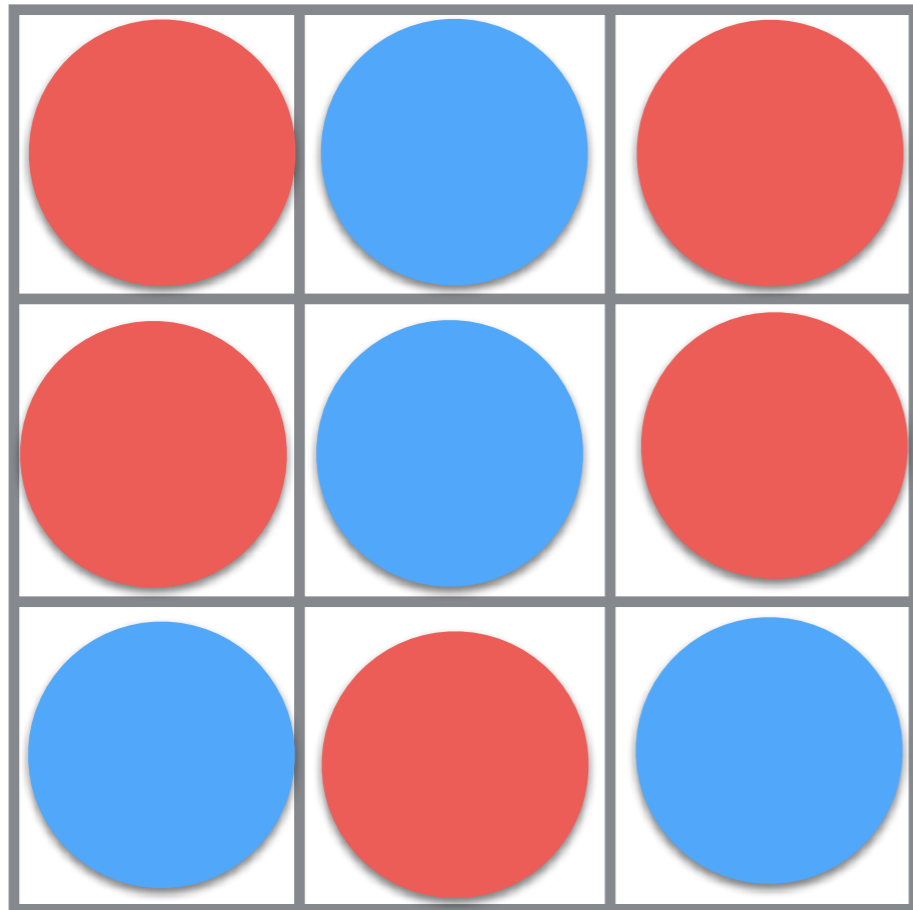
"More is Different"



- A group is not simply the sum of a collection of individuals
- Individuals act locally, creating a global effect
- The global state that emerges may be in direct contrast with the behavior of the individual

Economist: won the Noble Memorial Prize in 2005

An example: the Schelling Segregation Model

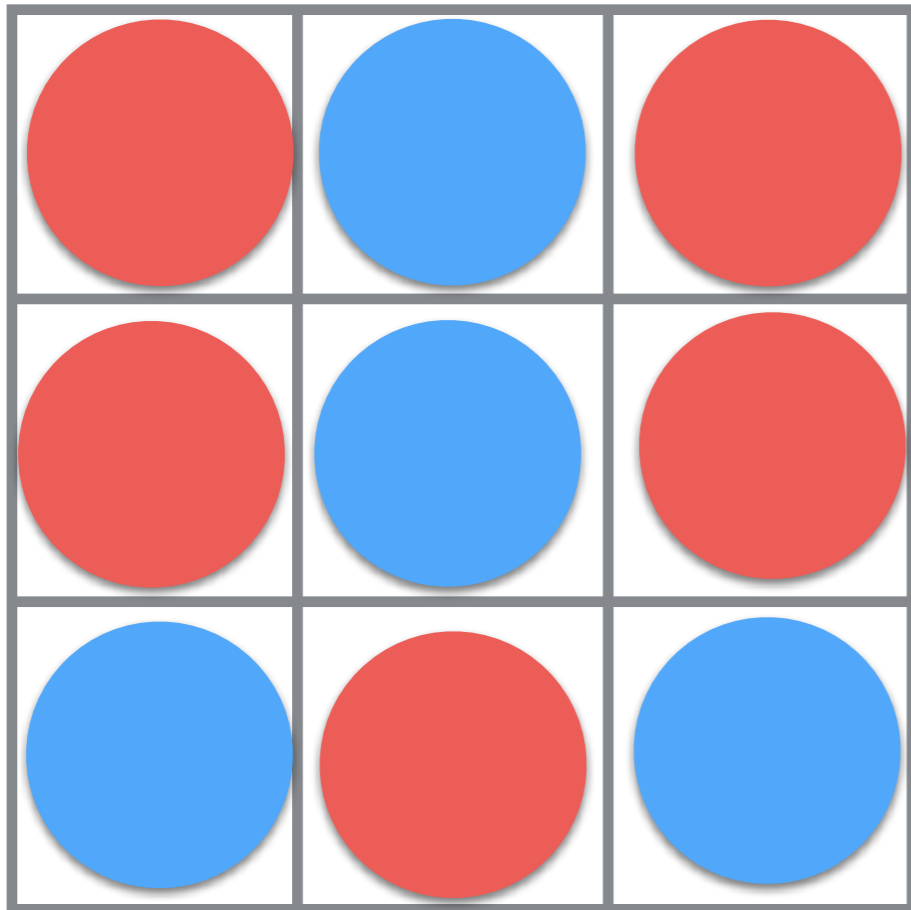


Suppose two types of people:
red and blue

Homophily: the tendency of
people to know people like
themselves

- blue people would like to live near some blue people
- red people would like to live near some red people

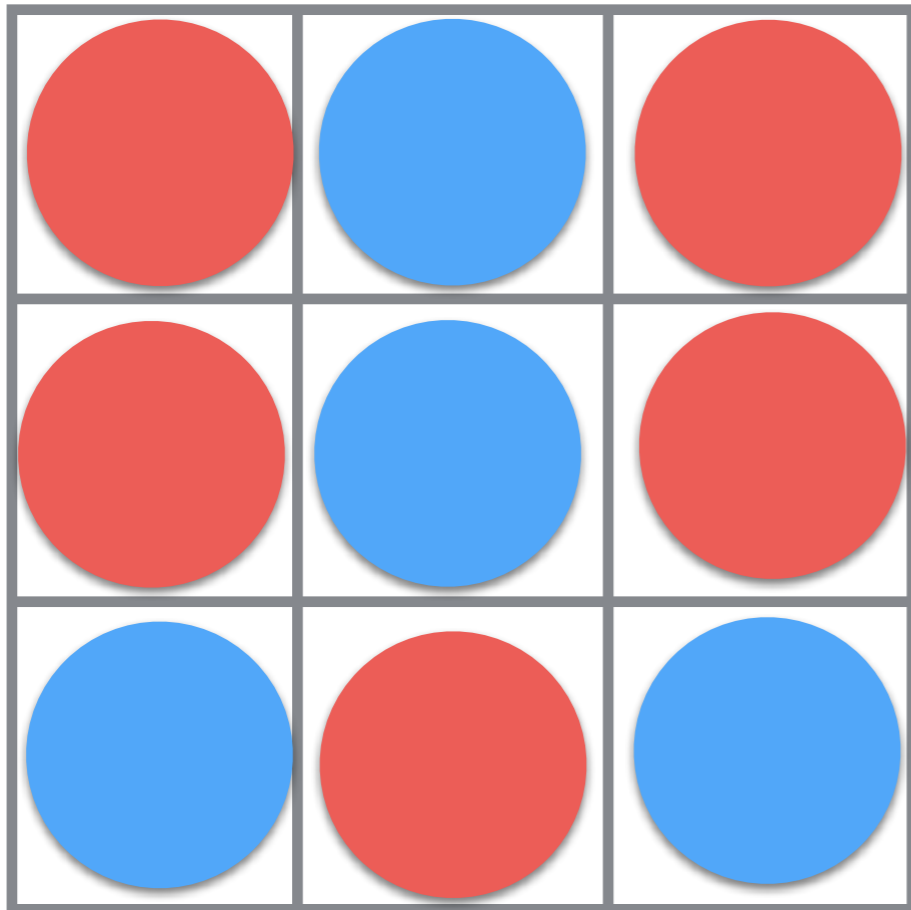
An example: the Schelling Segregation Model



An Agent Based Model (ABM):
Individuals are given a behavior rule, which is executed locally.

Red and Blue agents are placed on a grid

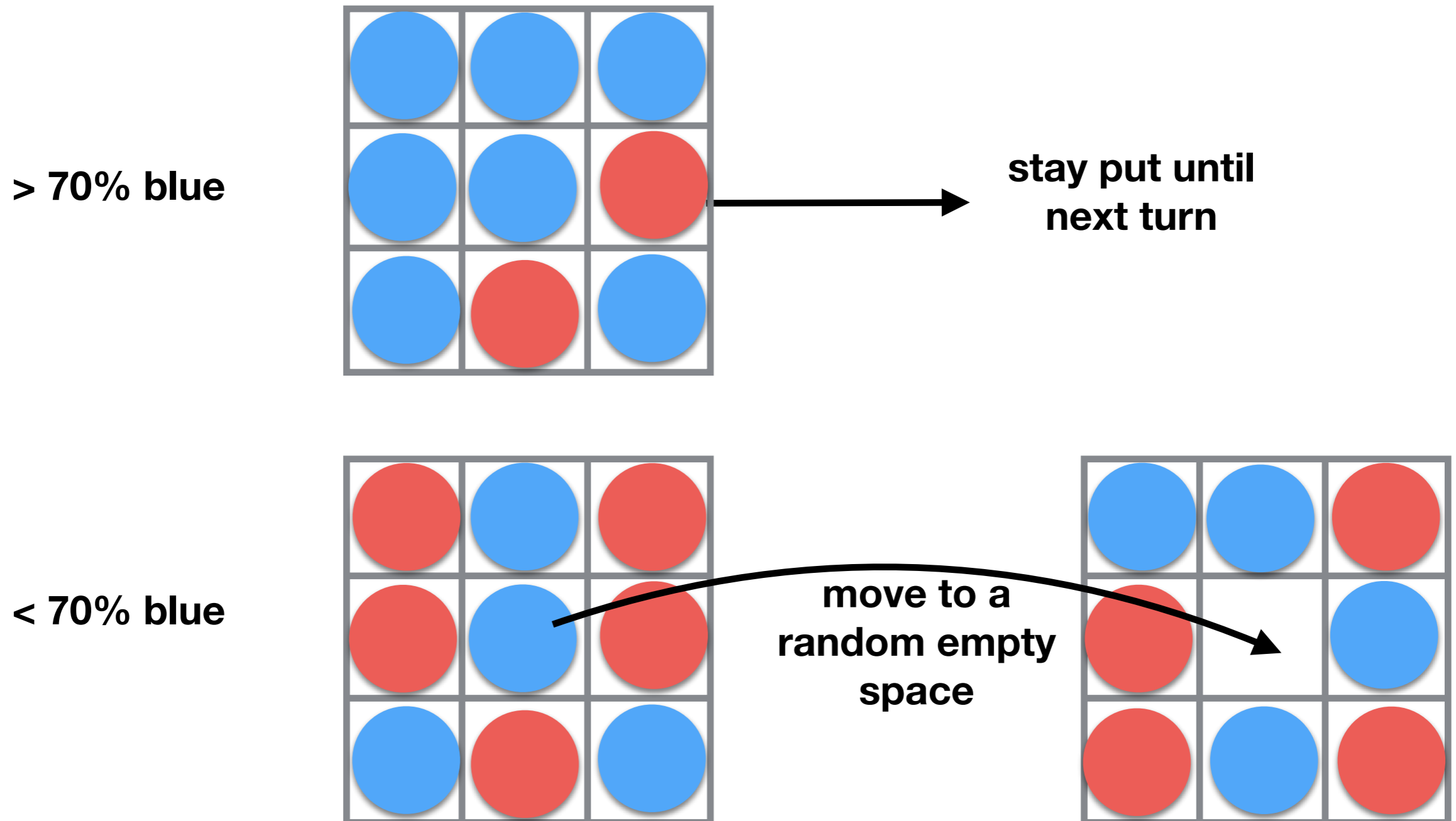
An example: the Schelling Segregation Model



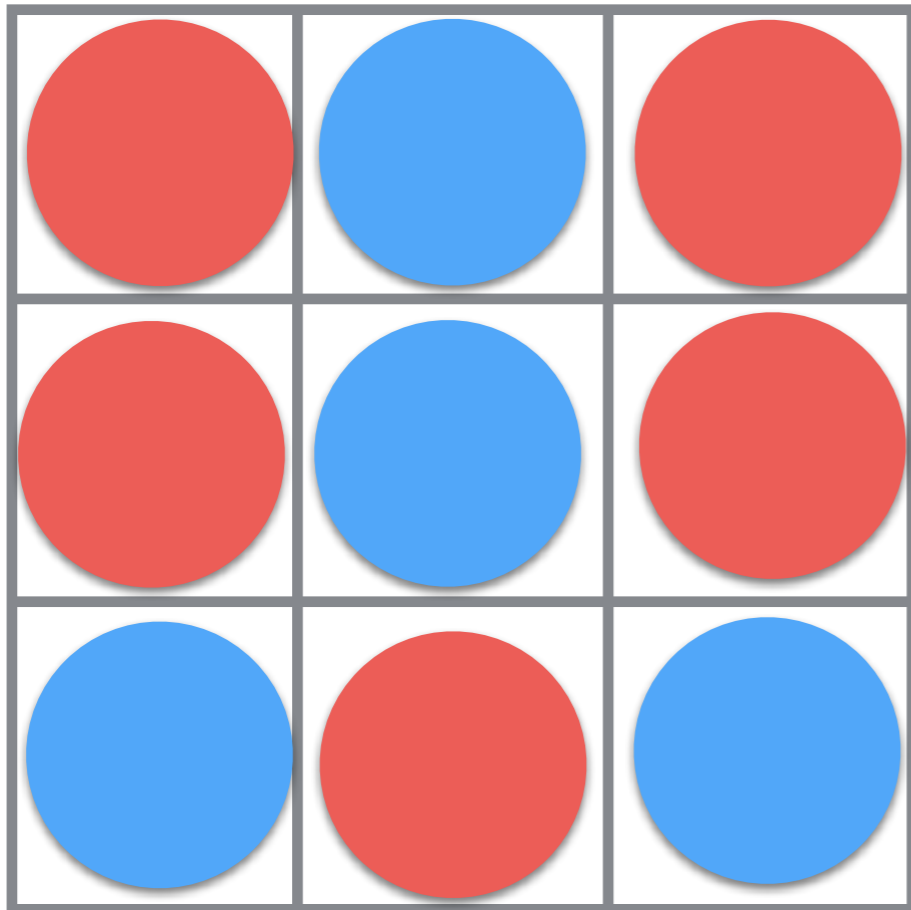
On each turn:

- Every person checks the 8 adjacent squares
- If at least $x\%$ are the same as them, they stay put
- If fewer than $x\%$ are the same, they move to a random open space

An example: the Schelling Segregation Model



An example: the Schelling Segregation Model

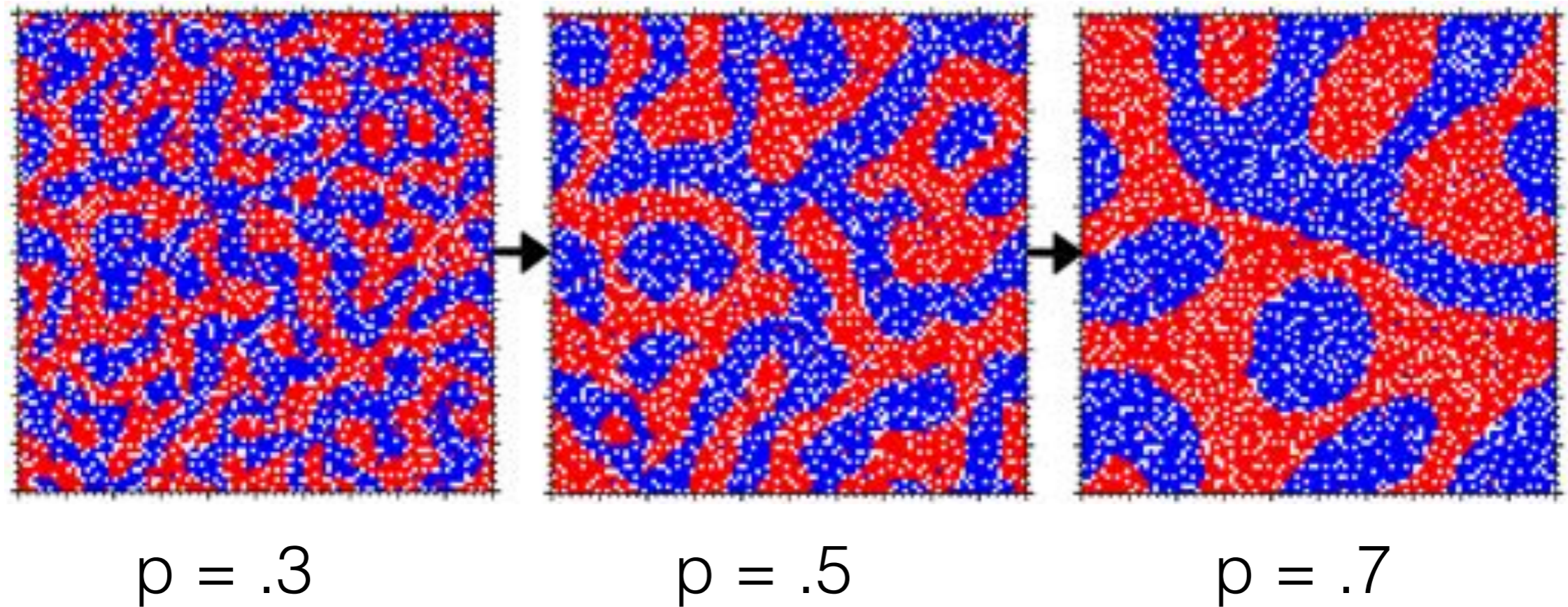


x is called a *threshold value*

Question: as we increase the individuals' tolerance for difference, how does the distribution of red and blue agents change?

At what point do we stop seeing segregation?

Schelling Segregation Model



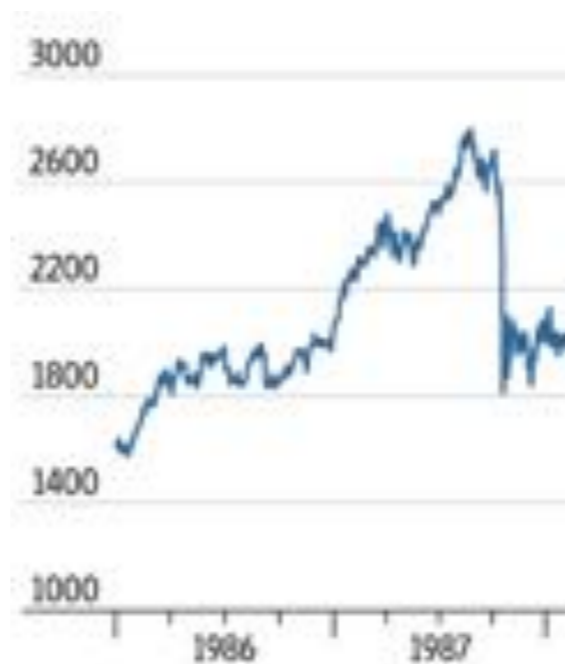
The individual's behavior does not translate directly into the global outcome: the whole is different than the sum of its parts!

Social Effects: Herding, Network Effects, and Cascades

The choices we make (products we adopt, political causes we back, rumors we believe, people we trust) depend on the people we talk to in complex ways...



US News



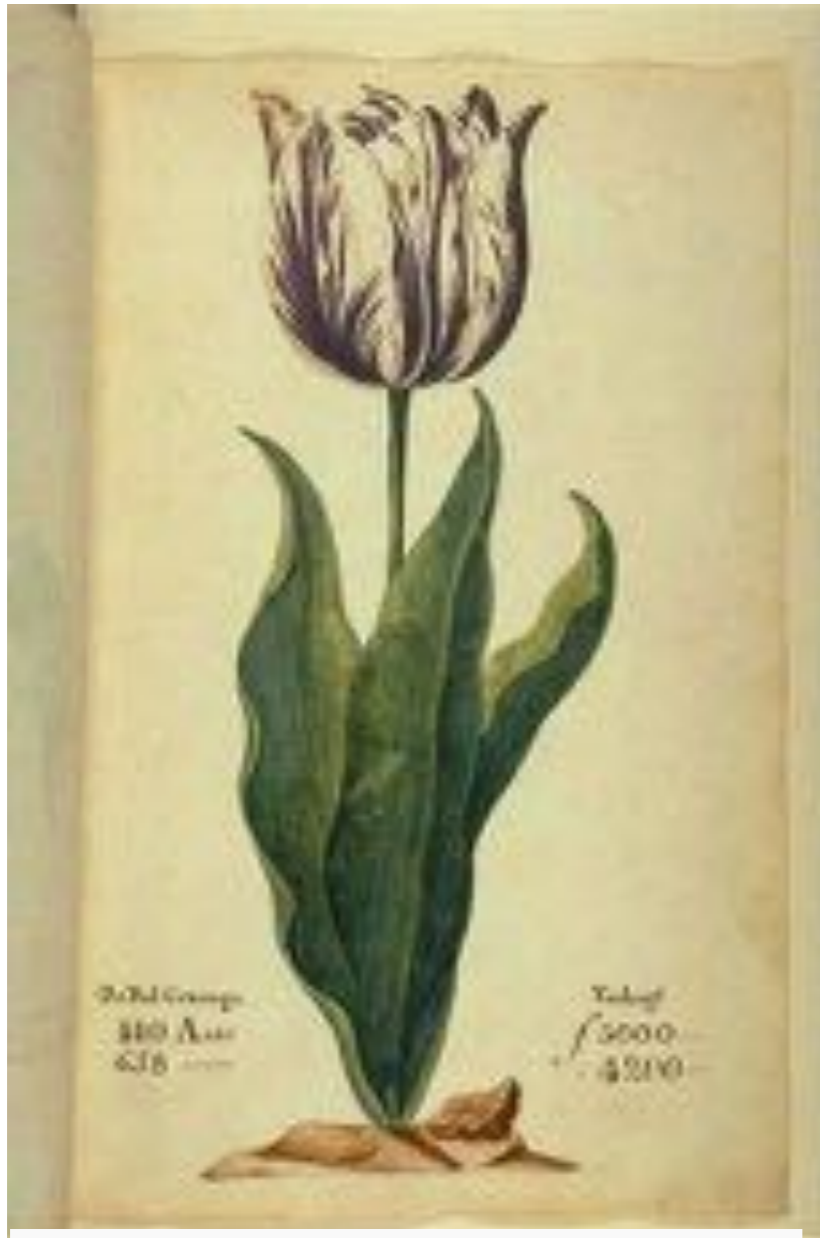
An example: tulips



In the mid 17th-century, the Netherlands was a nation full of newly-wealthy merchants.

One way to display of wealth was gardens: tulips were a new and ultra-exclusive flower

An example: tulips



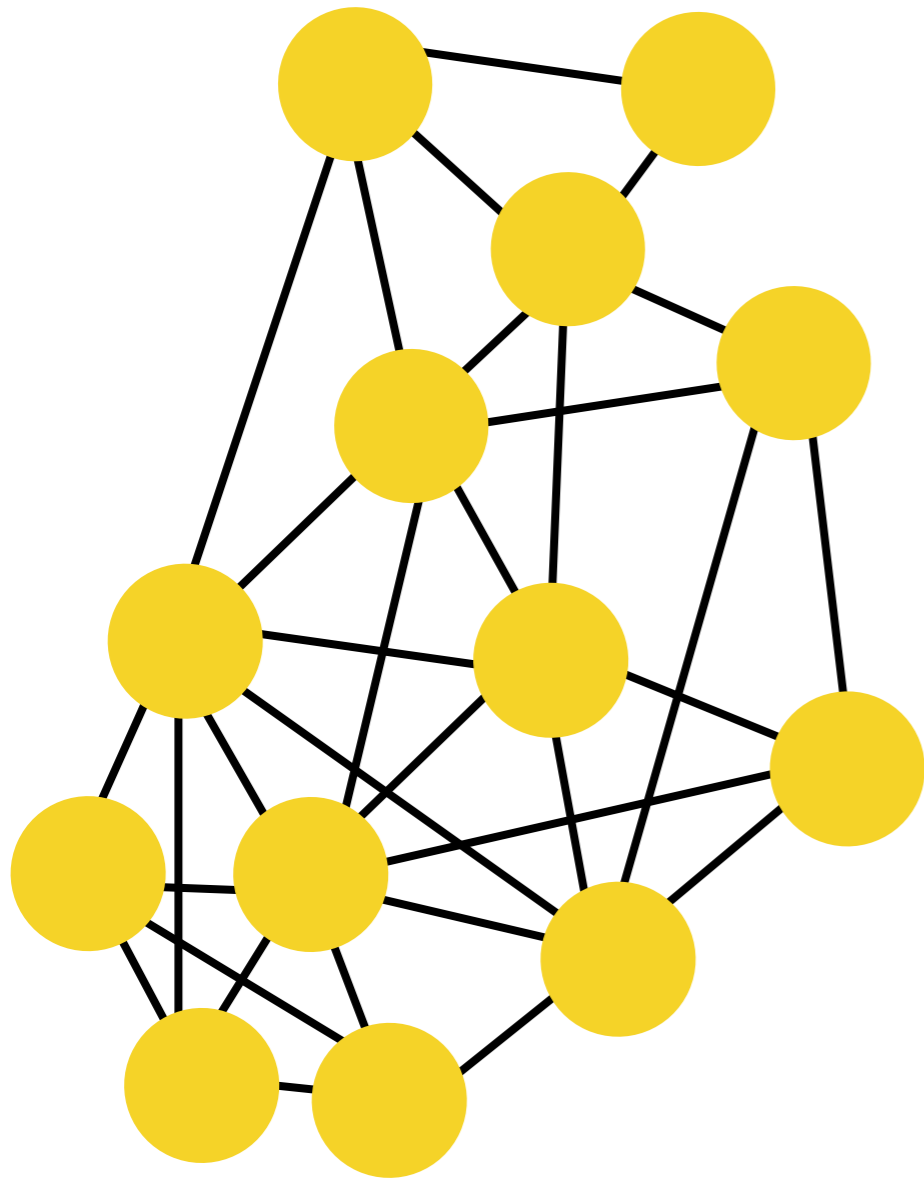
The "Viceroy" tulip in the 1637 Dutch catalog 'Verzameling van een Meenigte Tulipaanen'

Tulips became a huge fad: a viral product before that term existed.

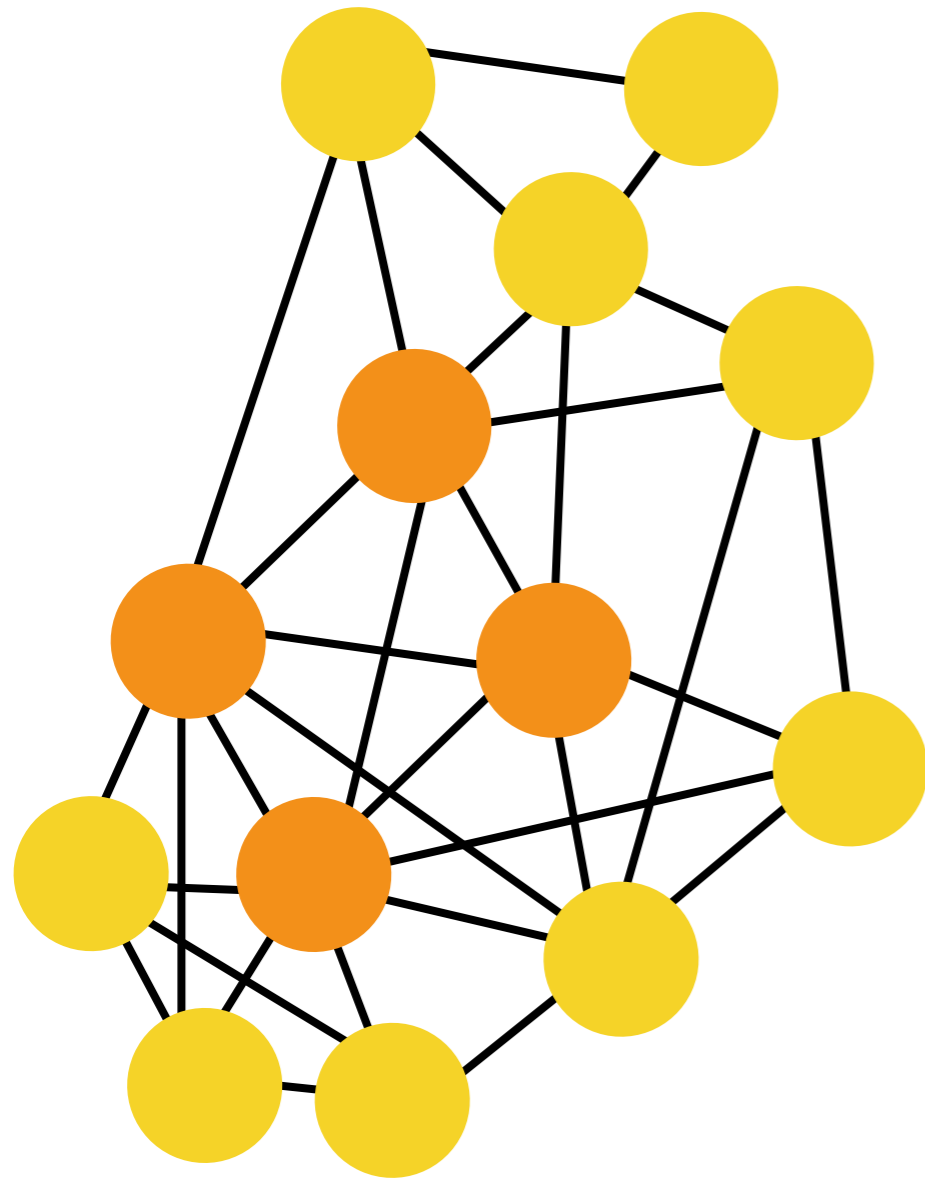
The popularity of tulips led to a proliferation of varieties.

The most desirable varieties became increasingly expensive.

An example: tulips

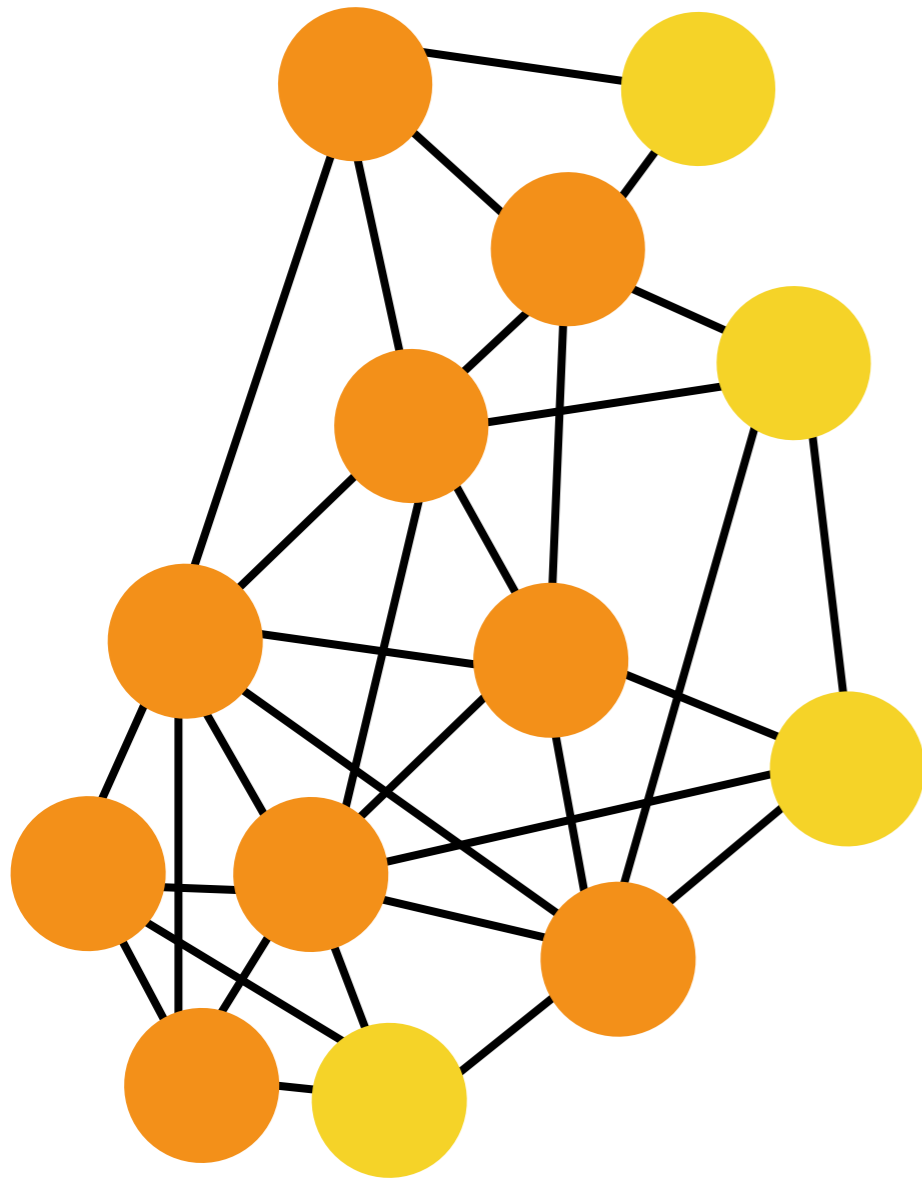


An example: tulips



Speculators started buying bulbs, not to plant, but as an investment

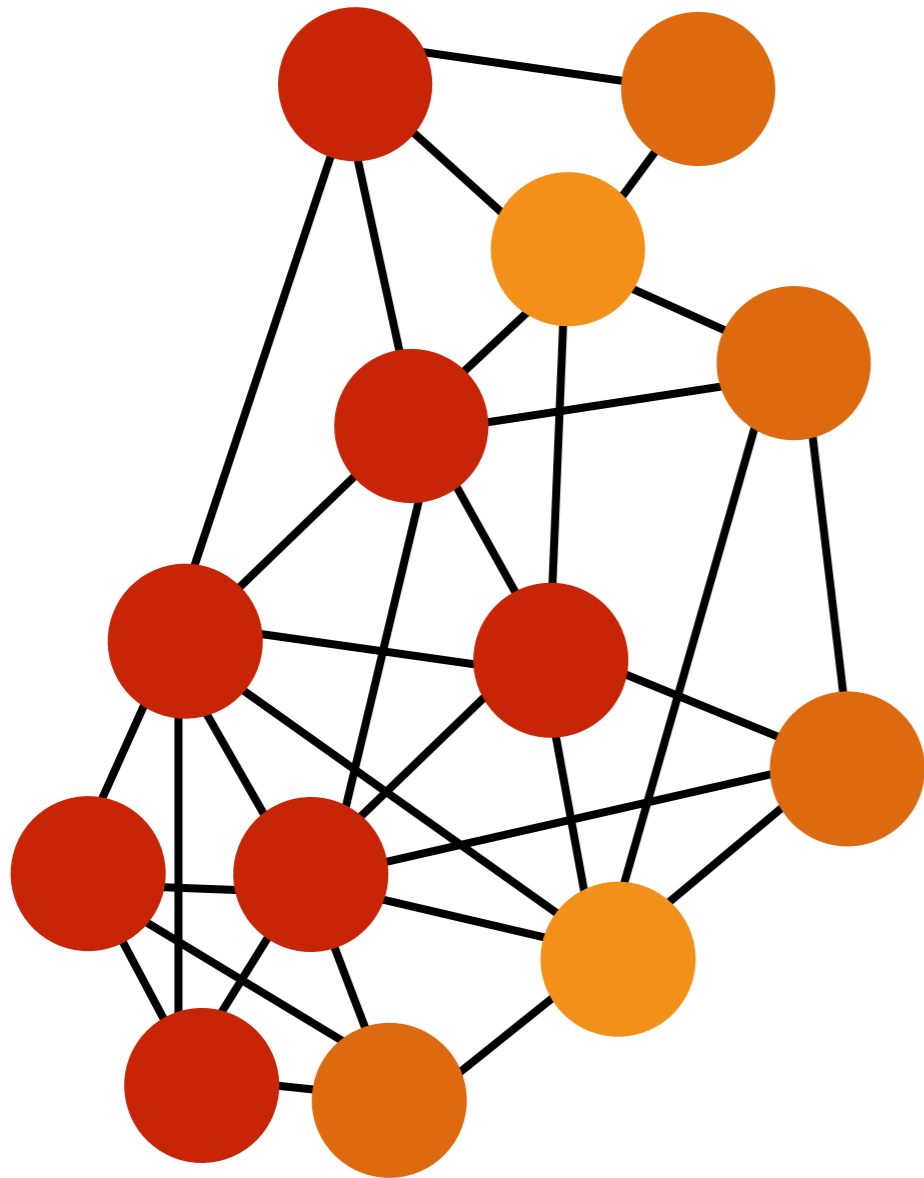
An example: tulips



Speculators started buying bulbs, not to plant, but as an investment

Very few people actually sold the bulbs, but there was a lot of talk!

An example: tulips



Speculators started buying bulbs, not to plant, but as an investment

Very few people actually sold the bulbs, but there was a lot of talk!

That talk fueled the belief that the bulbs were a good investment, which drove prices even higher!

An example: tulips



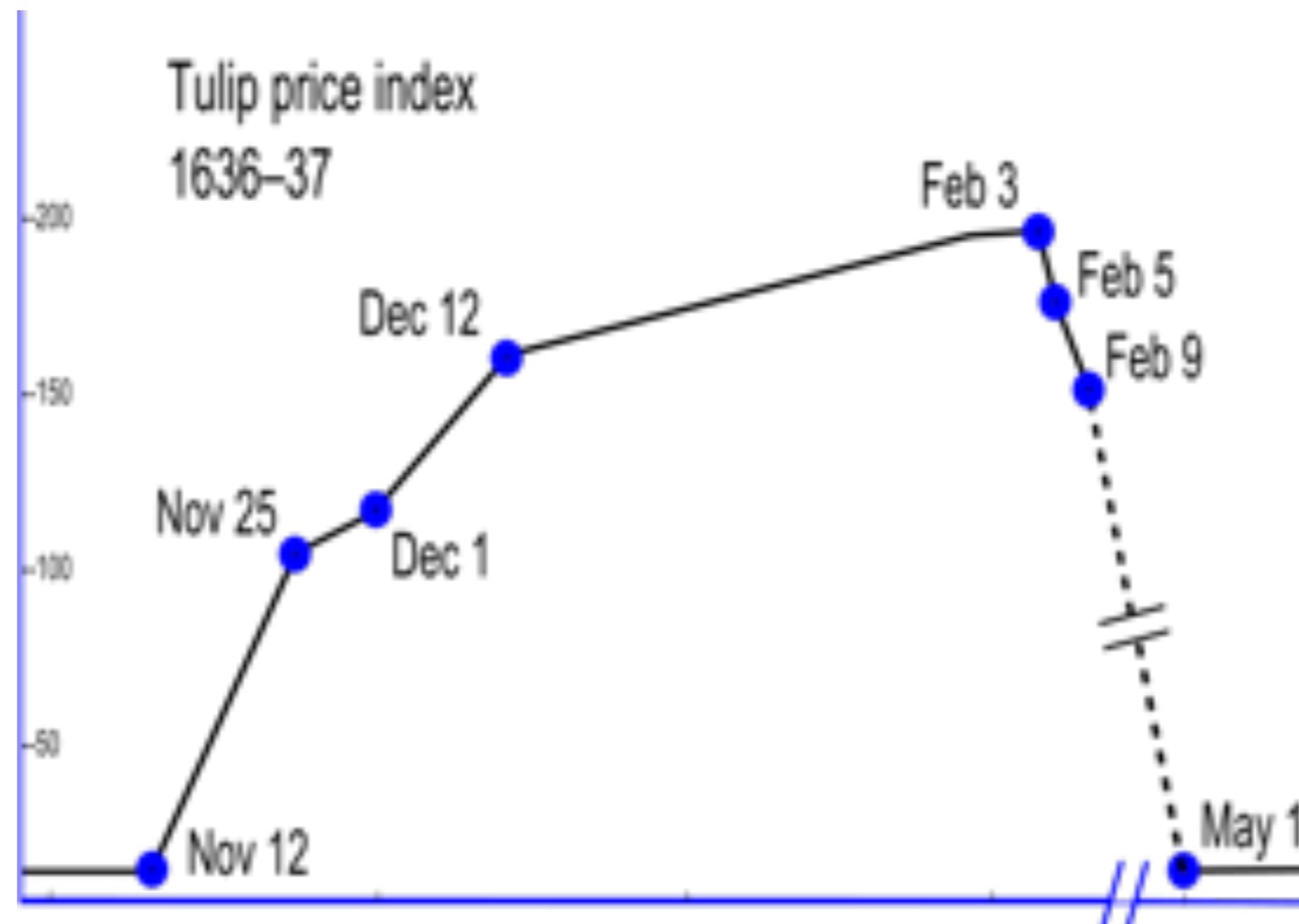
The *Semper augustus*, famous for being the most expensive tulip sold during tulip mania.

Eventually, prices got totally out of control.

These days, there is considerable disagreement over how bad it got at the peak: the original source of the story puts a single bulb being priced at a year's wages for 16 skilled laborers

Speculative Euphoria

This run up in prices due to collective beliefs is called *a bubble*

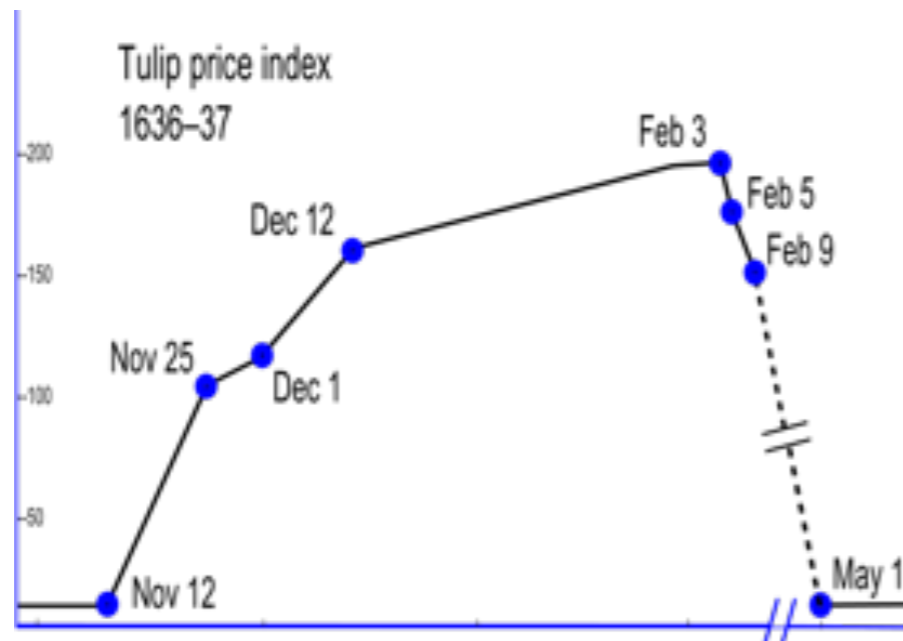


ref: Earl Thompson

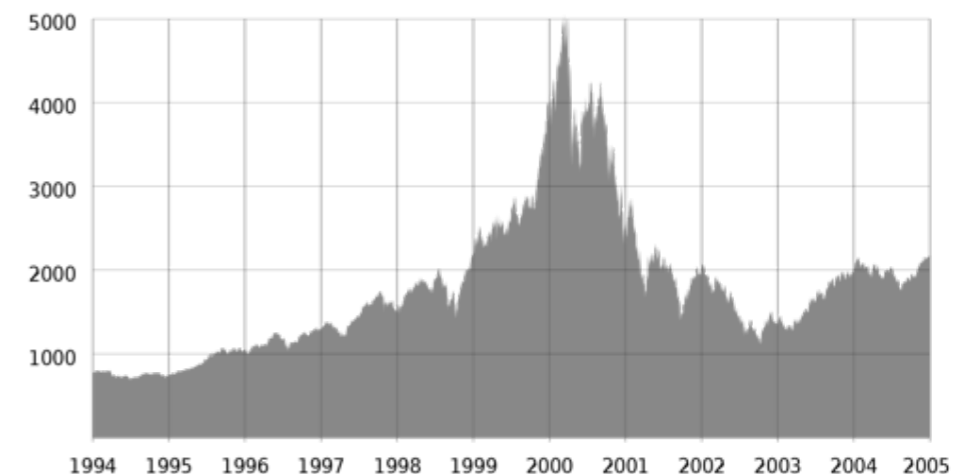
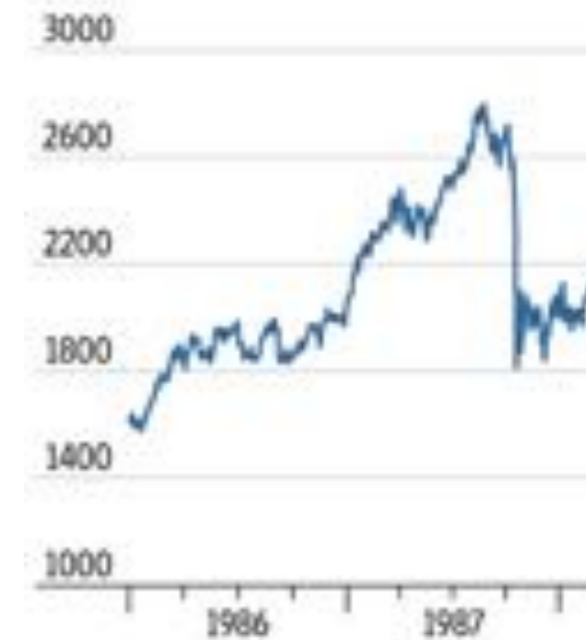
When people realized the tulips had no real value, the bubble “burst”

Bubbles

In *A Short History of Financial Euphoria*, John Kenneth Galbraith points out that financial bubbles are a persistent feature of economic history...

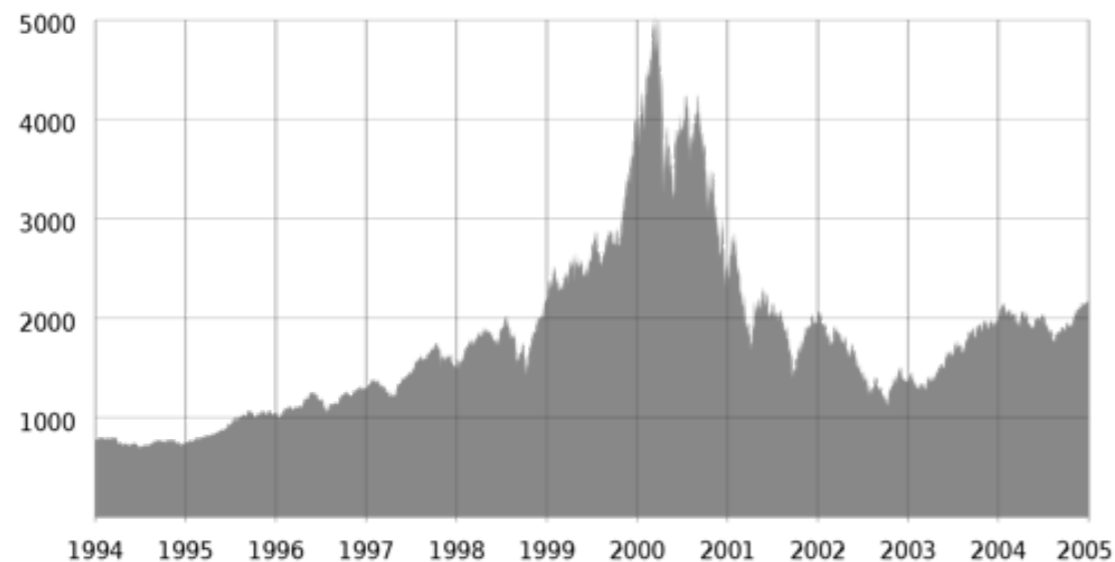


ref: Earl Thompson



“Speculative Euphoria”

It's a pattern of behavior that traditional, neoclassical economics can't understand.



Galbraith points out that people don't behave in isolation: they are subject to mass psychology and collective error.

He also points out that financial memory is “notoriously short”

This book was written in 1994, so clearly he was correct

Case 1: The Solomon Asch Experiment: Social Pressure and Herding

Which of these lines is closest in length to the line at the left?



A



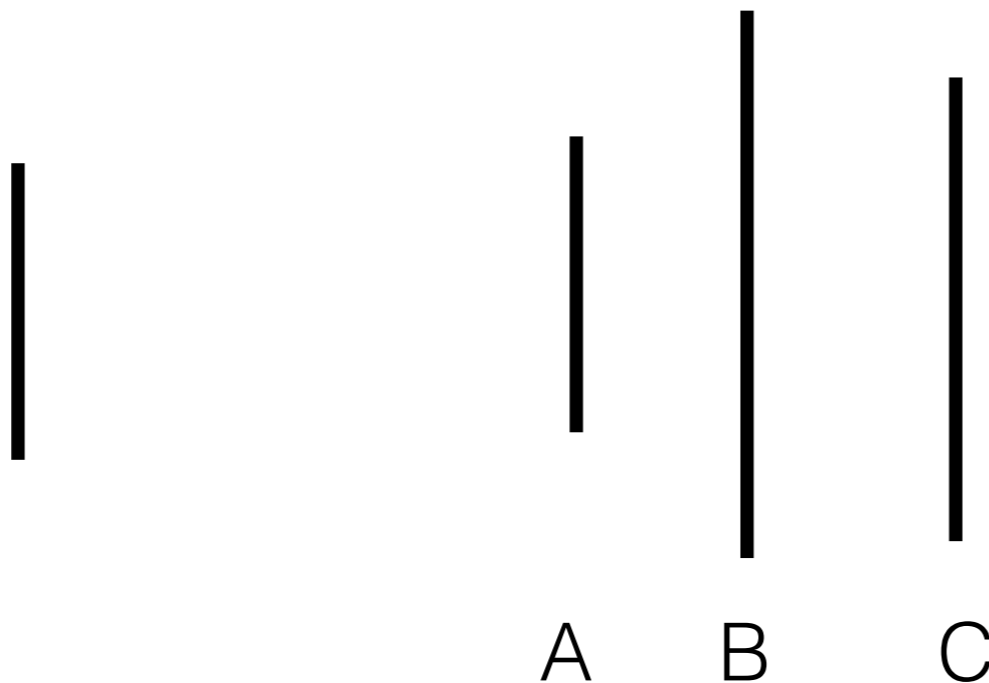
B



C

Solomon Asch Experiment

This question was designed to have an obvious answer, but when 7/8 (planted) subjects gave the wrong answer, a surprising number of real subjects wound up agreeing with the majority



This kind of social influence is sometimes called “herding”

Case 2: Perceptions of neighbors





Your heritage is being vandalized every day by theft losses of petrified wood of 14 tons a year, mostly a small piece at a time.



VS

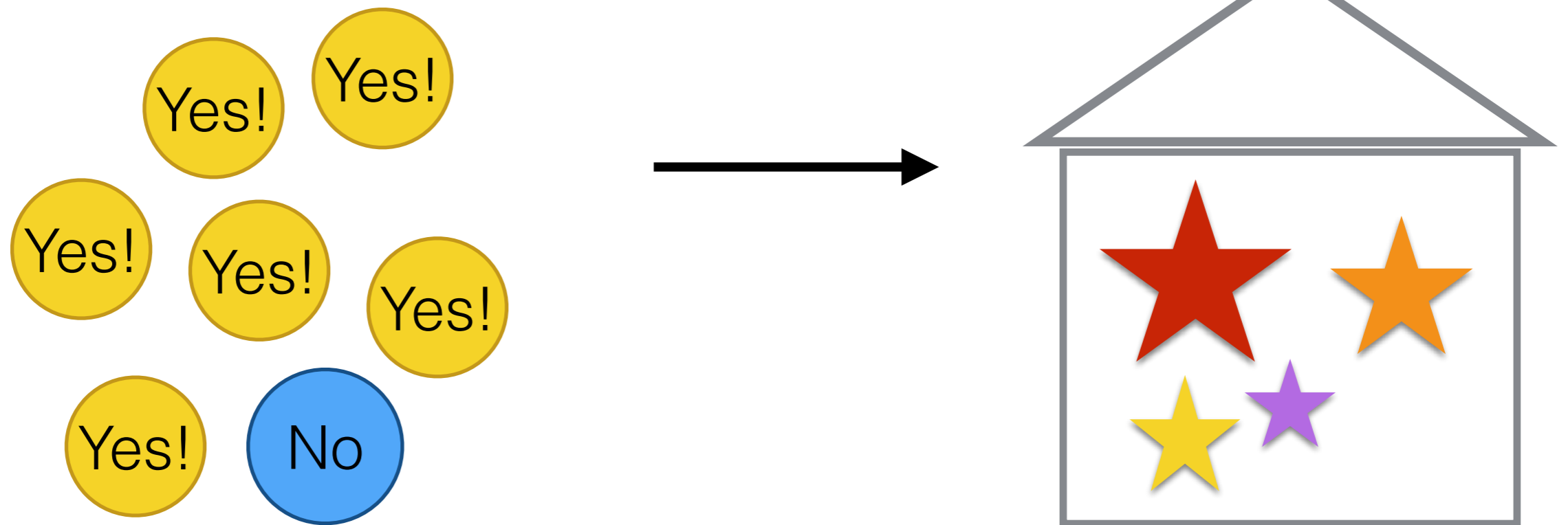
Please don't remove the petrified wood from the Park, in order to preserve the natural state of the Petrified Forest

Perceptions of neighbors

Condition and Graphic	Doorhanger Text	
Descriptive Normative Information 	Join Your Neighbors in Conserving Energy. Summer is here and most people in your community are finding ways to conserve energy at home. How are San Marcos residents like you conserving this summer? By using fans instead of A/C! Why? In a recent survey of households in your community, researchers at Cal State San Marcos found that ____% of San Marcos residents often use fans instead of air conditioning to keep cool in the summer. Using fans instead of air conditioning- Your Community's Popular Choice!	-
Self-Interest 	Save Money by Conserving Energy. Summer is here and the time is right for saving money on your home energy bill. How can you save money this summer? By using fans instead of A/C! Why? According to researchers at Cal State San Marcos, you could save up to \$54 per month by using fans instead of air conditioning to keep cool in the summer.	+
Environment 	Protect the Environment by Conserving Energy. Summer is here and the time is right for reducing greenhouse gases. How can you protect the environment this summer? By using fans instead of A/C! Why? According to researchers at Cal State San Marcos, you can prevent the release of up to 262 lbs of greenhouse gases per month by using fans instead of air conditioning to keep cool this summer! Using fans instead of air conditioning- the Environmental Choice.	++
Social Responsibility 	Do Your Part to Conserve Energy for Future Generations. Summer is here and we need to work together to conserve energy. How can you conserve energy for future generation? By using fans instead of A/C! Why? According to researchers at Cal State San Marcos, you can reduce your monthly demand for electricity by 29% using fans instead of air conditioning to keep cool this summer! Using fans instead of air conditioning- the Socially Responsible Choice.	+++
Information Only	Energy Conservation. Summer is here and the time is right to conserve energy. How can you conserve energy this summer? By using fans instead of A/C!	++++

Case 3: Self Fulfilling Prophecies

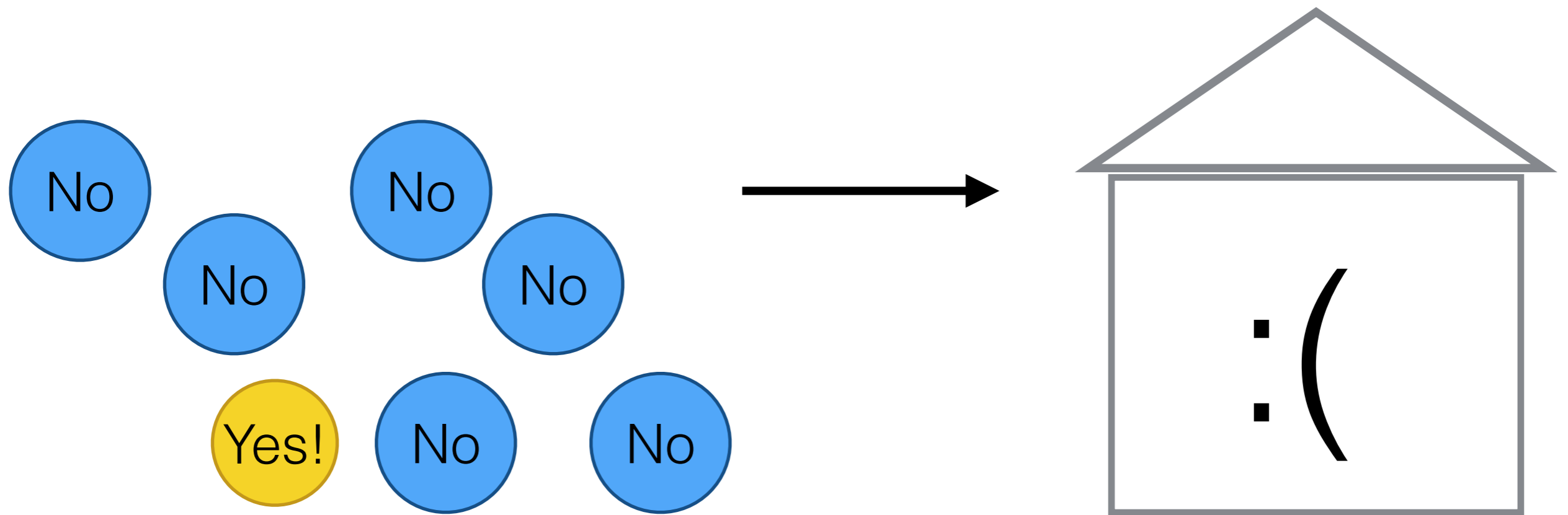
You want to go to a party if it is well-attended, but not if nobody is there.



If lots of people *think* the party will be well-attended, then they will go. And it will be well-attended.

Self Fulfilling Prophecies

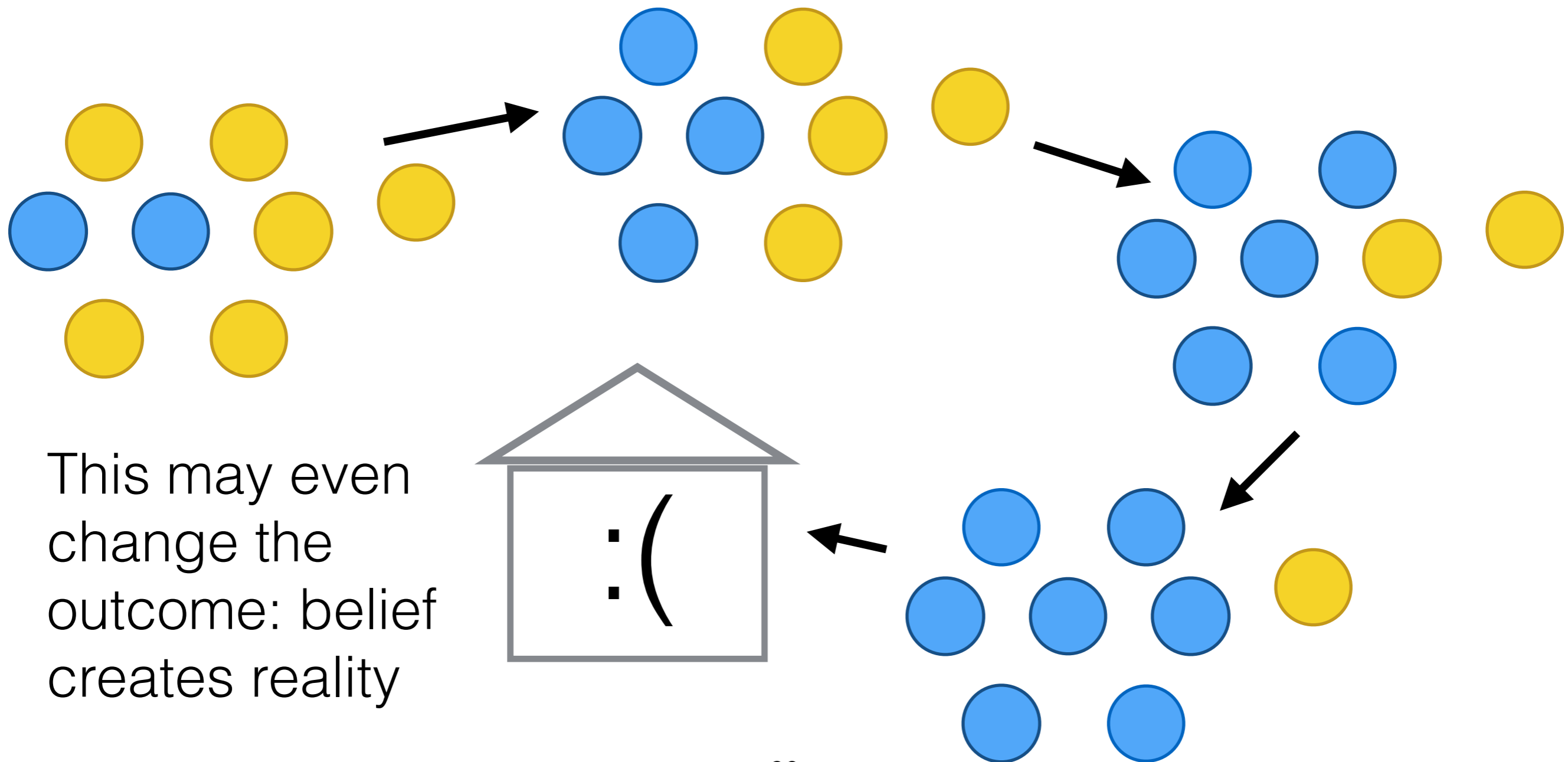
If people believe that it will be poorly attended, nobody will go, and it will be poorly attended.



This is true, *regardless of how many people would have enjoyed themselves if everyone had attended:*
perception becomes reality

Self Fulfilling Prophecies

If people talk to each other, they may become convinced their initial guess was wrong, even if it wasn't

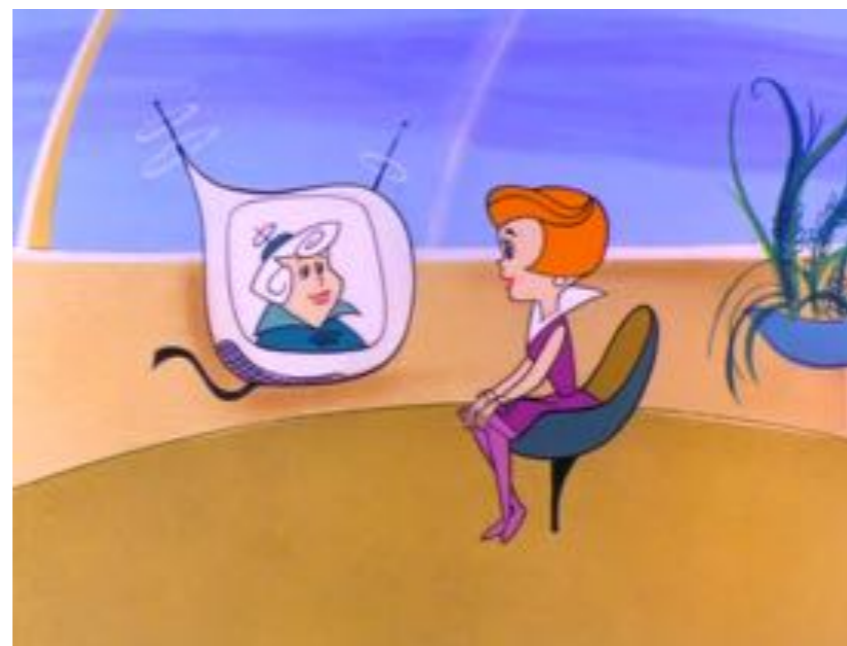


Case 4: Network Effects

Sometimes, you are influenced by your social circle, not because of peer pressure or information, but because they are more useful if more people have them



Nobody wants to be the only person with a video phone.



Network Effects

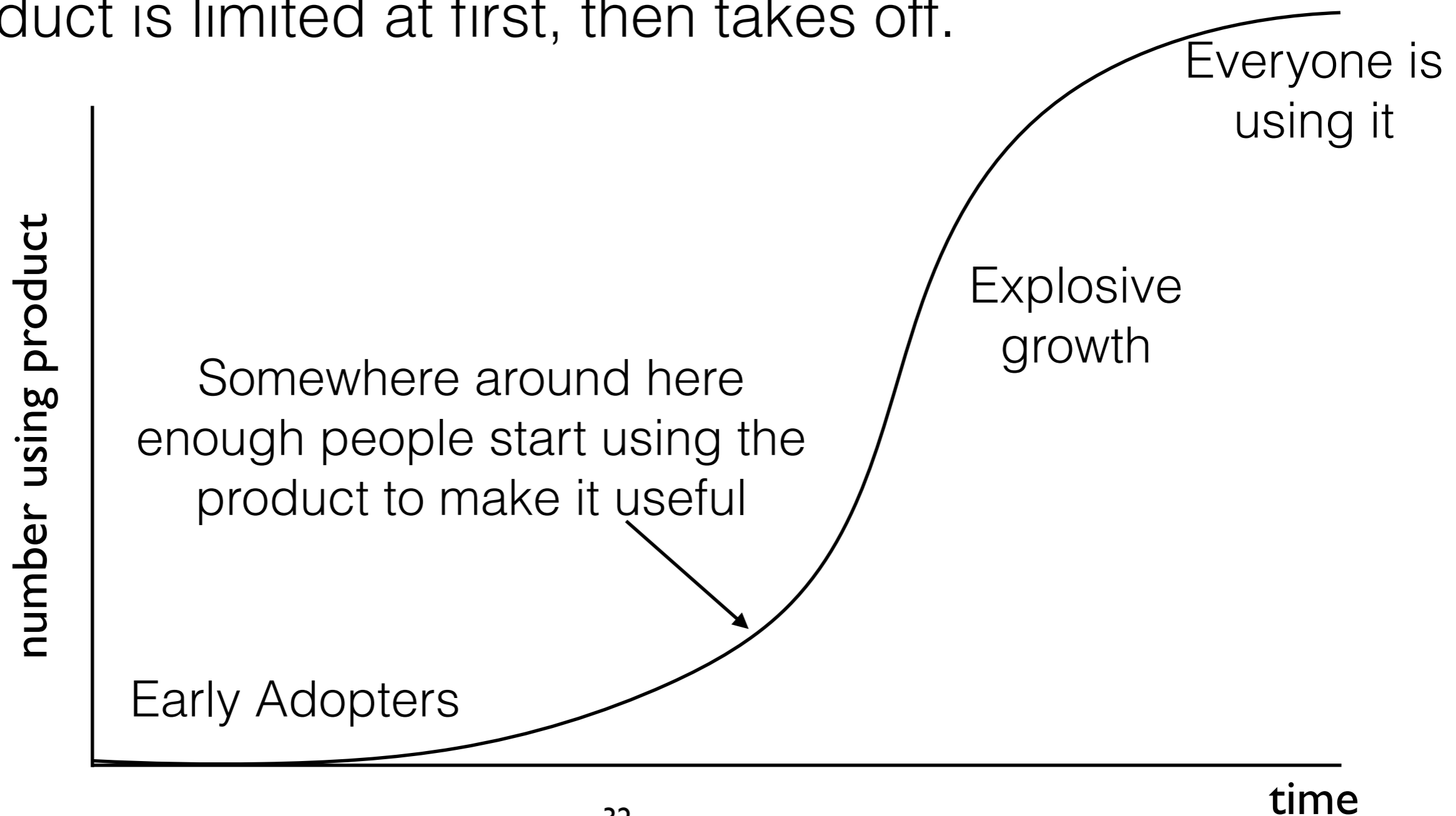
This is one of the things that is preventing the spread of hydrogen-powered cars...nobody wants a car that you can't fuel up.



But there will only be fuel points when enough people own hydrogen-powered cars.

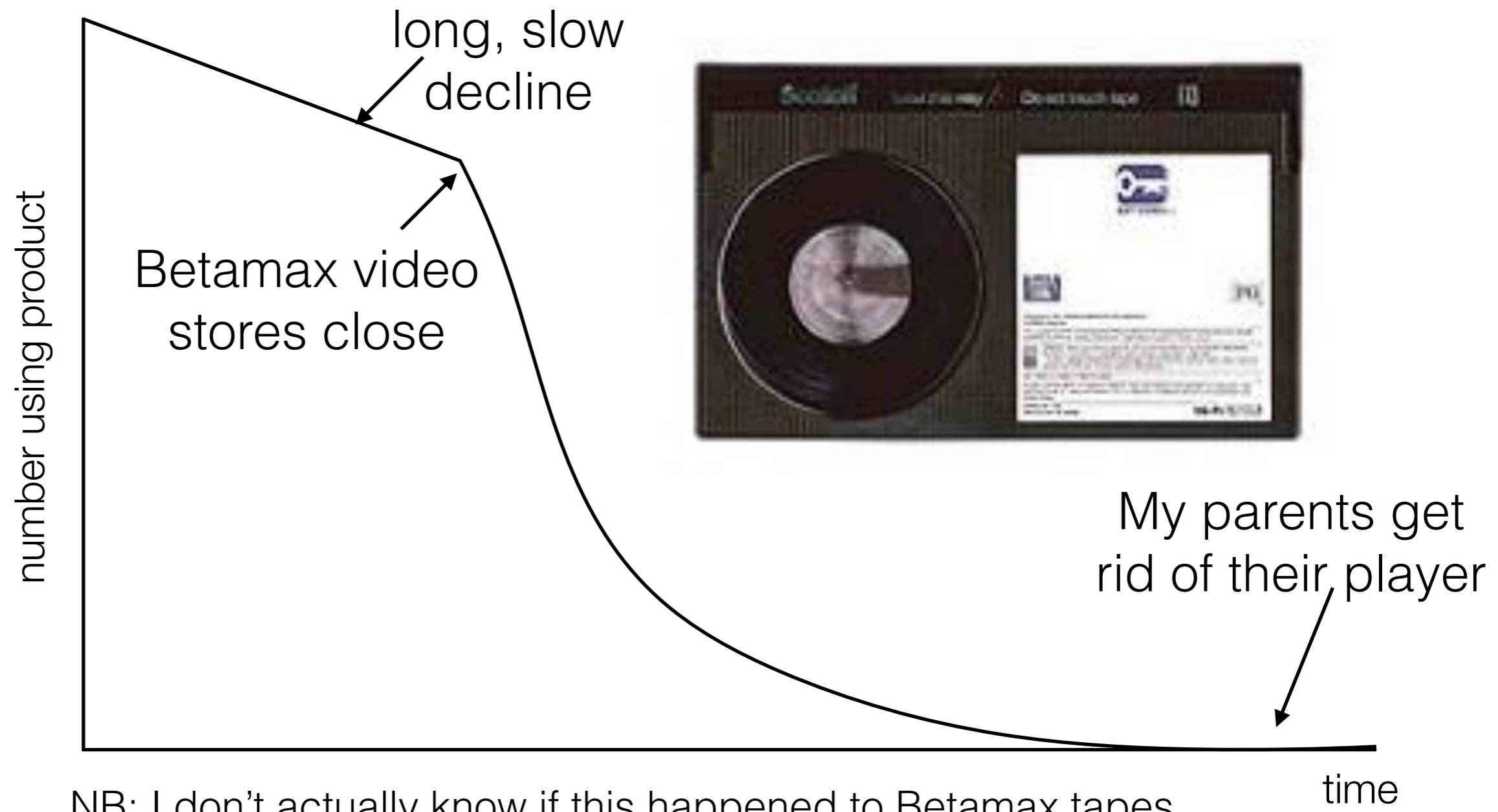
Network Effects

This creates a kind of threshold effect: the adoption of a product is limited at first, then takes off.



Network Effects

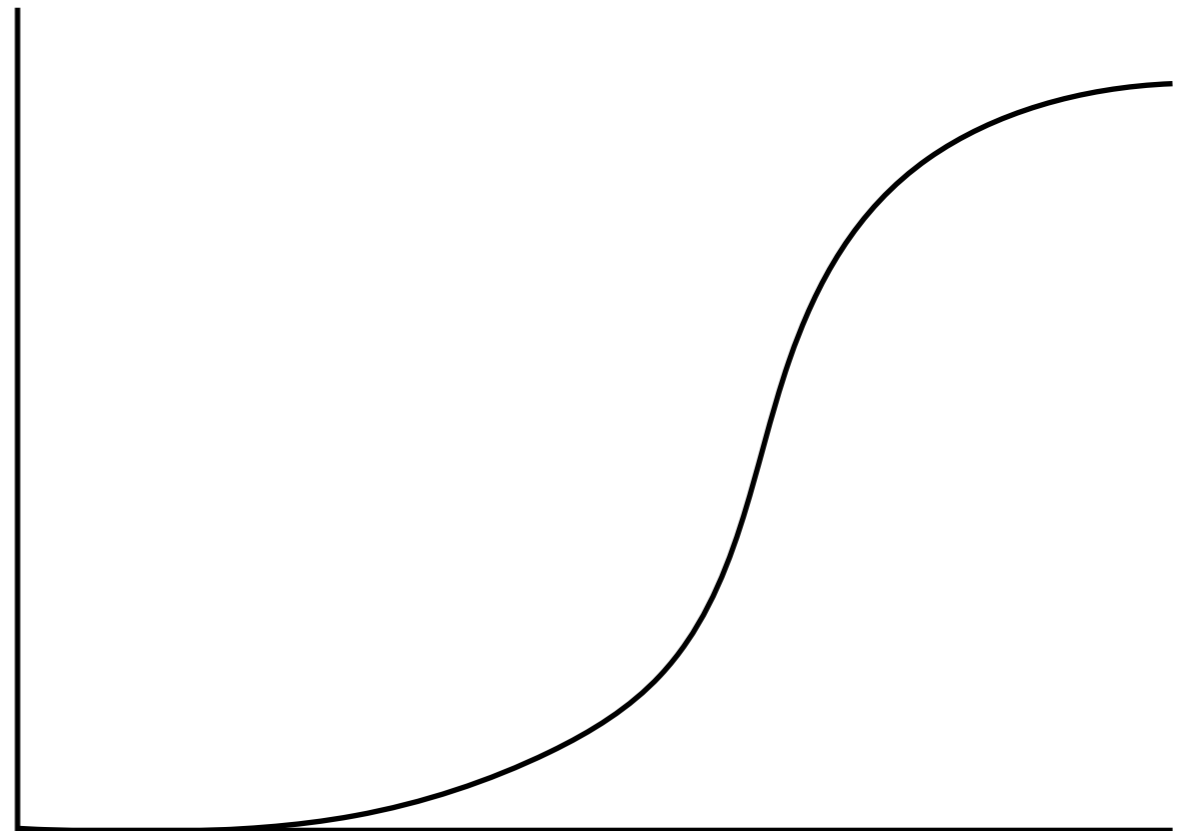
The effect can work in reverse too...it can completely kill products that otherwise might have lingered on



NB: I don't actually know if this happened to Betamax tapes. I don't have the data on that ~~But~~ but it seems plausible.

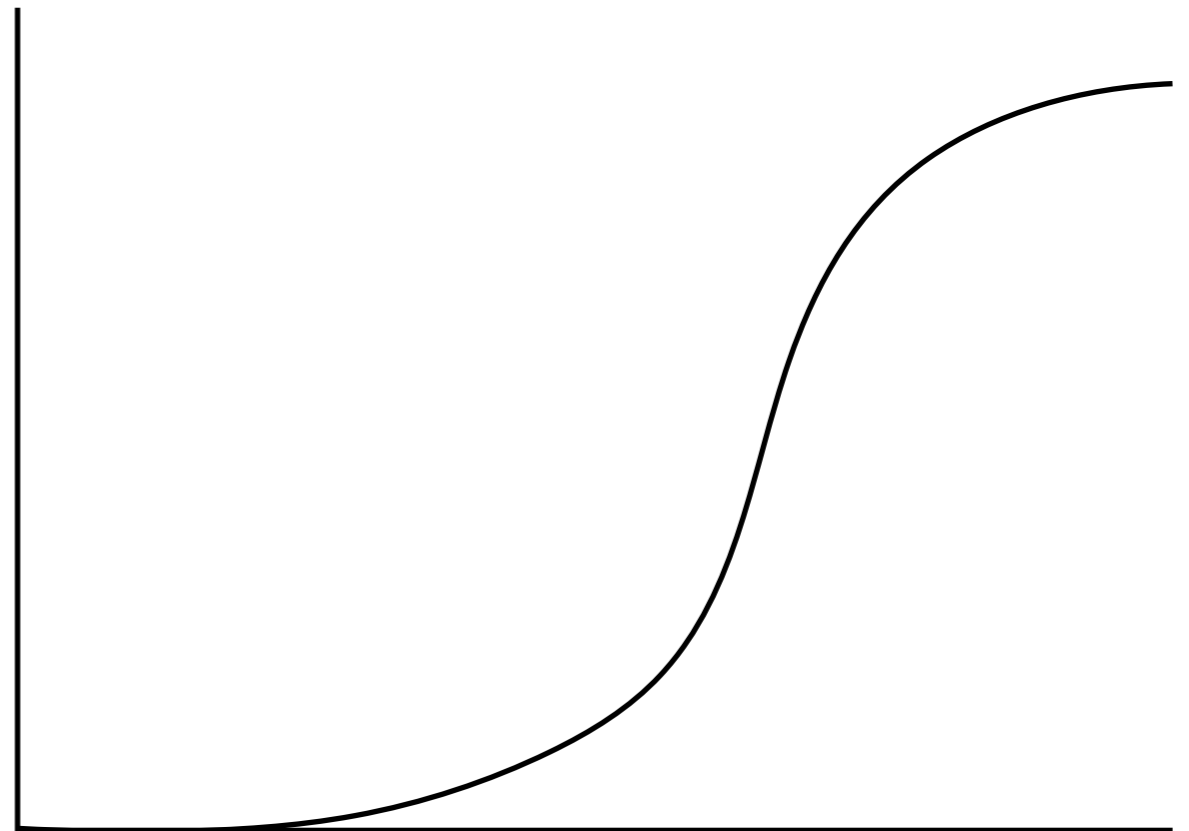
Network Effects

Getting past that initial threshold is a challenge many modern products face, because they involve a social element. Social products only work once they have a large enough user base



Network Effects

Getting past that initial threshold is a challenge many modern products face, because they involve a social element. Social products only work once they have a large enough user base



Social Science is Hard

Social Science is the study of interaction...

- Bargaining
- Trade
- Learning
- Job Search
- Voting
- Opinion formation
- Information Gathering
- Collaboration

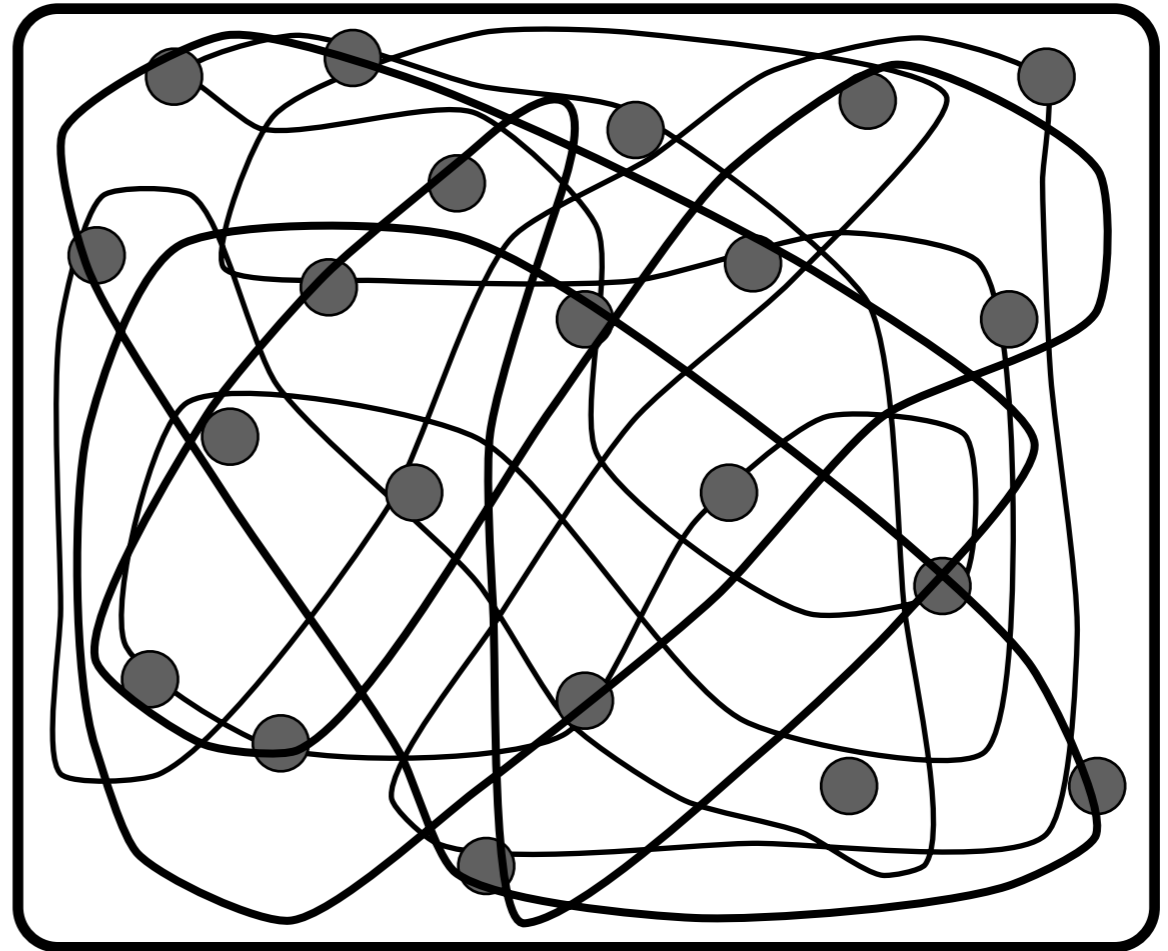
But how do we model interaction?

Models of Social Interaction

One way of thinking about social interaction is “perfect mixing”



Everyone interacts with everyone else at random



Sometimes it perfect mixing is a totally reasonable assumption. But sometimes it misses the point!



An example...

My husband's geeky growth chart, created for our daughter's first birthday: geeky-dad.tumblr.com

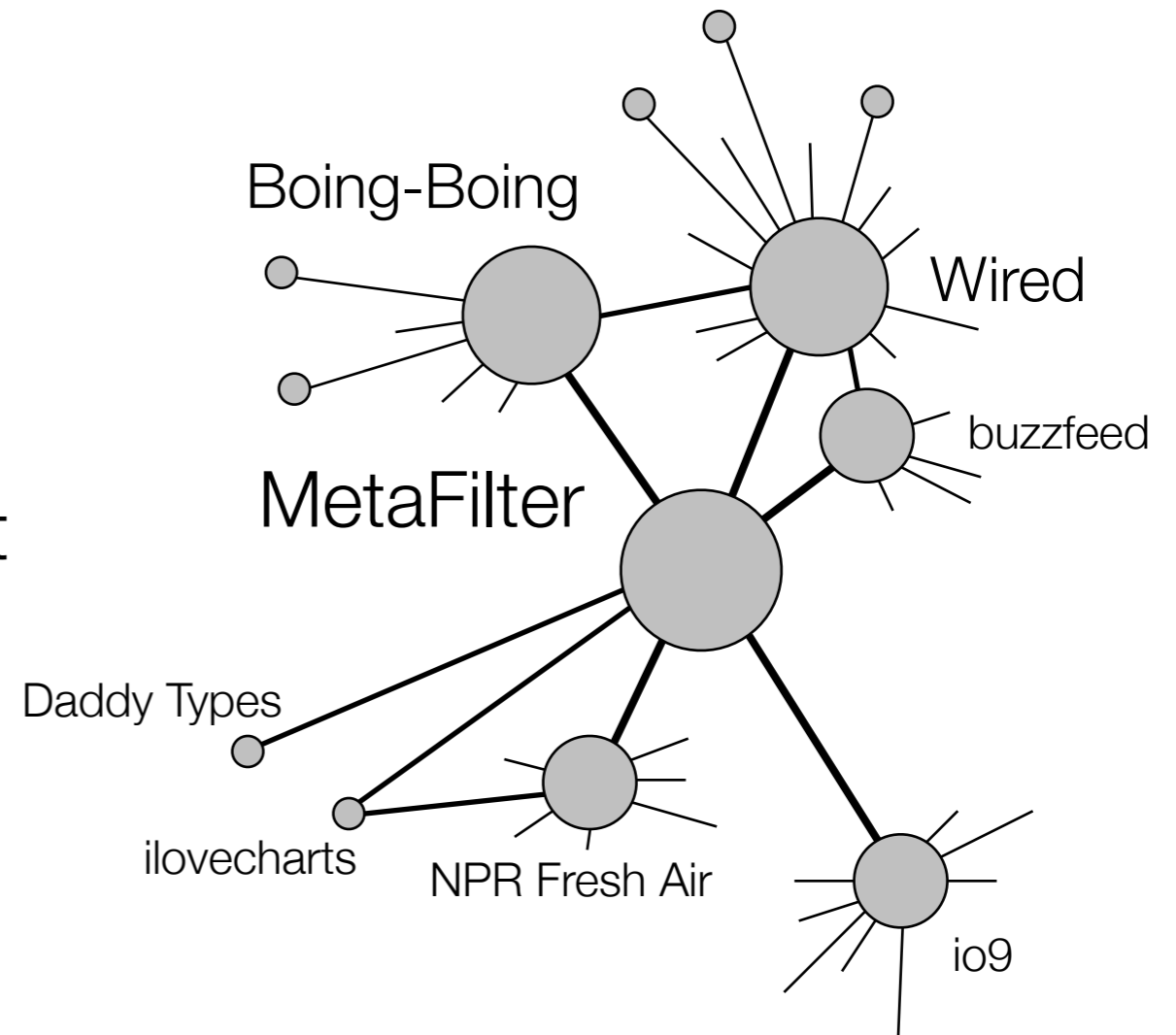
- March 15th, 2011: uploaded--1,500 downloads
- March 28th, 2011: 2,500 downloads
- March 29th, 2011: posted to metafilter
- March 30th, 2011: 30,000 downloads

To date, it has been downloaded over 60,000 times

A Network Perspective

Perfect mixing is not the right way of looking at the spread of the growth chart

- Some sources have a larger audience than others
- Not every person who posts the chart is equally important



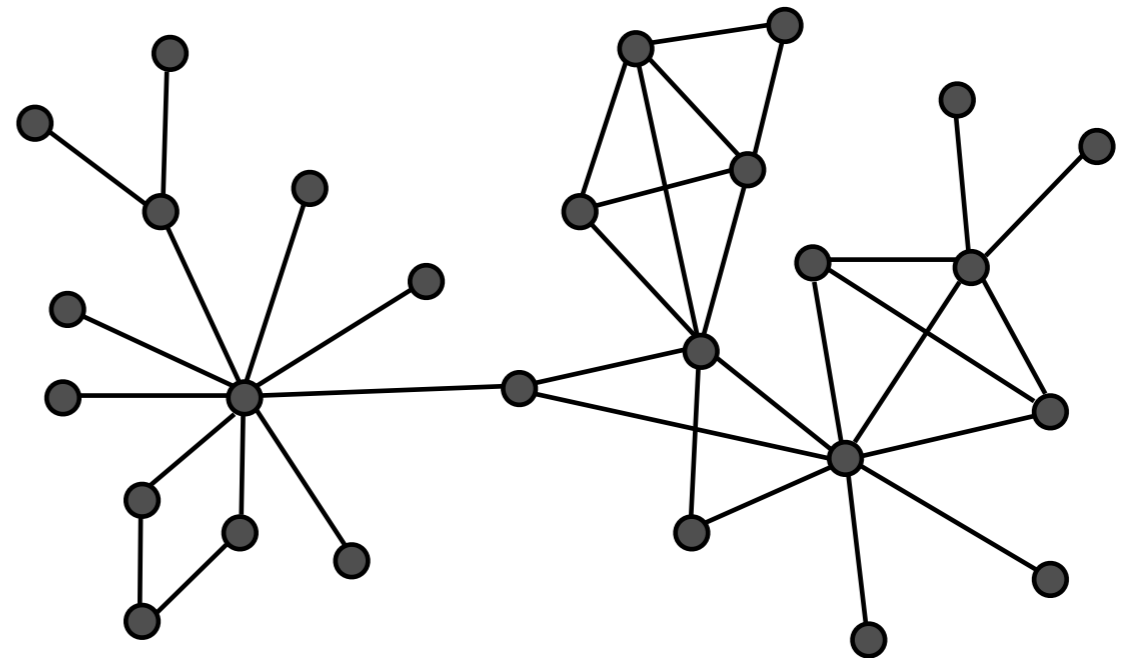
The problem: people are *heterogeneous*

Social Networks as a way of studying human interaction

Nodes: people, firms, organizations

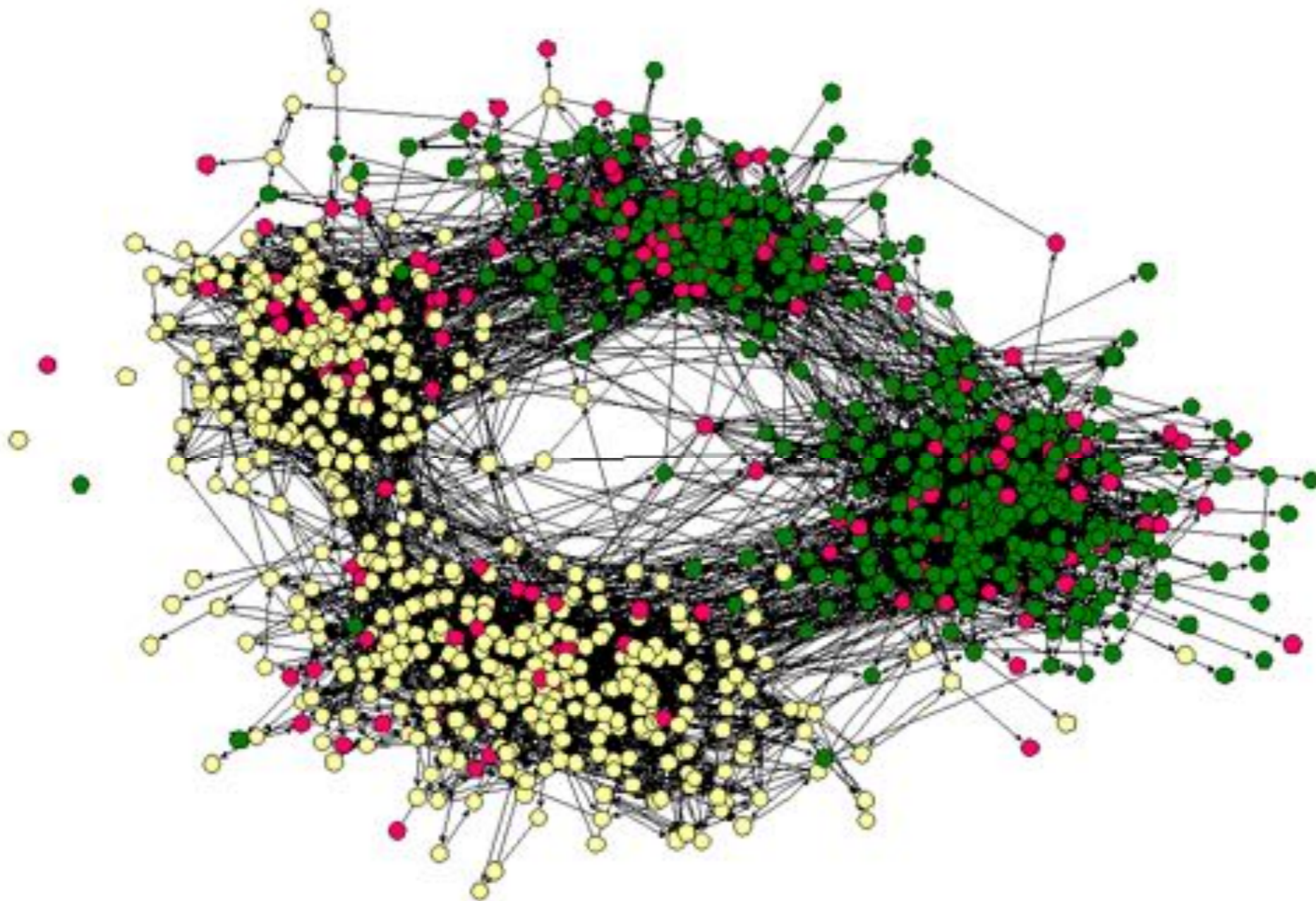
Edges: interactions

- Friendships
- Acquaintances
- Professional contacts
- Dating
- Co-location

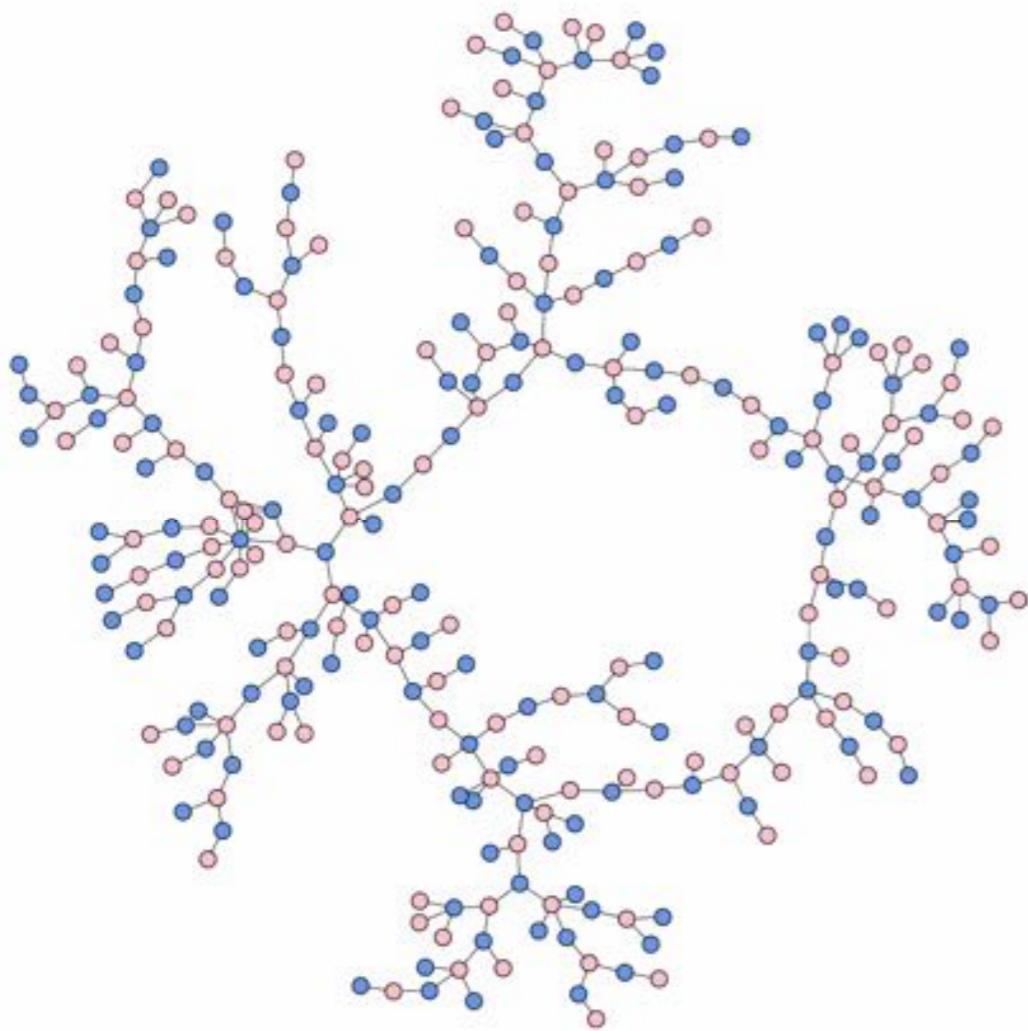


How you define a node and an edge depends on what you want to understand...

High School Friendships

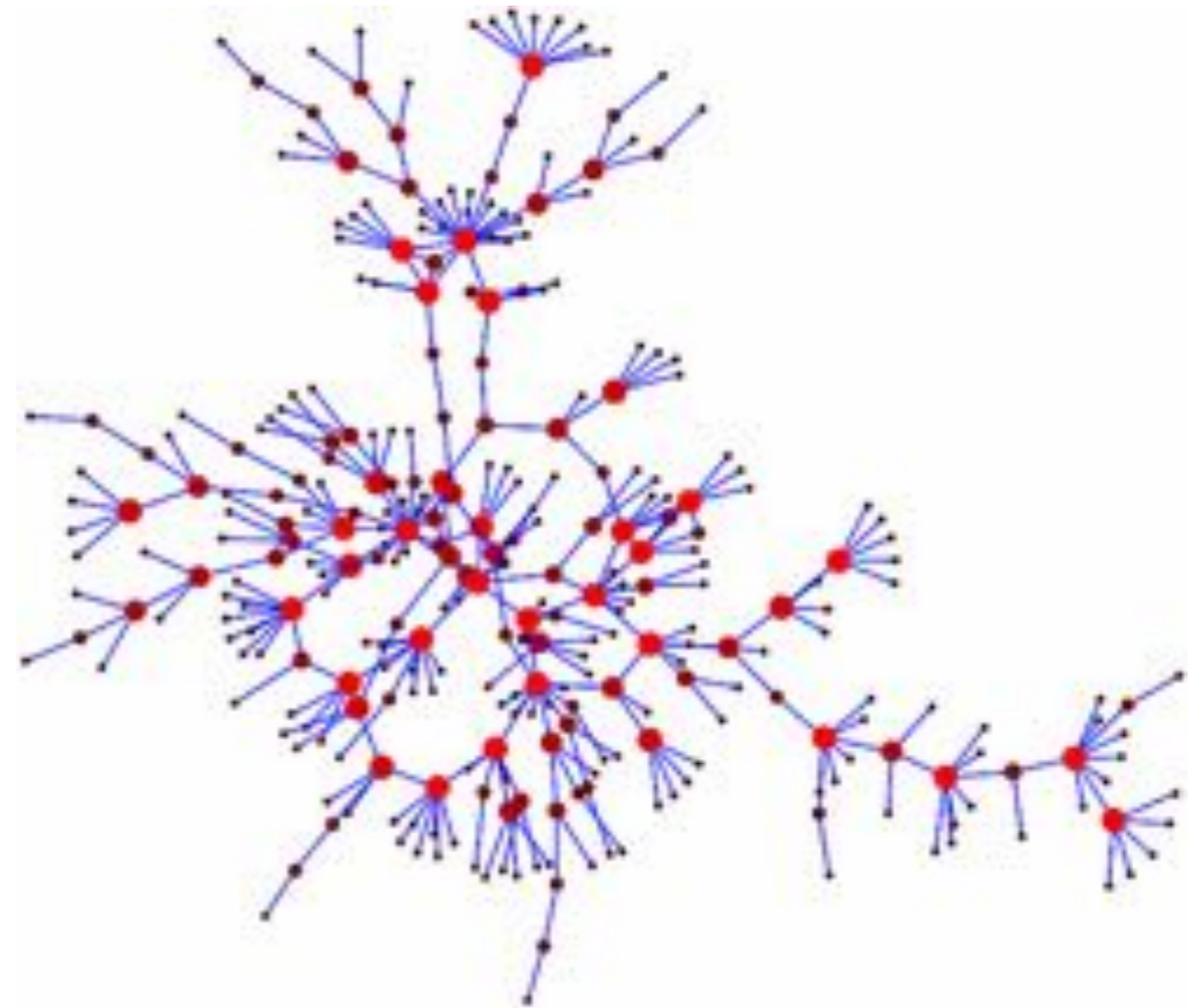


ref: James Moody (2001)



High School Dating

ref: Data by Bearman et al (2004)
Graphic by M.E.J. Newman



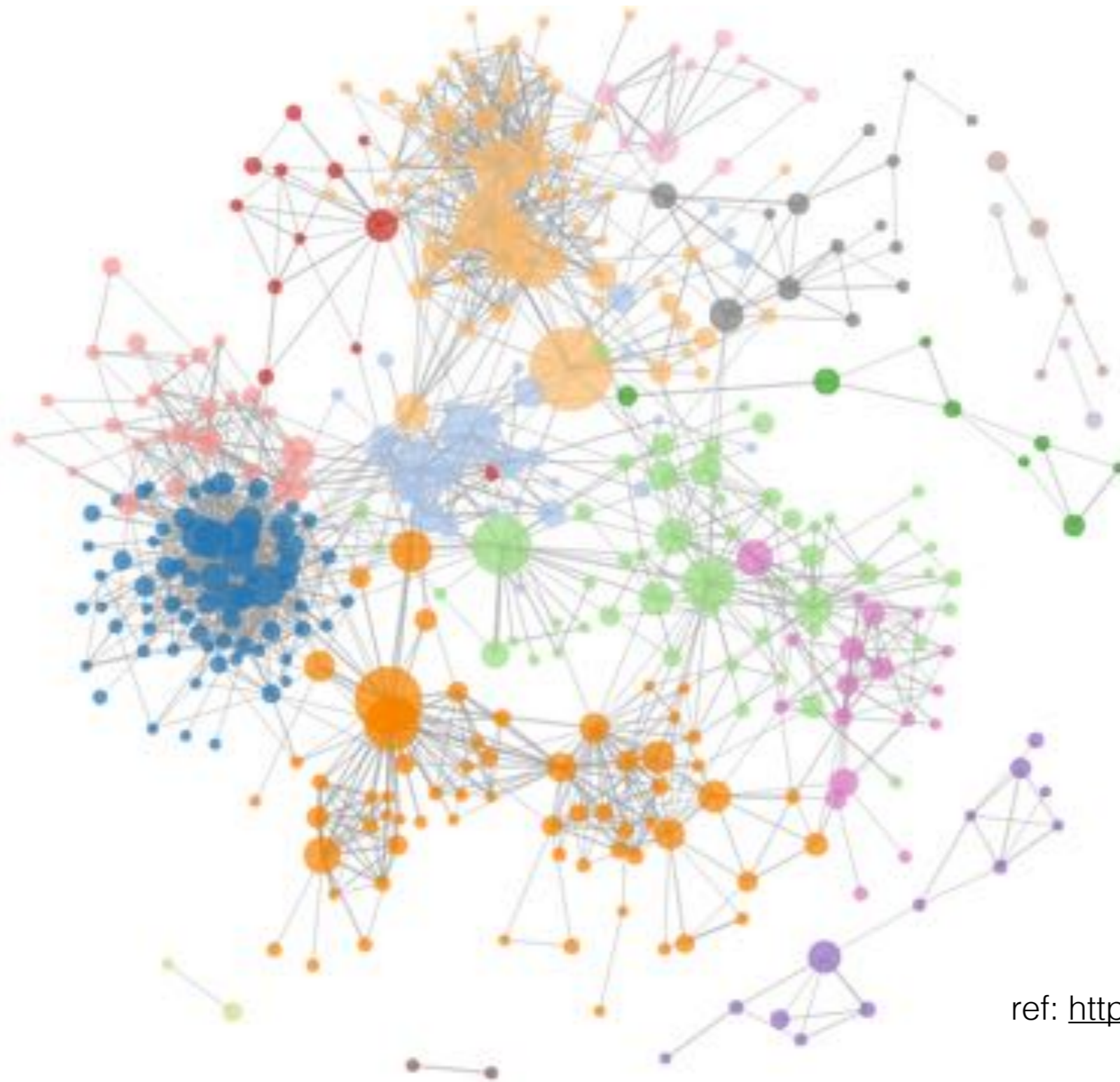
Sexual Contacts

ref: Potterat et al (2002)

All Personal Contacts

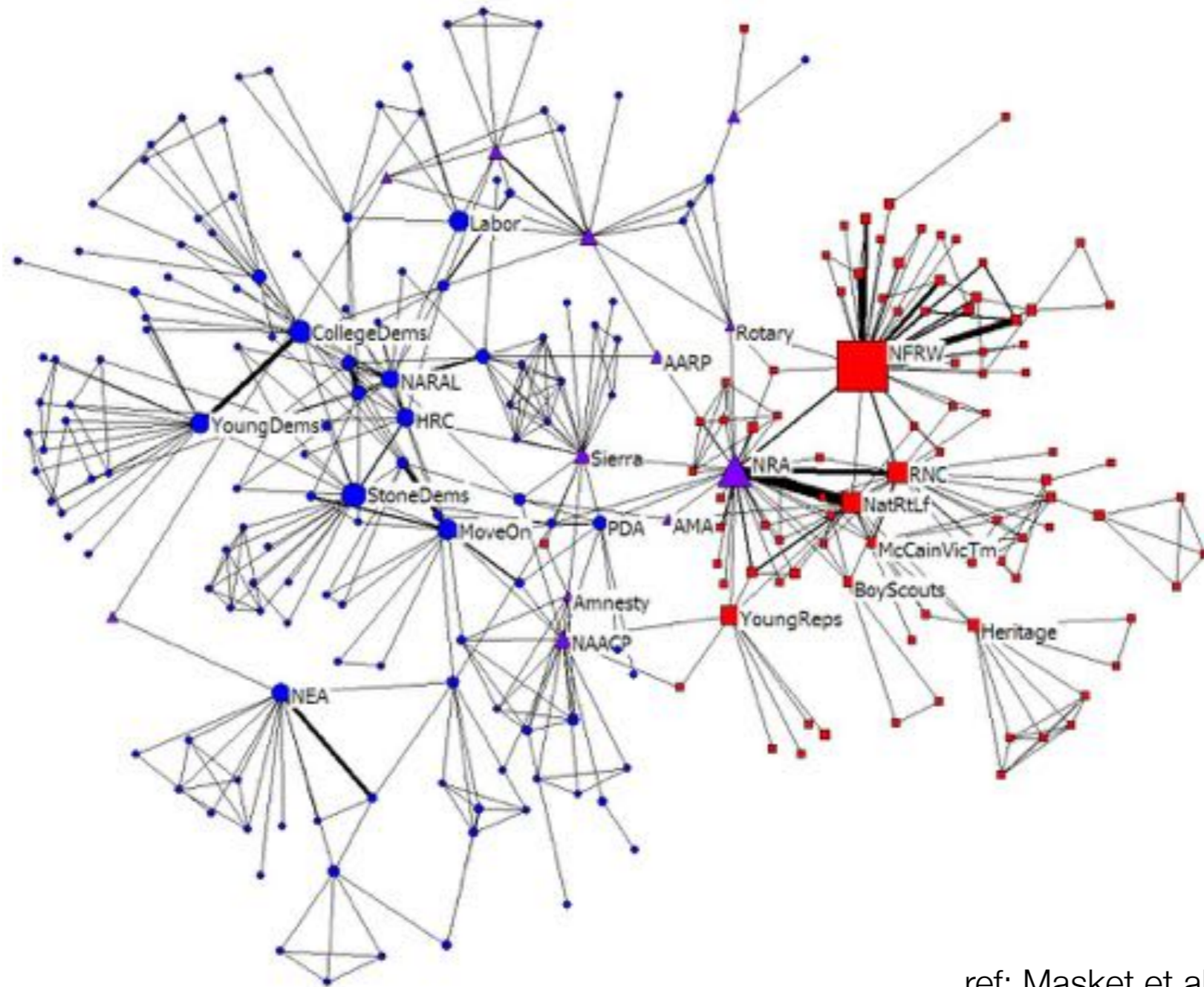


ref: Andre et al



ref: <http://goo.gl/L9ars>

Sociology Citation Network

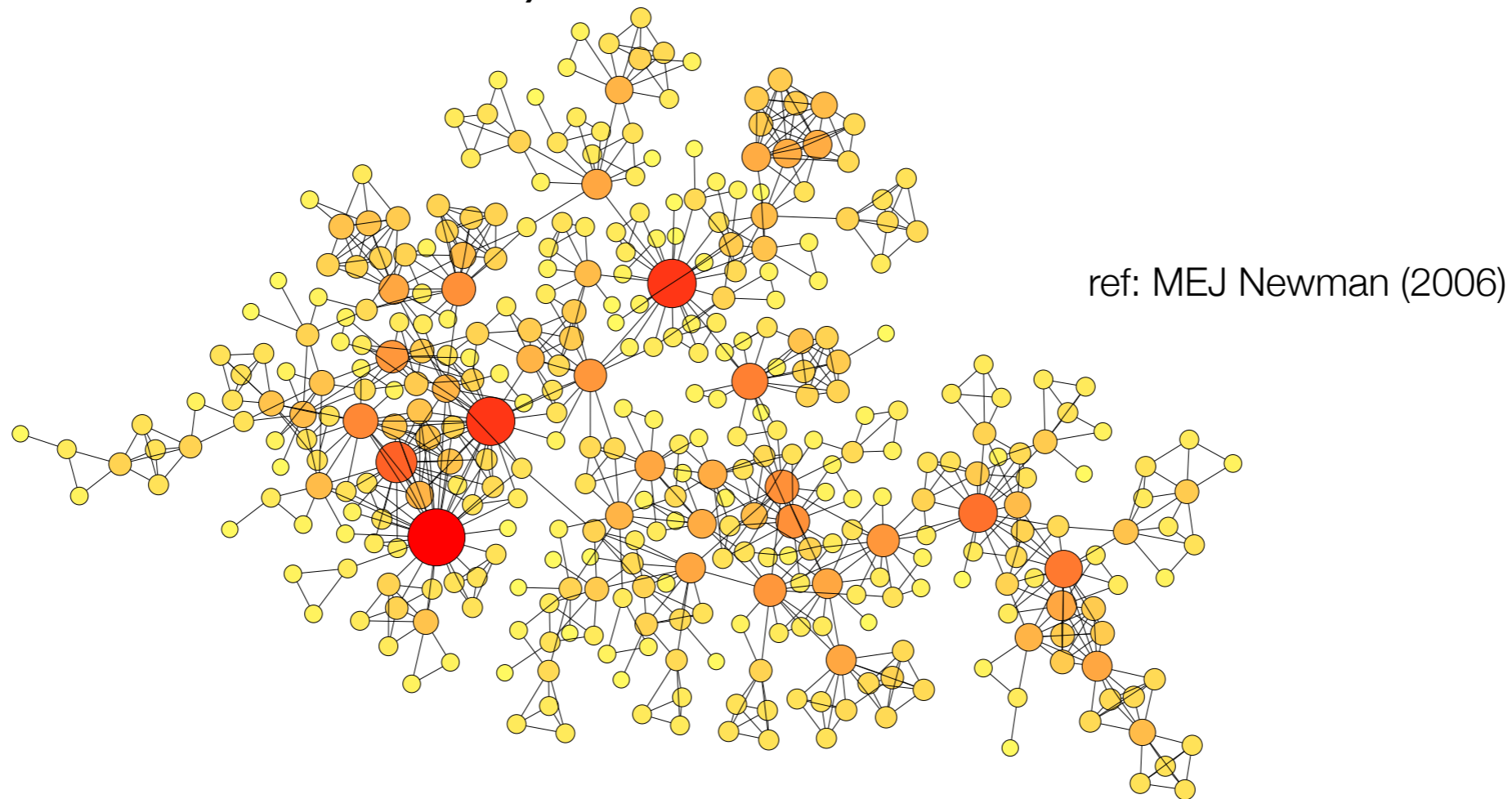


ref: Masket et al (2009)

Co-membership Networks: US delegate survey

What makes networks special?

Networks are heterogeneous (in a way that we can understand)



The reality of social and economic interaction is messy, and social networks give us methods to deal with that messiness

Case 1: Microfinance in Rural India

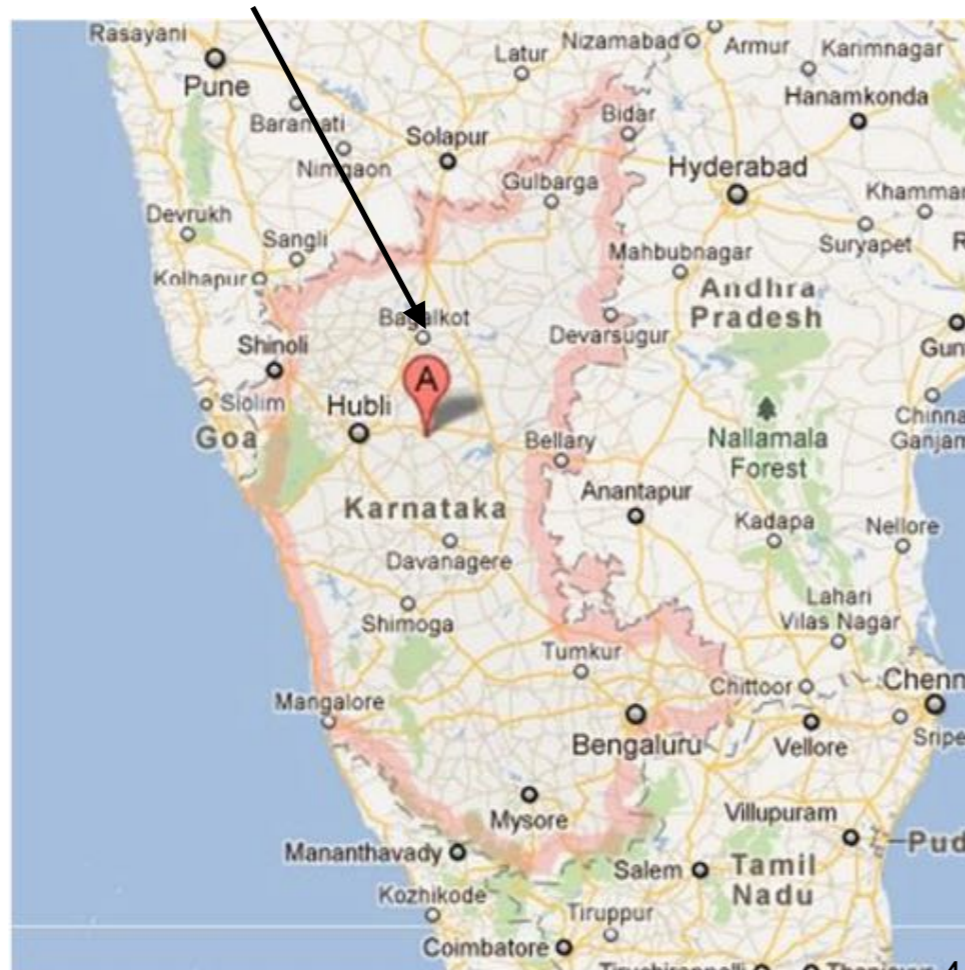
Note: The following is based on a presentation by the authors of the paper:

The Diffusion of Microfinance, by Abhijit Banerjee, Arun G. Chandrasekhar, Esther Duflo, Matthew O. Jackson

(It is a great paper: one of my favorites)

Microfinance in Rural India

The context: An organization called Bharatha Swamukti Samsthe (BSS) provides access to a group-based microcredit program in rural southern Karnataka



Borrowers form groups of five women, who are jointly responsible for the loan repayment of their group

Microfinance in Rural India

It's infeasible for BSS to talk to everyone, so they talk to people they think are important in each village, and ask them to spread the word.

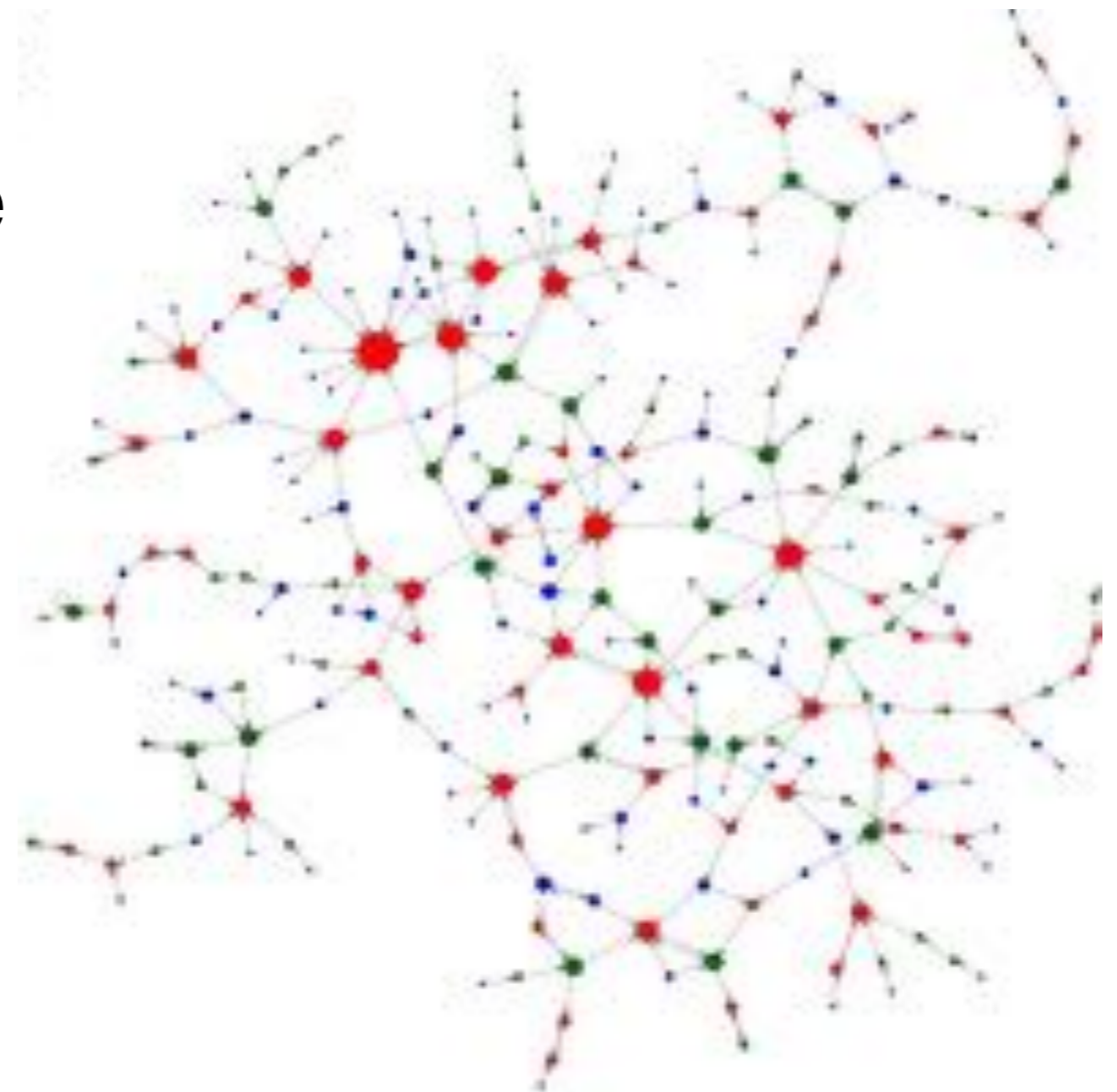
- Local Leaders
- Teachers

But this is much more successful in some villages than in others! They do the same thing, but adoption rates are very different.

Microfinance in Rural India

Hypothesis:

Maybe the differences are related to the social structure of the different villages?



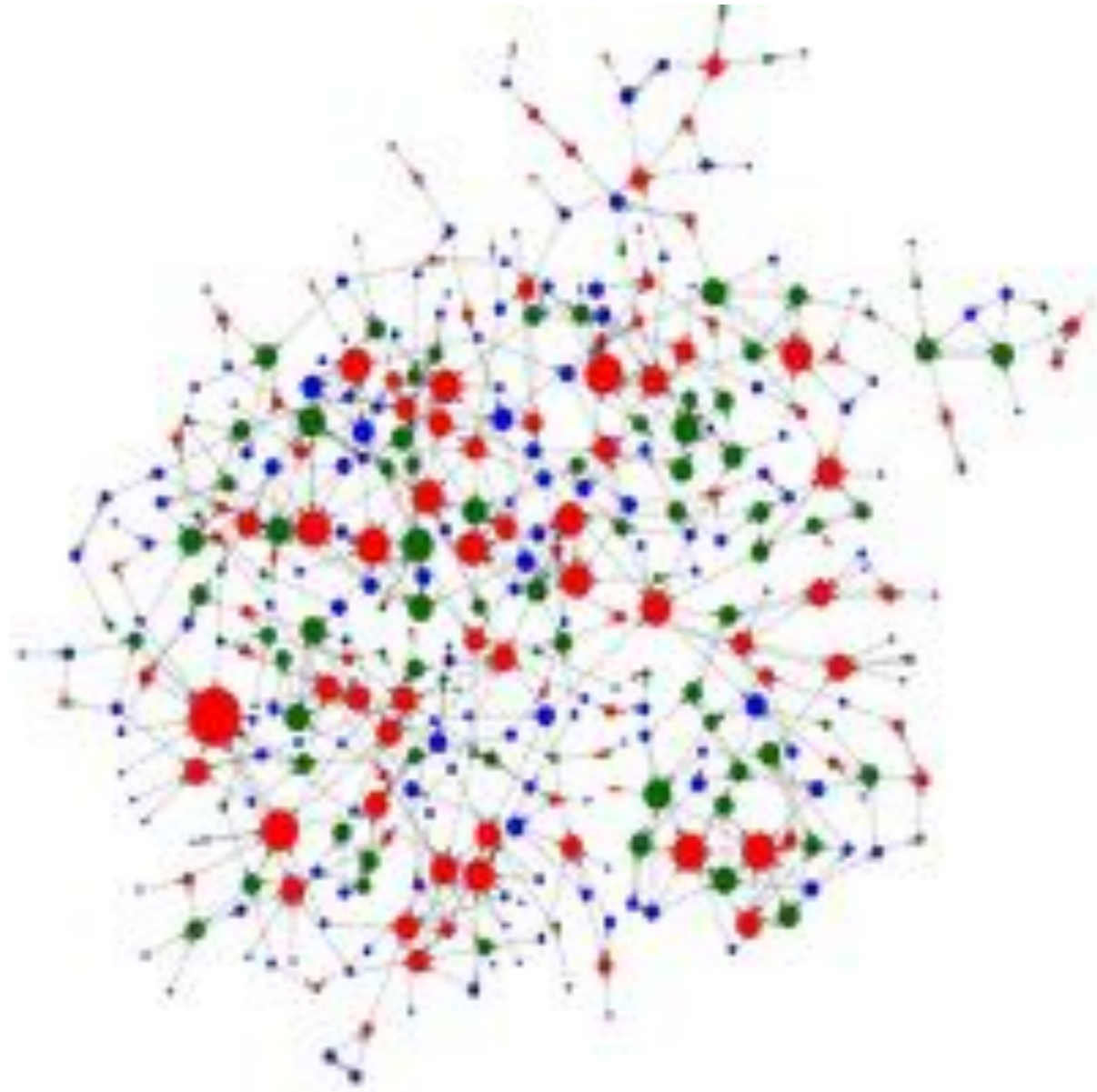
advice network

Microfinance in Rural India

Researchers travel to the region and survey households about their relationship to other households in the village:

- Who has asked you for advice?
- Who has borrowed money from you?
- Who has borrowed kerosene from you?
- Who has visited you lately?

Microfinance in Rural India: Some Results



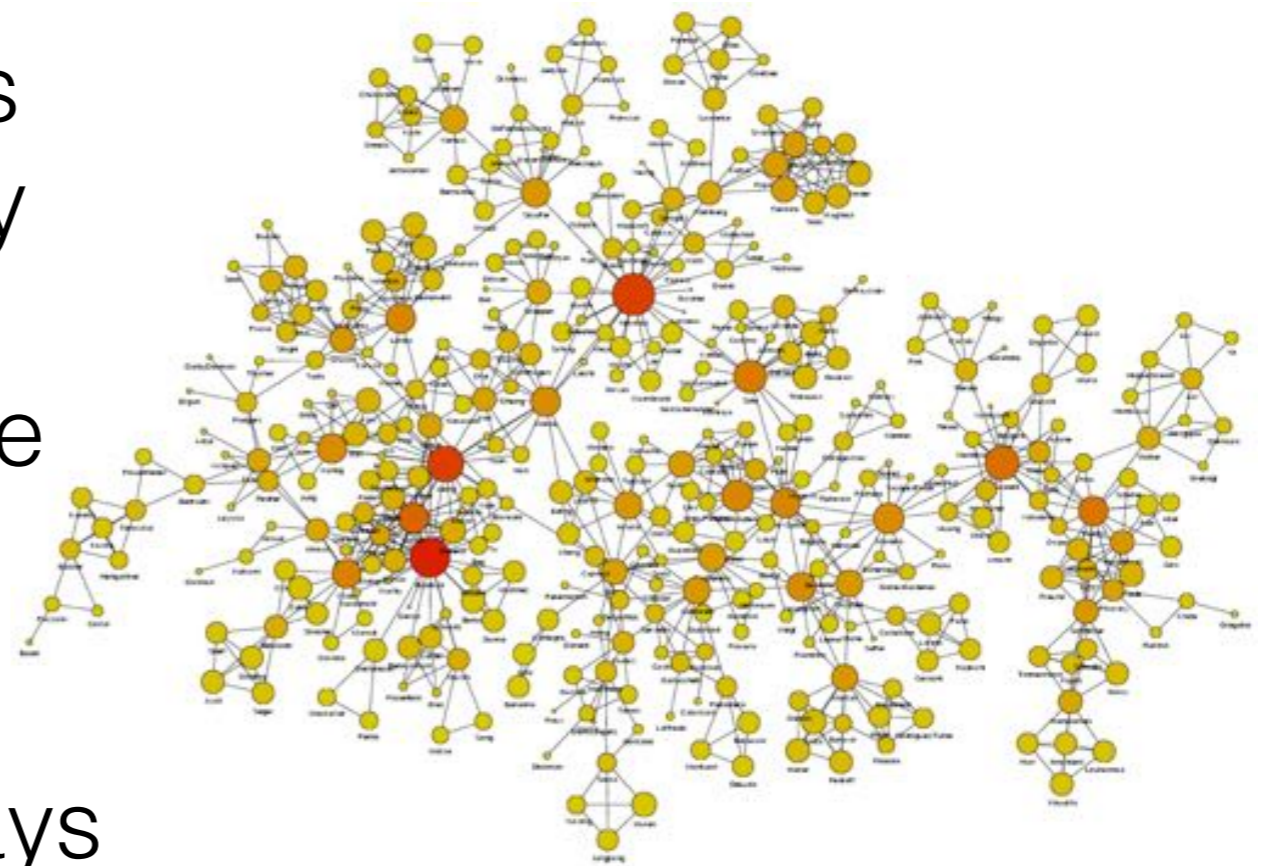
rice/kerosene network

Result: The best people to spread information are those with high eigenvector centrality on the social network

That is: those people who know other well-connected people

Microfinance in Rural India: Some Results

Important: that measure is determined endogenously from the network, rather than imposed from outside



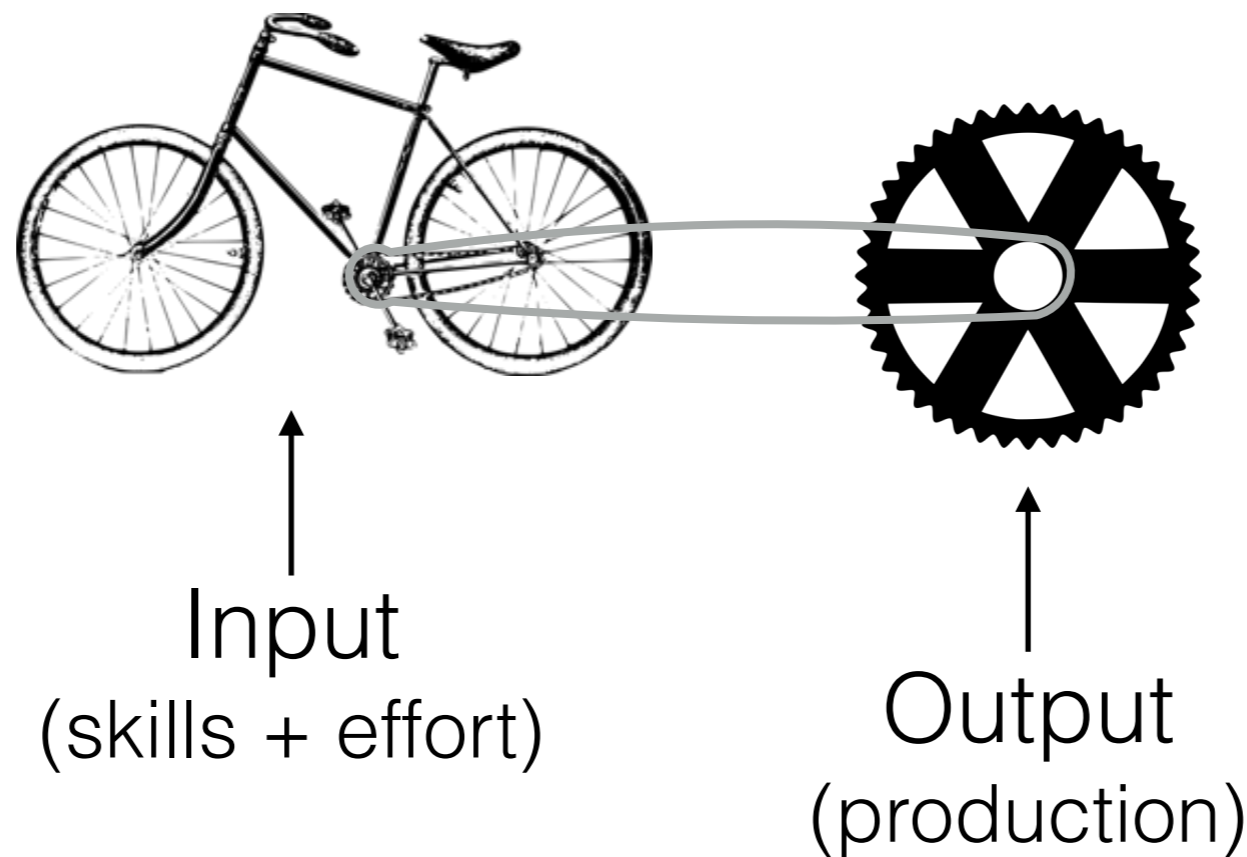
The teacher doesn't always occupy the same social role

Case 2: Skill Heterogeneity and Wages

Big Economic Question: what is the relationship between a person's skill set and their wages?

Economic Models of Skills and Production

Economists usually think about skills in terms of production:

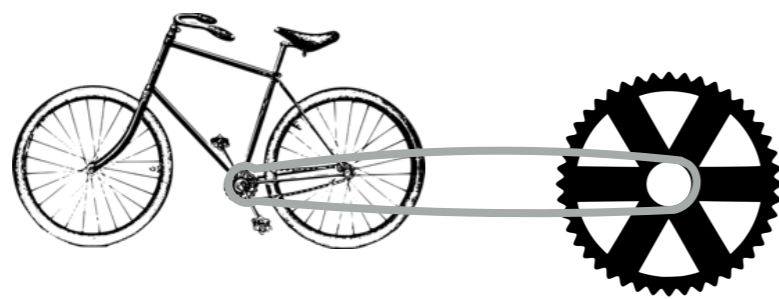


The value that people bring to production is called *human capital*

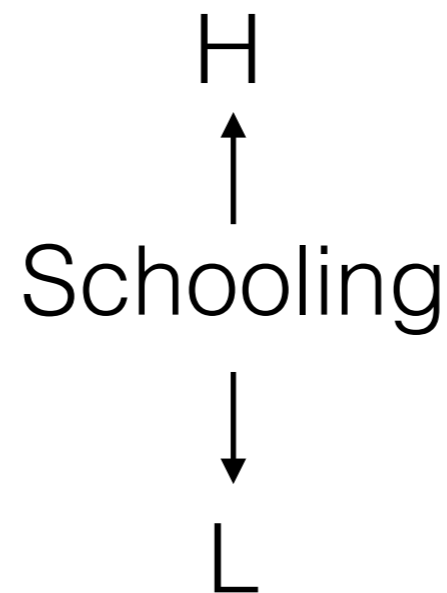
Measures of Human Capital

The way economists traditionally modeled skills is motivated by manufacturing:

One-dimensional skill level



S ← Speed → F



Two types/occupations:



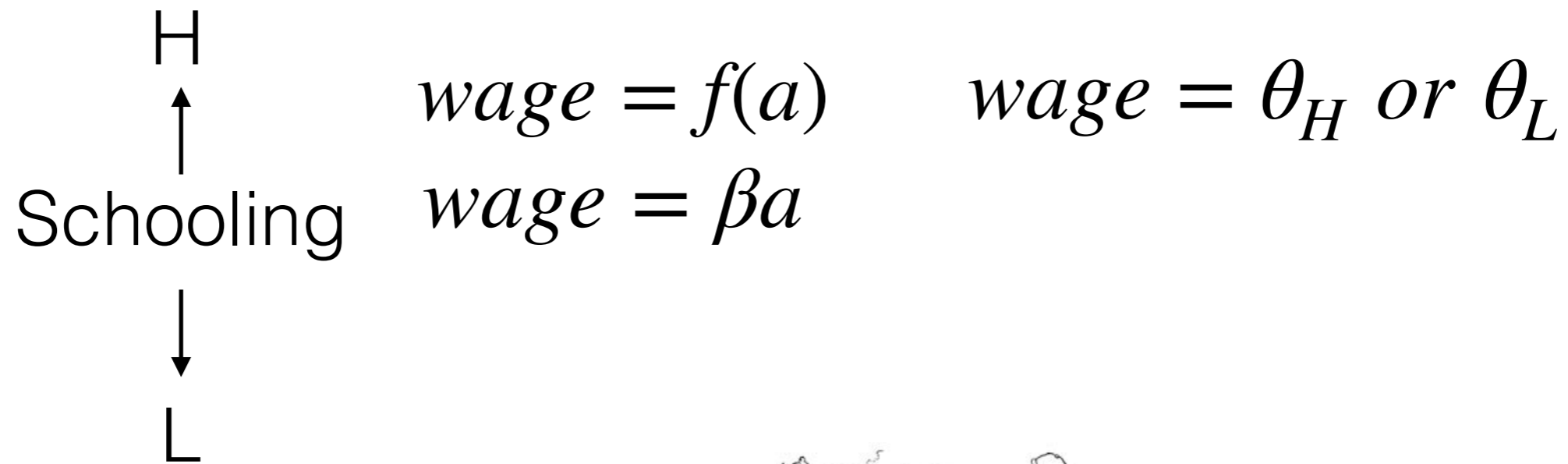
hunter



fisherman

Measures of Human Capital

- A person's wages increase with their education level



- Hunters earn hunter wages



$$= w_F$$

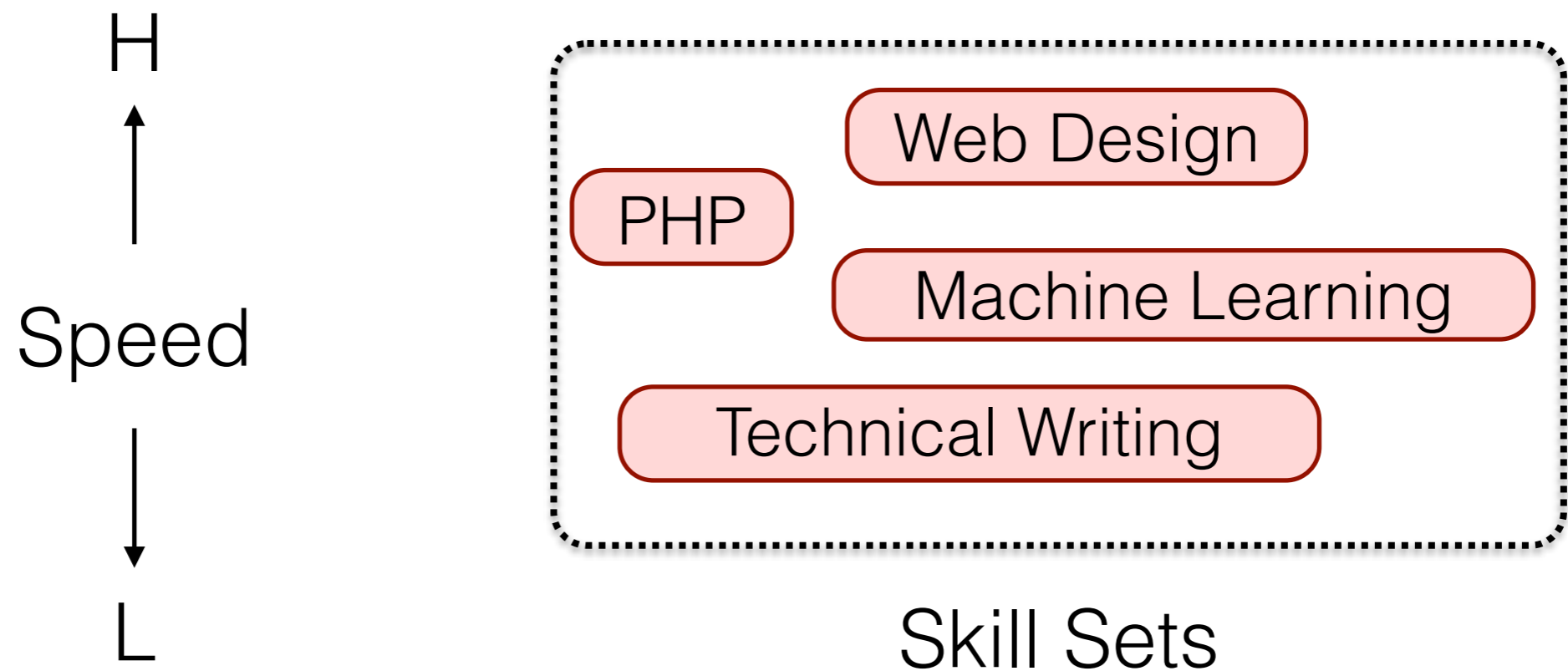
Fishermen earn fisherman wages



$$= w_H$$

Skills and Production

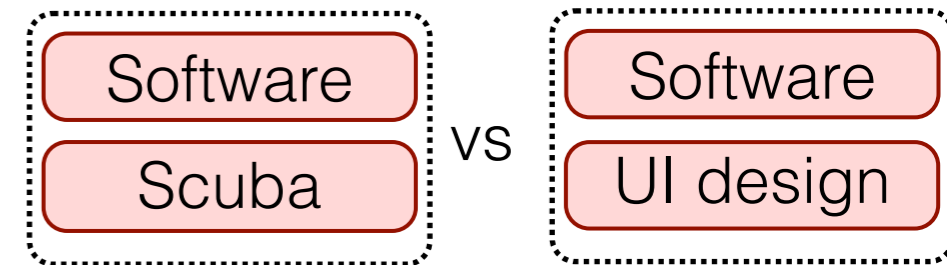
But that manufacturing model works less well with knowledge-based production:



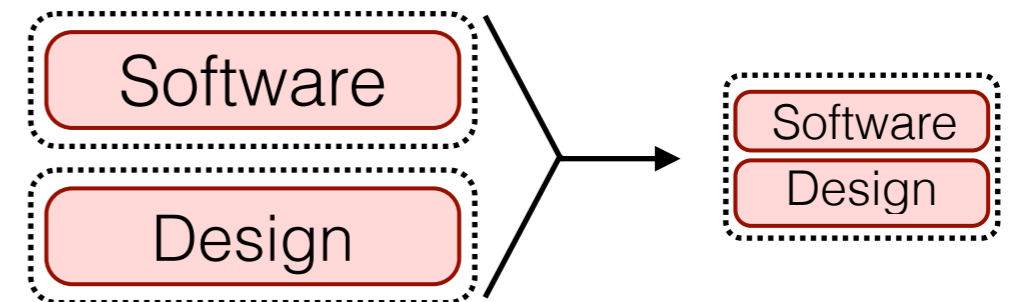
Complex Human Capital

But more is different!

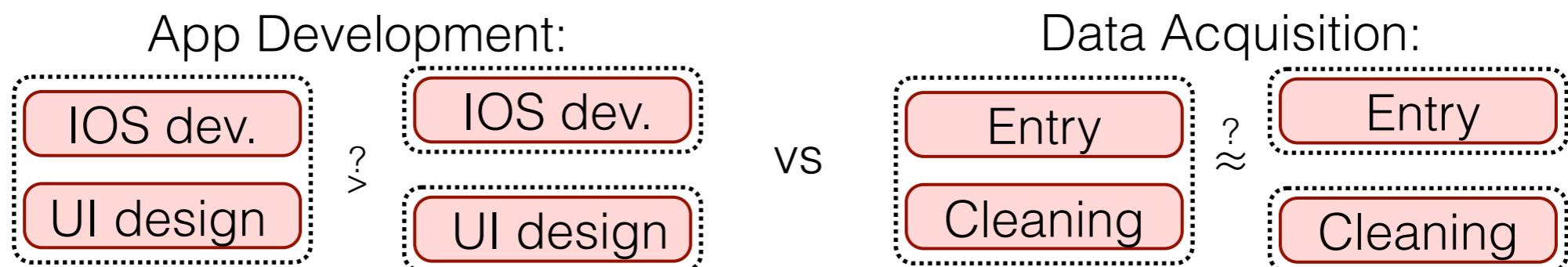
- Some skills are valuable in combination and others are not



- Skills that are common individually may be rare in combination

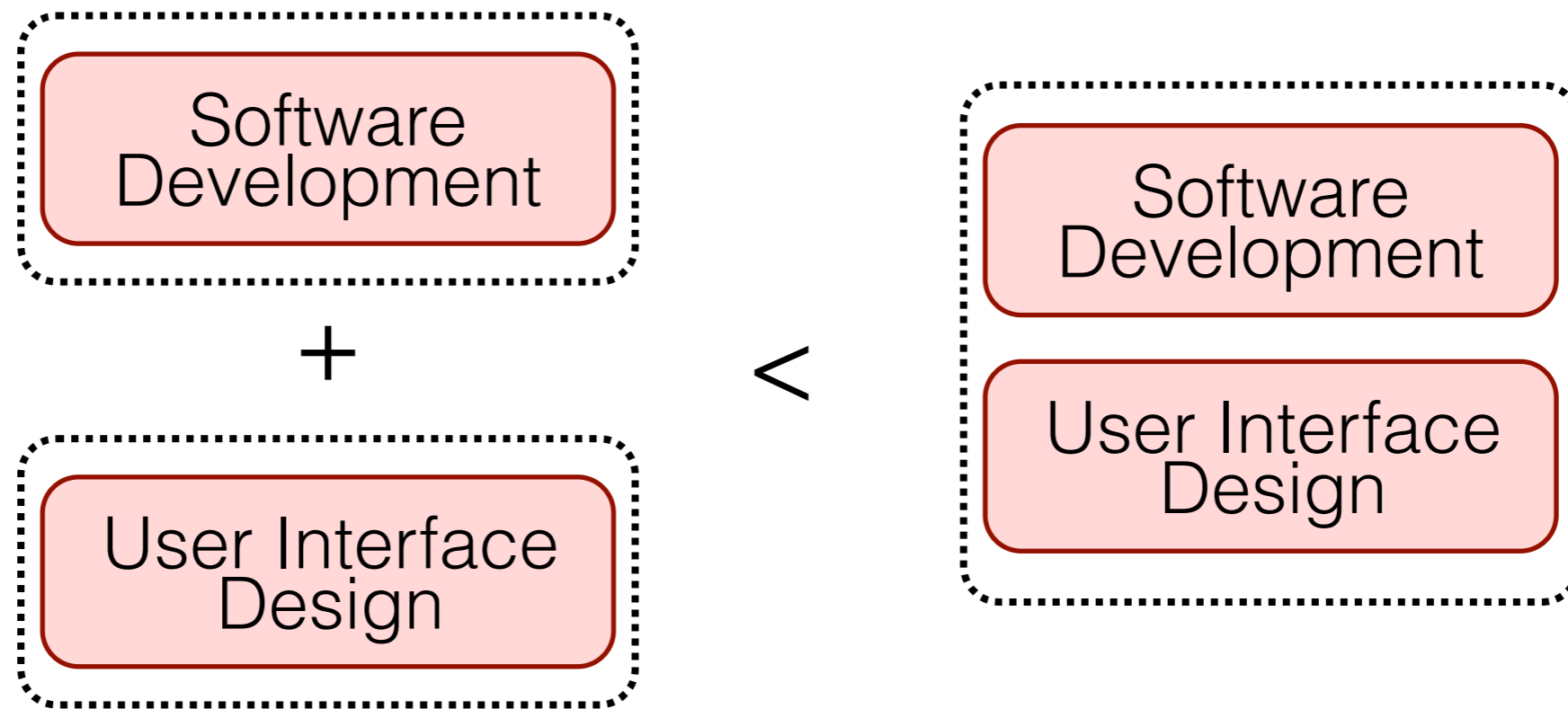


- Some tasks are more “separable” than others



Complex Human Capital

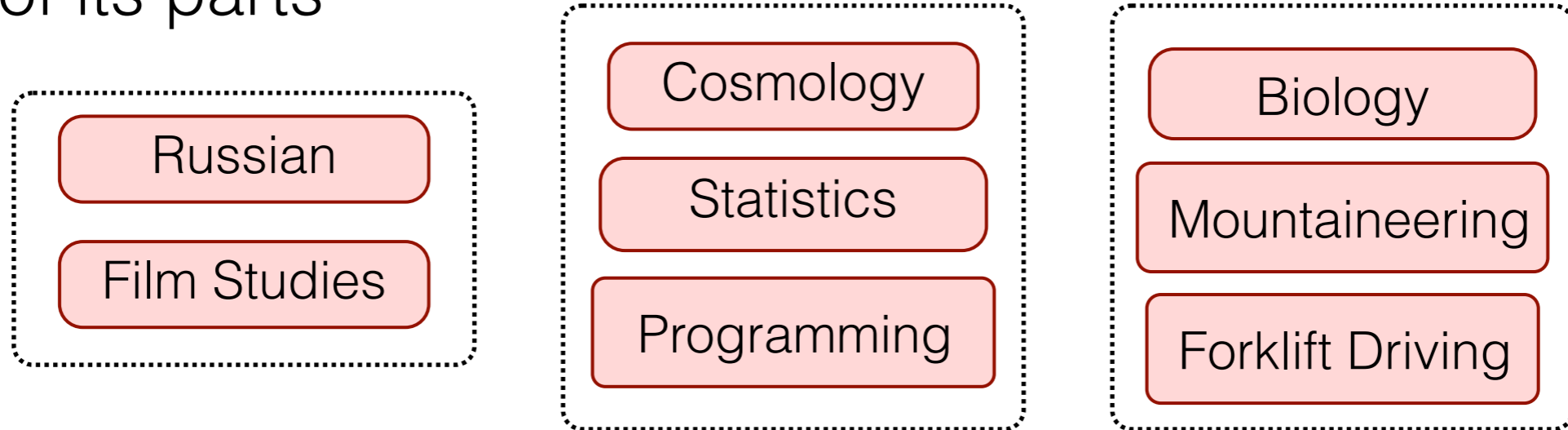
And these synergies between skills often distinguish workers in the labor market!



Skill Sets and Productivity

This creates a huge problem for economists!

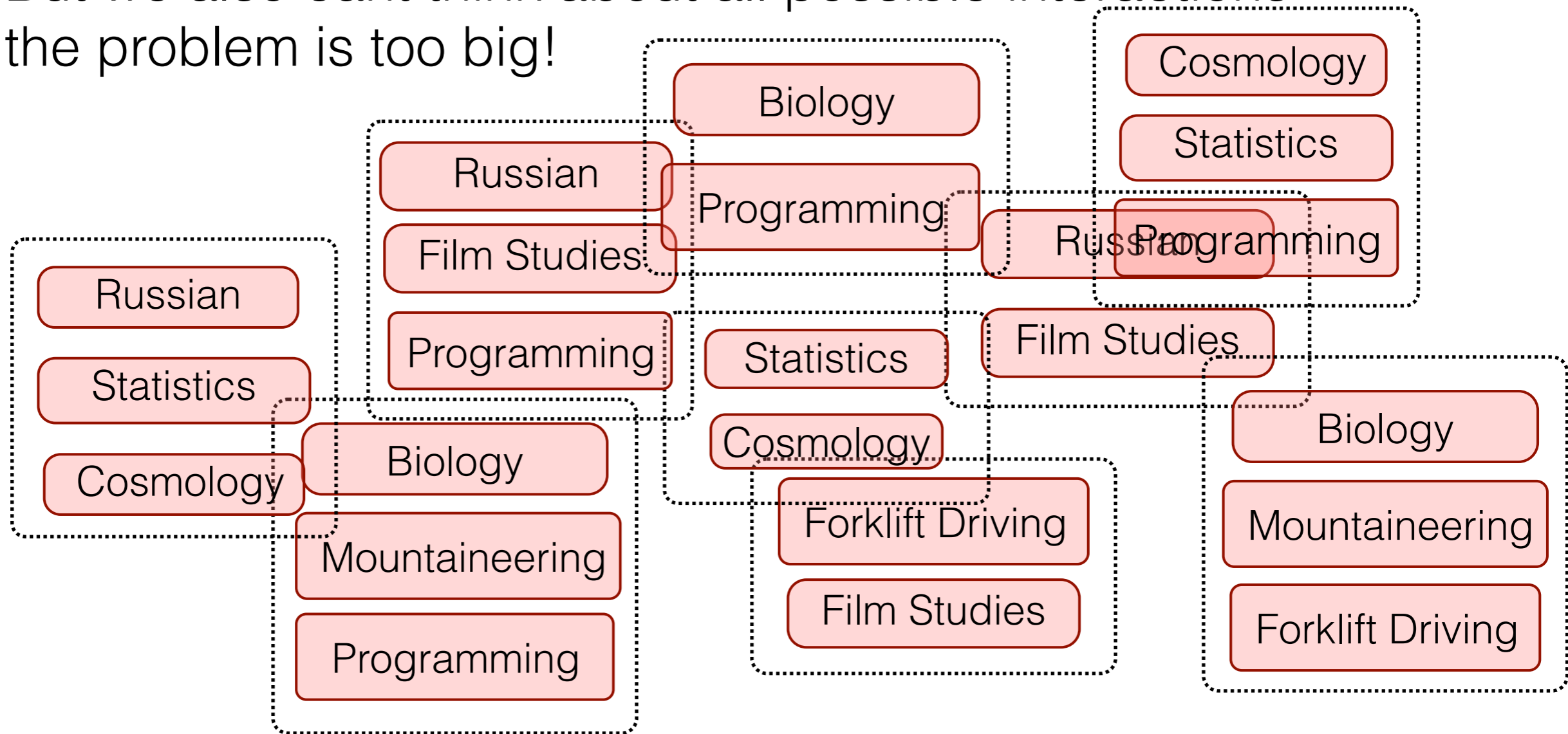
- The value of adding a skill to a workers skill set depends on the skills she already has
- The value of a combination may be more than the sum of its parts



That means we can't assign prices to individual skills: so we can't compare wages

Wages with Skill Combinations

But we also cant think about all possible interactions—the problem is too big!



So we need to find a different way to measure the heterogeneity of peoples' skill sets

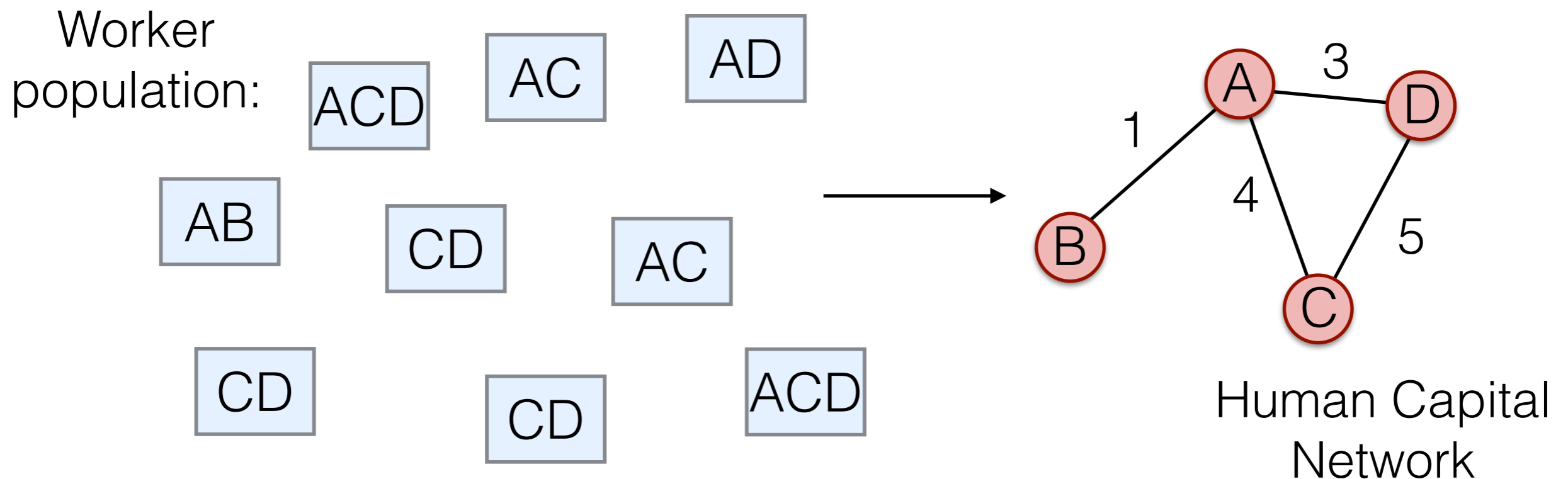
Human Capital Networks

Proposal: use a network to represent that heterogeneity

Nodes = skills

Two nodes are linked if at least one worker has both skills

Link are weighted according to how many workers have both





An illustration: a online freelance labor market

In 2014 there were 53 million contract workers, generating \$700 billion

Upwork is the largest online labor market

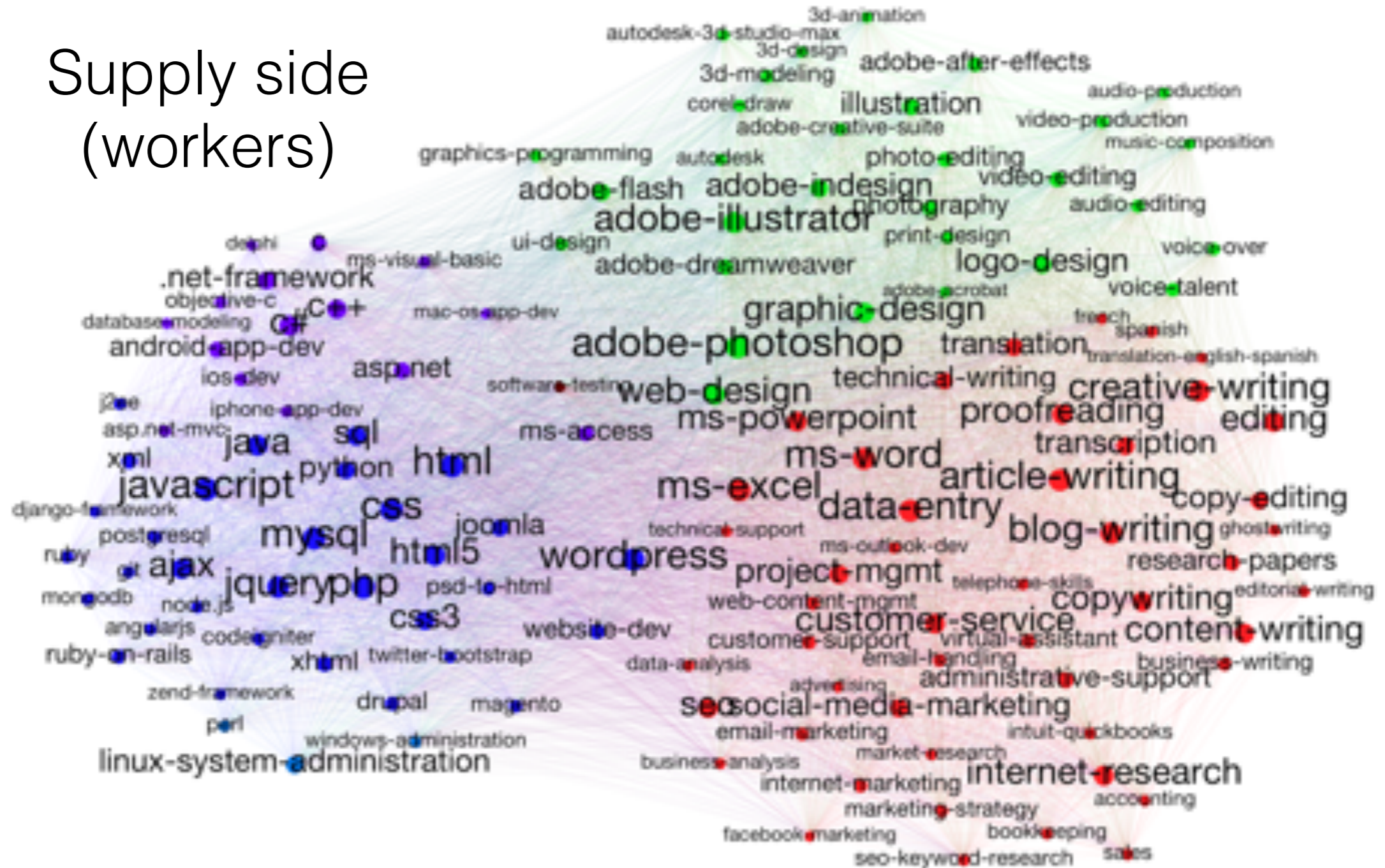
- 9 million workers
- 4 million clients
- \$1 billion/year

Worker Profiles (skills, biography, test scores, employment history, ratings...)

Job Listings: (skills required, description, wage rate...)

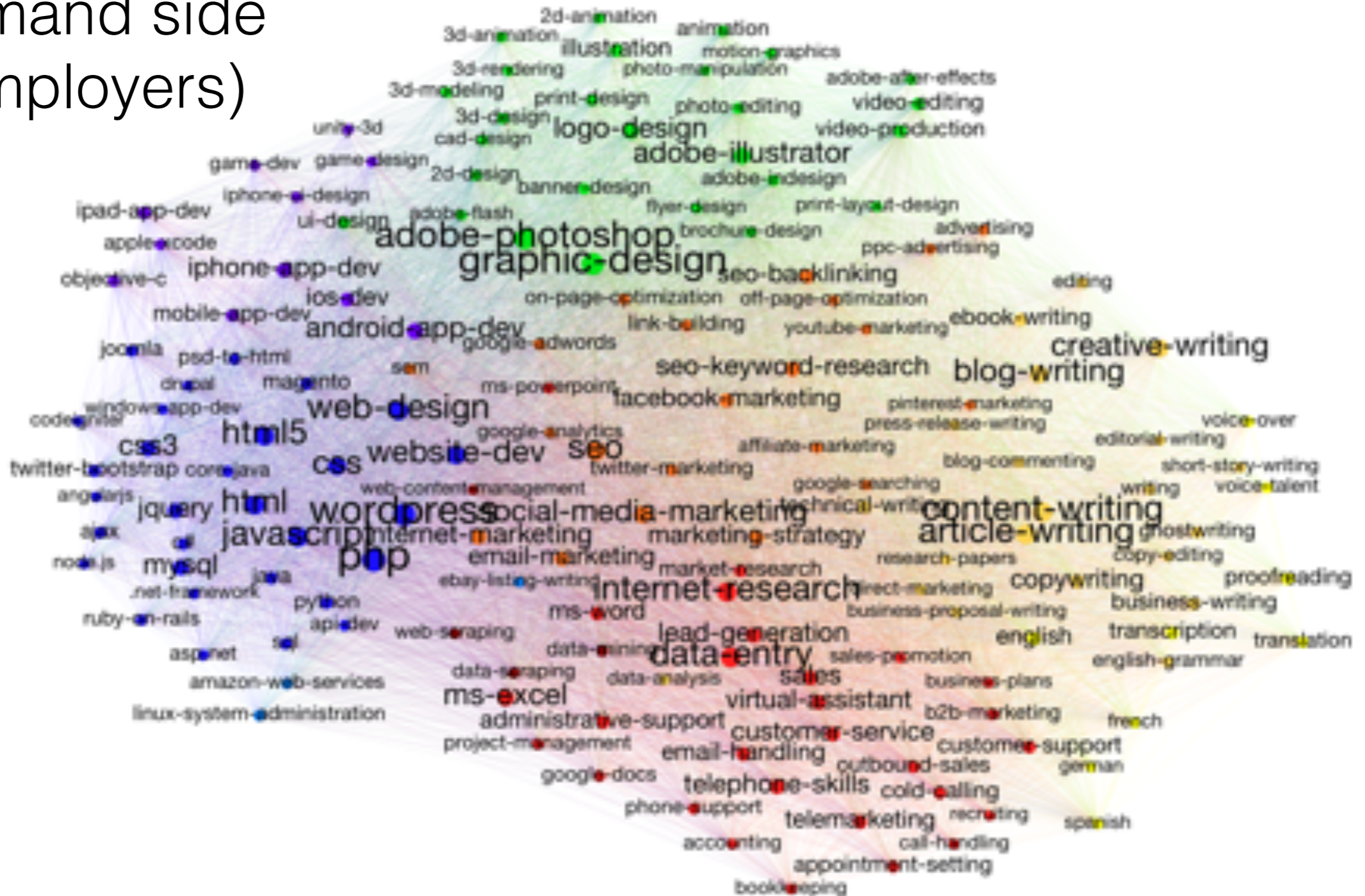
Human Capital Network

Supply side
(workers)



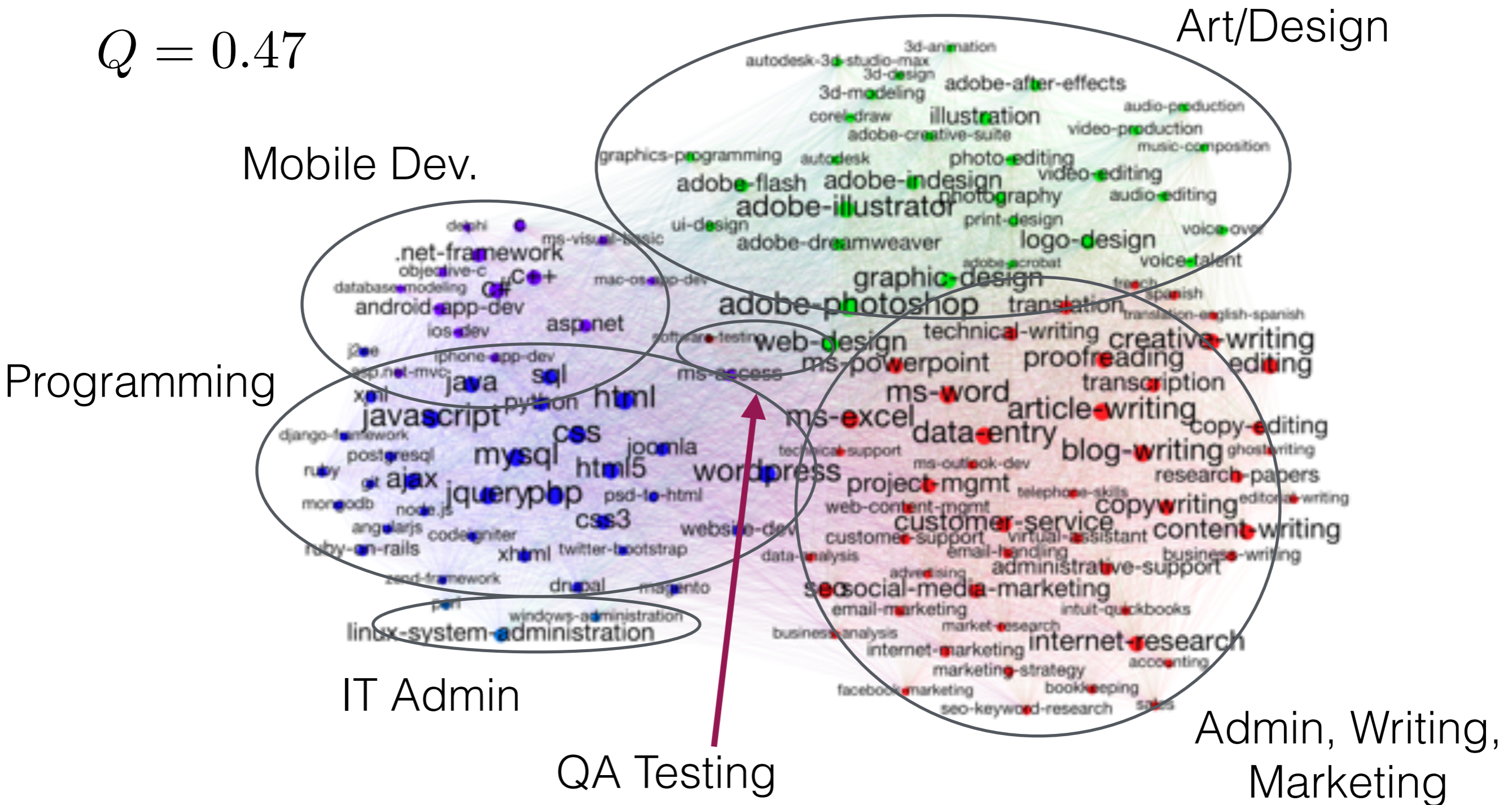
Human Capital Network

Demand side
(employers)



Supply side (workers)

$Q = 0.47$



Demand side (employers)

$Q = 0.5$

Mobile Dev

Art/Design

Music*

Writing

Programming

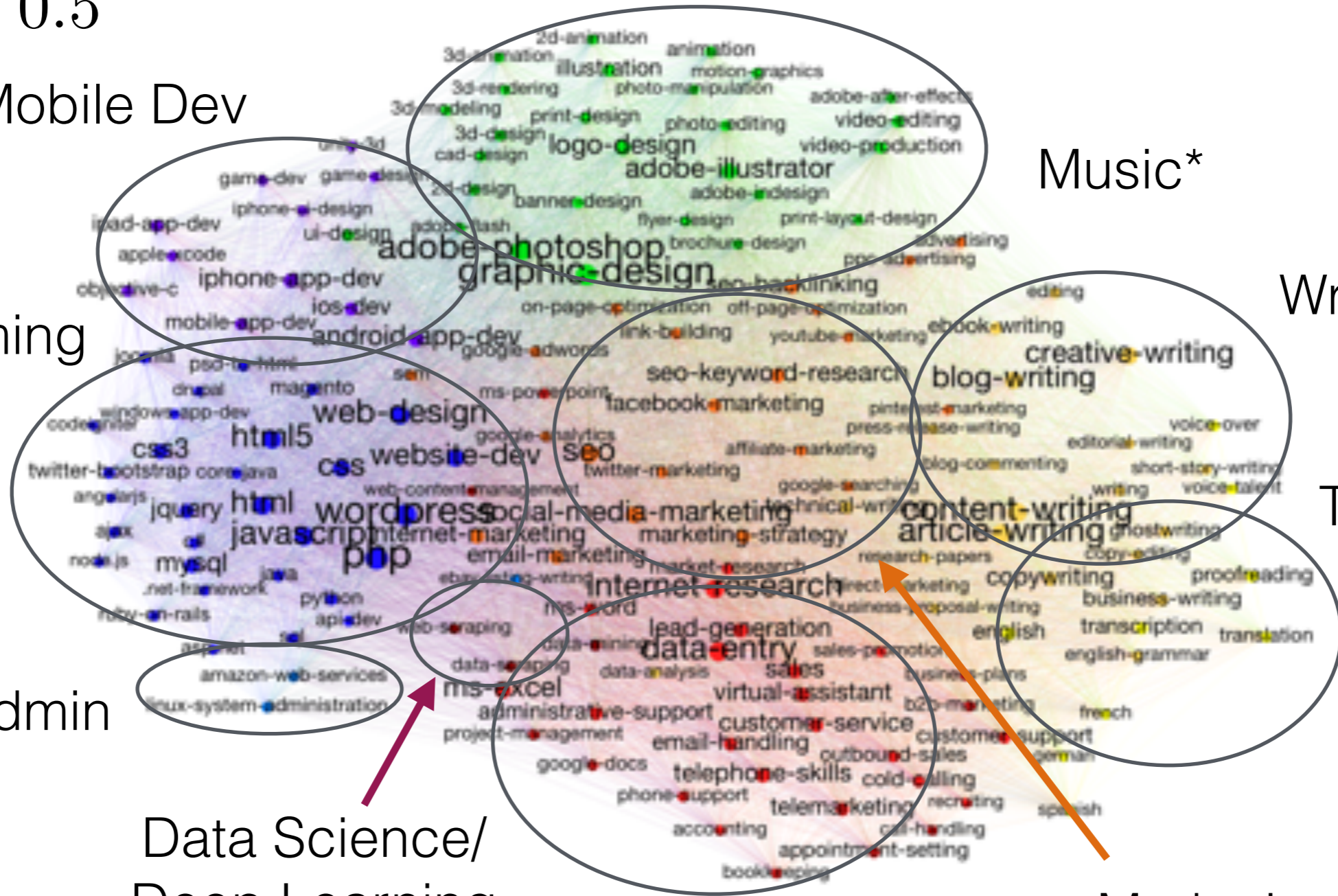
Translation

IT admin

Data Science/
Deep Learning

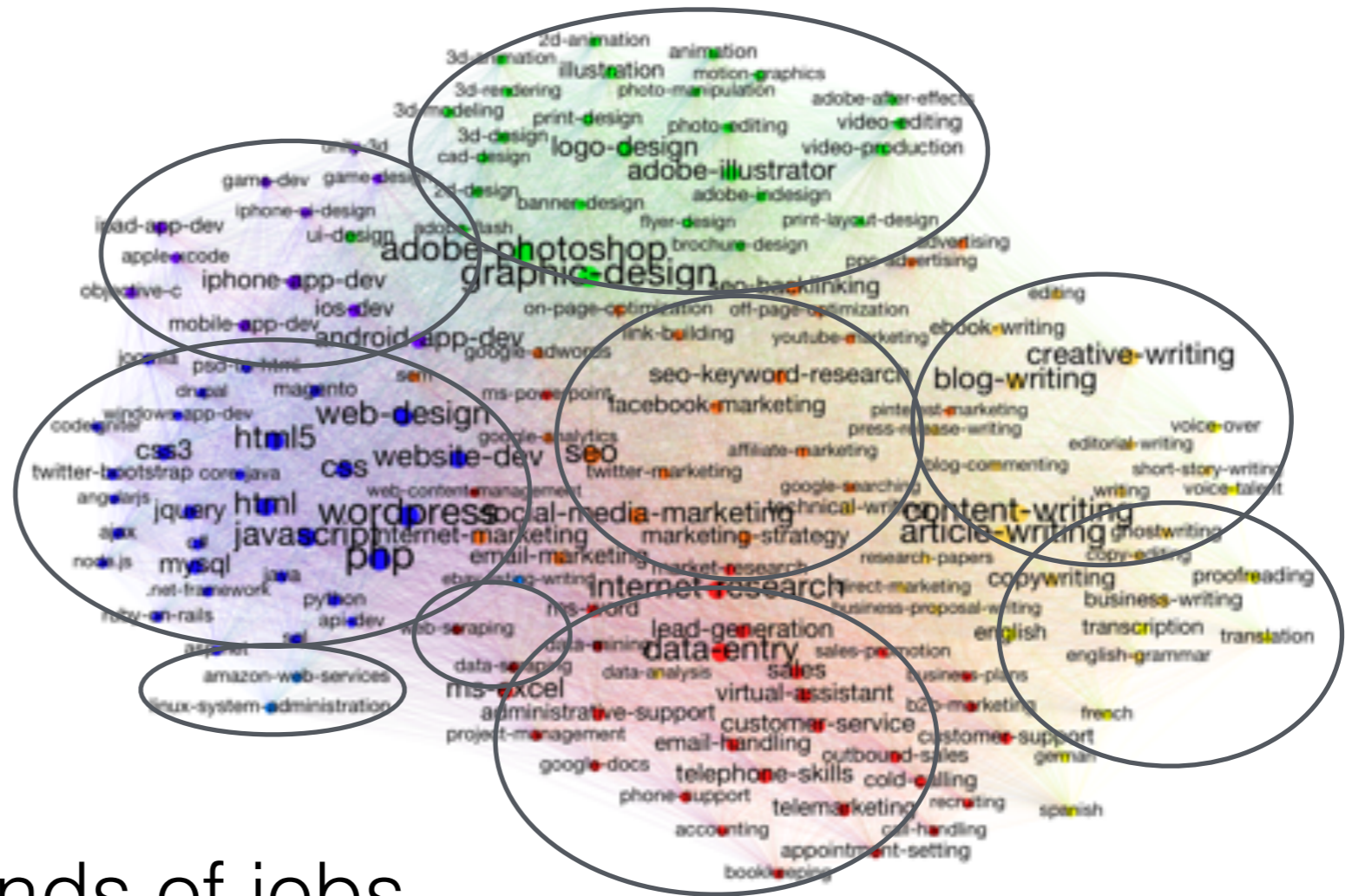
Admin

Marketing



A Taxonomy of Skills

These categories are endogenous: they reflect the way that skills are used in this particular labor market



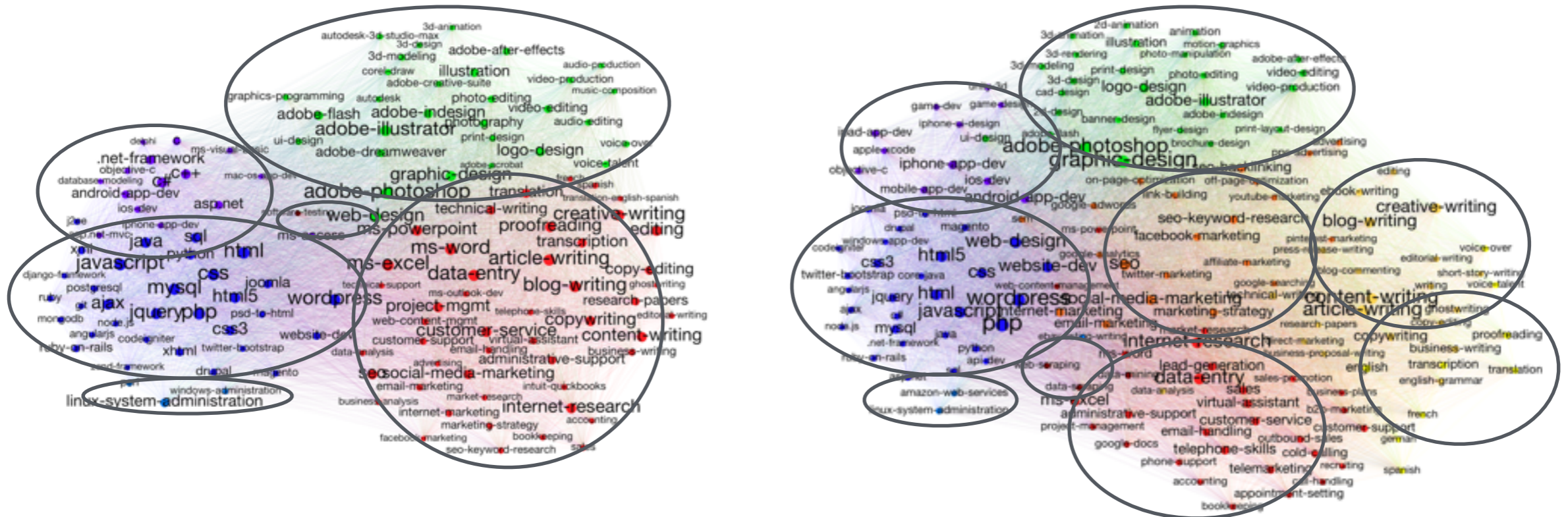
Demand side: kinds of jobs

Supply side: sub-pools of labor

A Taxonomy of Skills

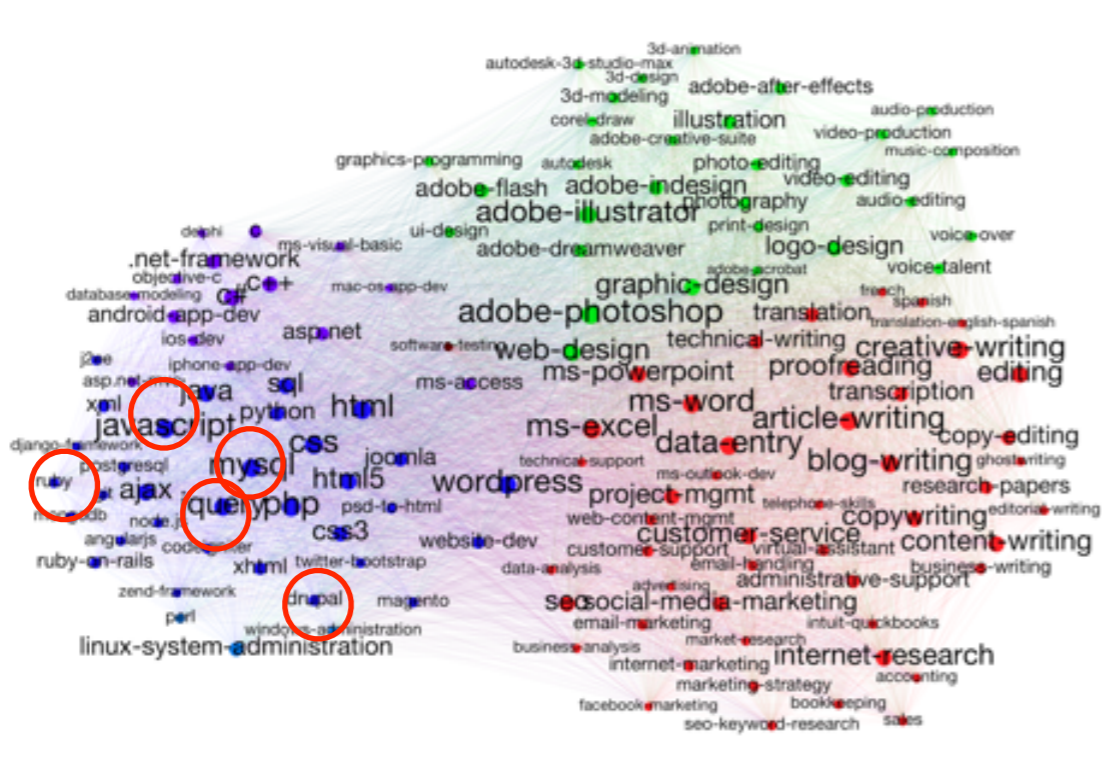
Some interesting notes:

- Jobs are more narrowly-defined than workers
- There are categories of job for which there is no dedicated labor pool



Complex Measures of Human Capital

The position of a workers skills on the two networks characterizes their skill set



Specialist

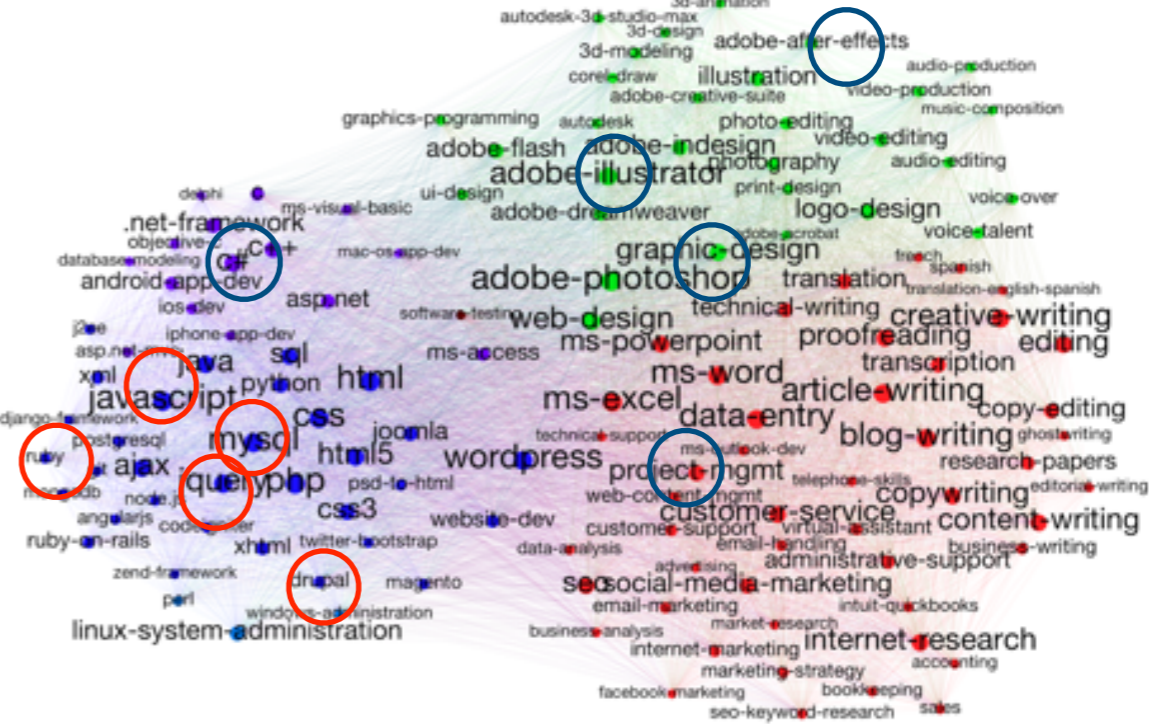
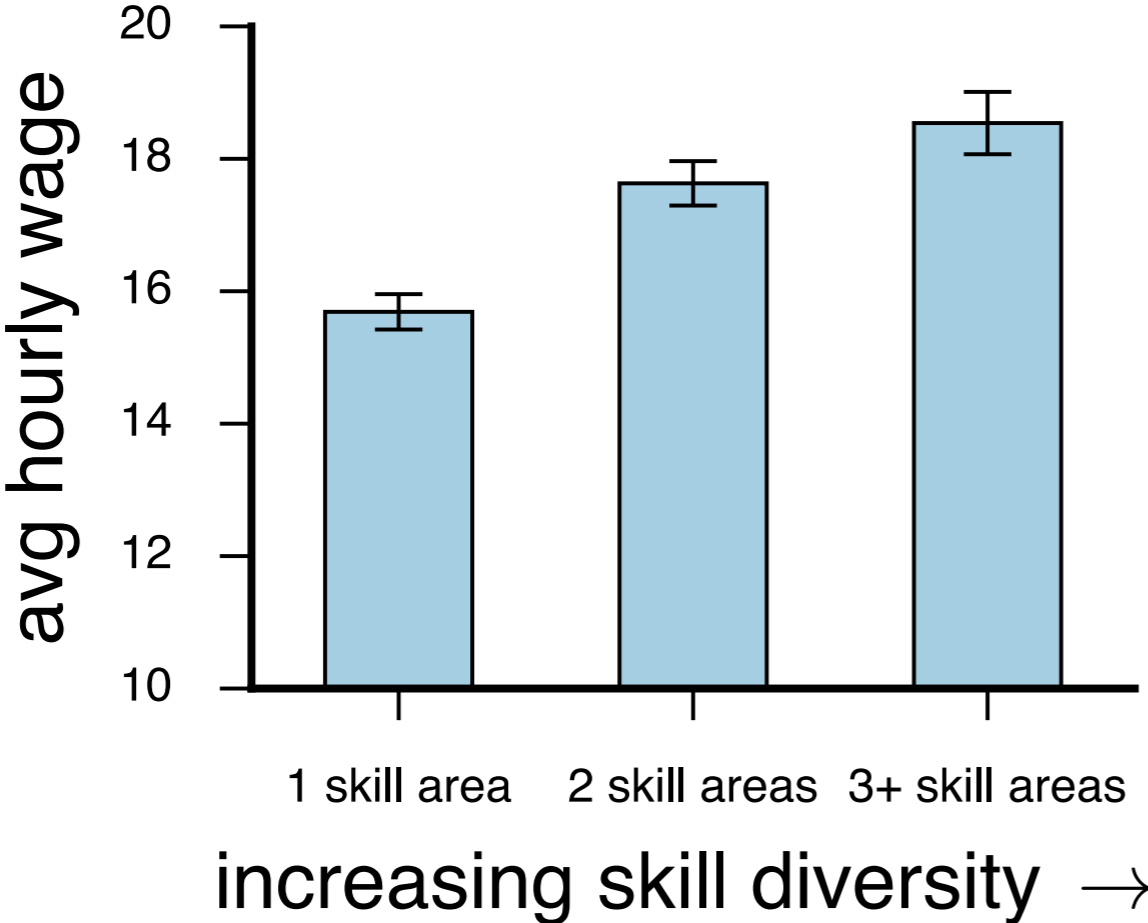


Diverse Skills

Measuring these differences opens up new questions

Complex Measures of Human Capital

Question: do workers whose skills are diverse earn more or less than people whose skills are focused in a single area?



People with diverse skills tend to earn more

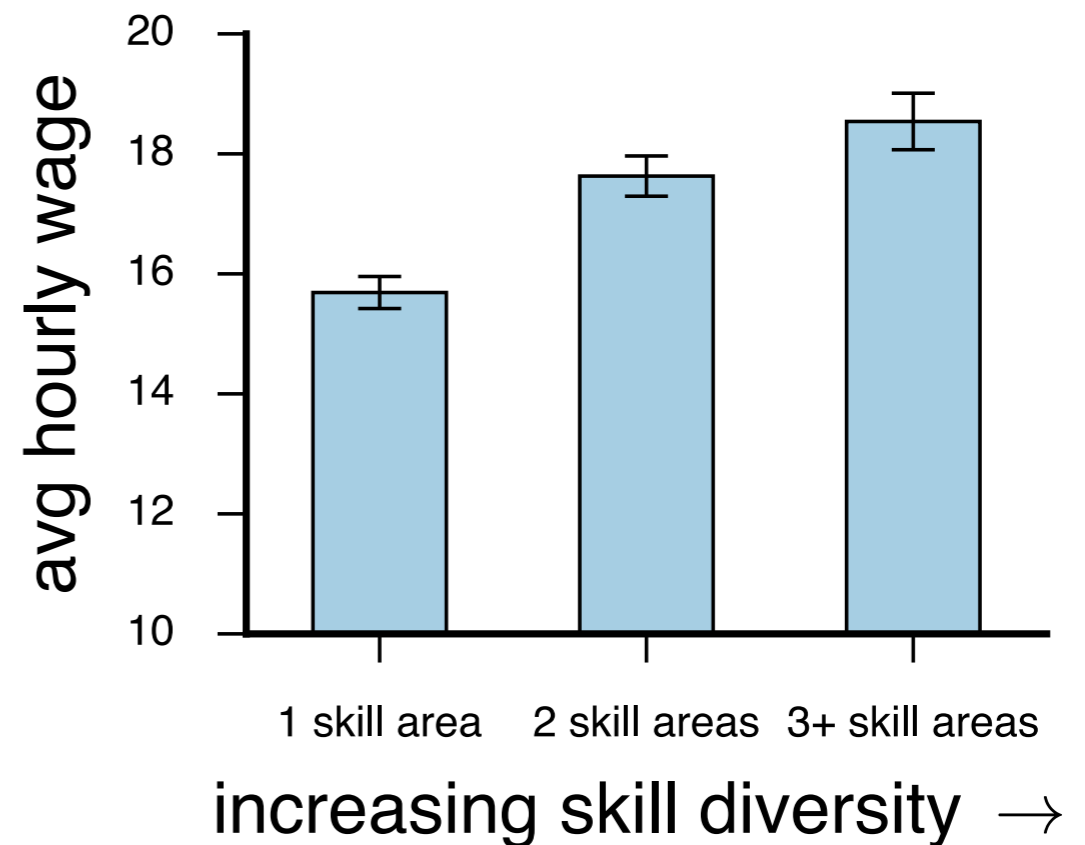
NB: This is just an illustration: I'm controlling for nothing here!

Complex Measures of Human Capital

But then the question is, *why* do workers with diverse skills earn more?

Two possible advantages:

1. diverse skills =
larger pool of jobs
2. diverse skills =
unique gap-filler



Complex Measures of Human Capital

Difference between the two can be seen in the job network



Skills tightly clustered on the job network are often required in combination

Complex Measures of Human Capital

Worker
Network

Job
Network

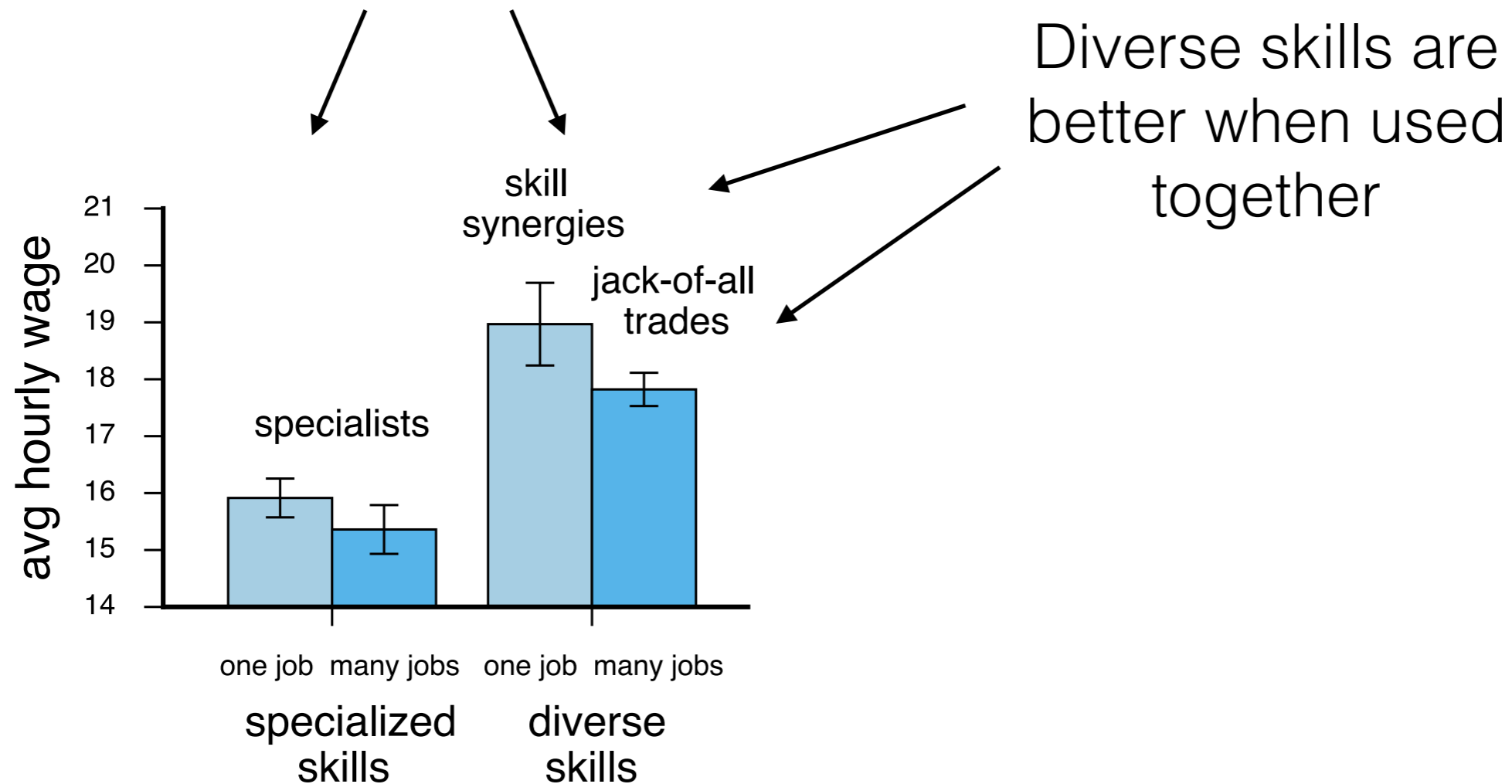
Fit Multiple
Job Areas

Fit One
Job Area



Complex Measures of Human Capital

Skill diversity = higher wages



People who use their diverse skills synergistically tend to earn higher wages

Summing up

- Social Science is hard!
- Models help us understand the big picture, and how conclusions generalize!
- Individual decisions sometimes generate surprising macro-level behaviors
- Peer effects generate big changes in behavior
- Networks can help us understand heterogeneity along a wide range of dimensions.