Epidemiological Expectations in Economics

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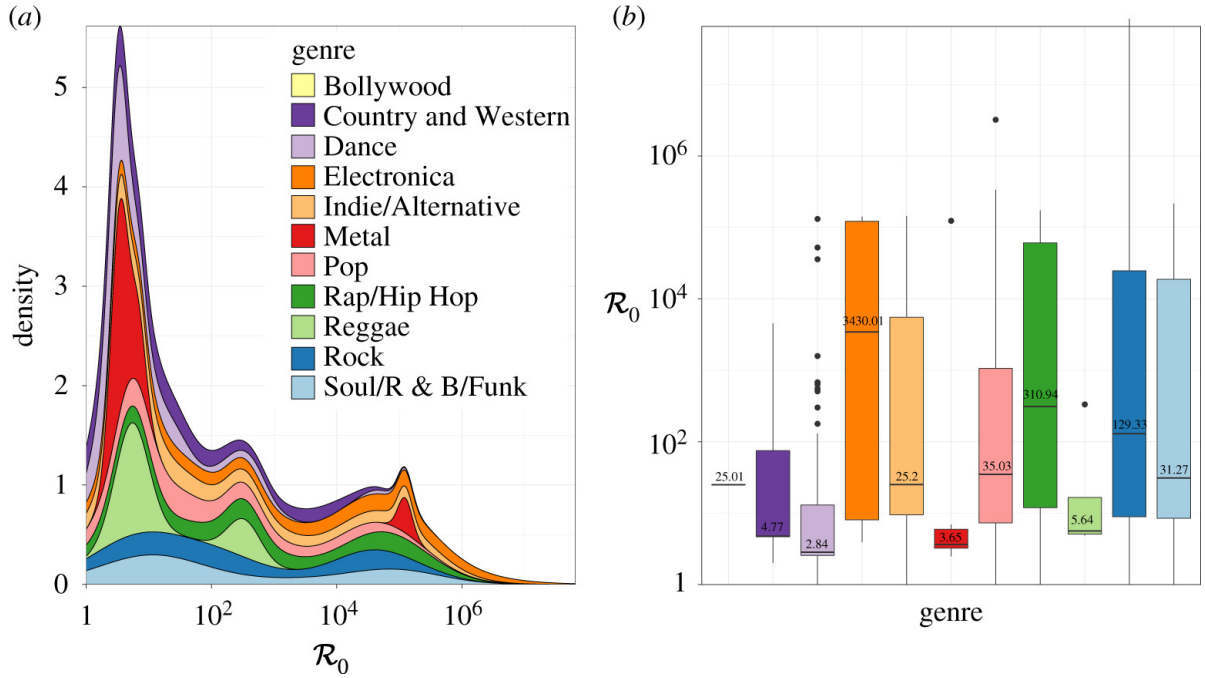
What This Paper Is Not About

Rosati, Woolhouse, Bolker, and Earn (2021), Sep 24:
Epi models fit songs better than diseases:



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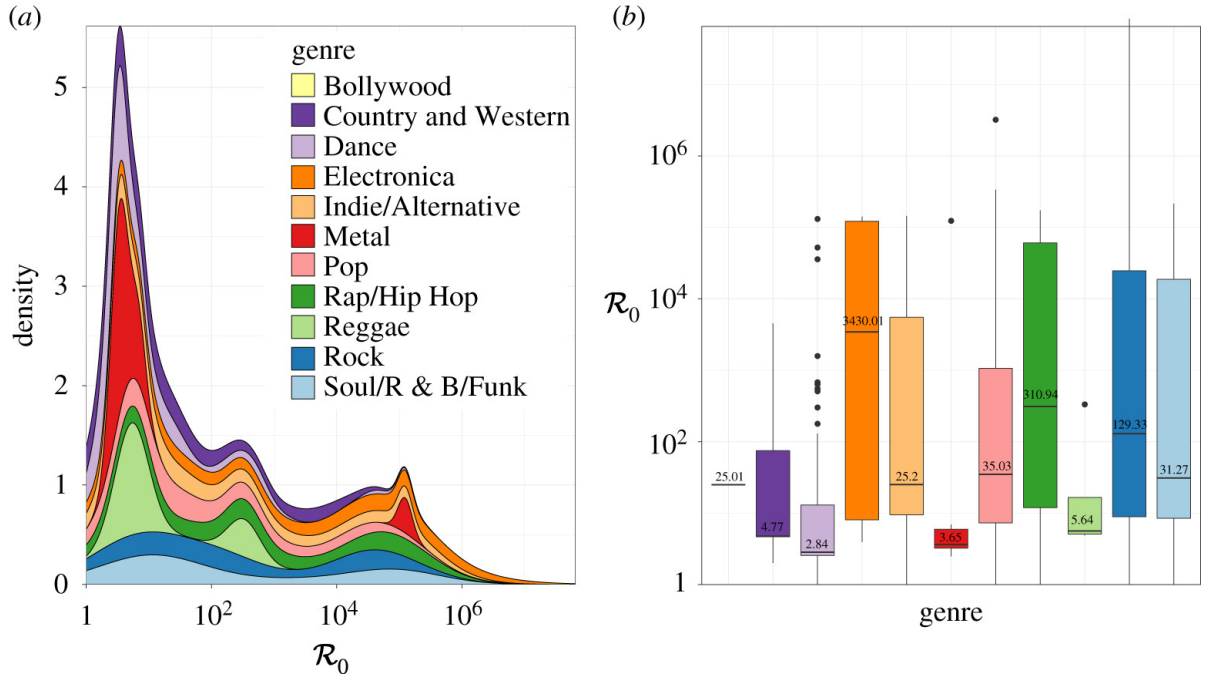

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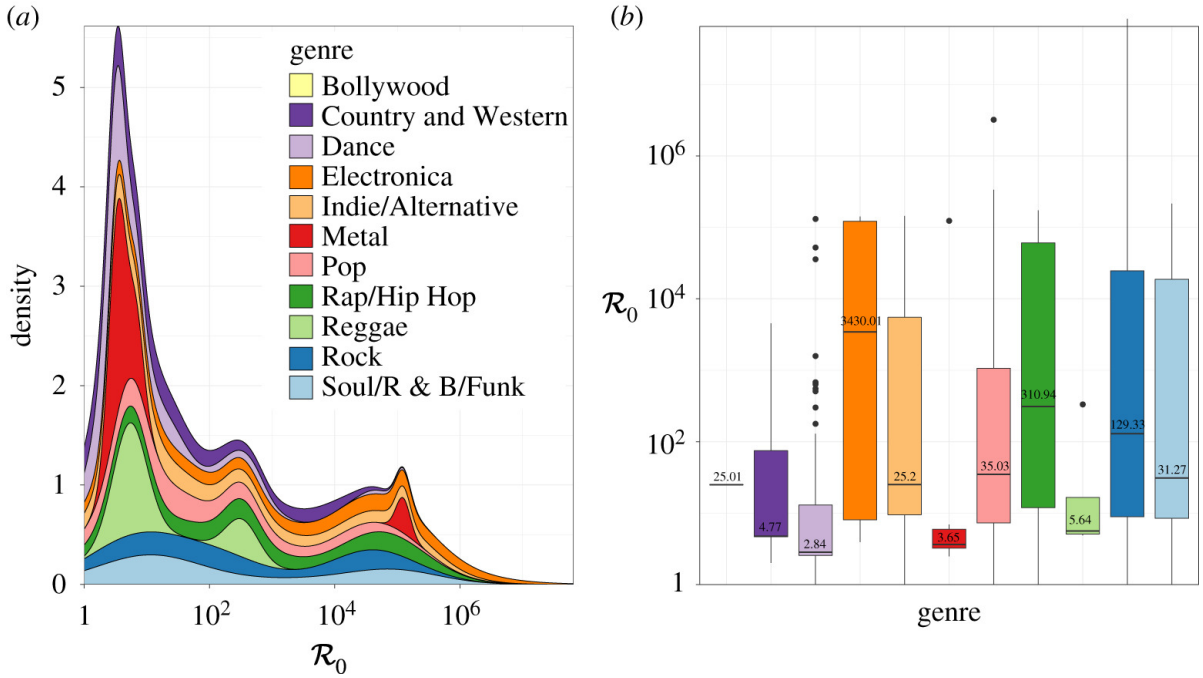

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Why Do Economists Care About Expectations?

Economic choices generically depend on $\mathbb{E}$

Goals:

1. Define EE: what is required to construct $\mathbb{E}$ in economic modeling
2. Describe existing literature using EE to answer economic questions
   - Technological Diffusion (entire literature)
   - Finance (a few examples)
   - Macroeconomics (a few examples)
3. Agenda for progress in building useful EE tools

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Core Element of 'Epidemiology'?

Add to some existing economic model:

- Social transmission of beliefs

"Full-fledged" model requires:

1. mechanism: math by which idea(s) transmitted
2. dynamics: ... that yields observable $\mathbb{E}$ dynamics ...
3. economic: ... those $\mathbb{E} \Rightarrow$ an economic outcome

- "source" of beliefs *could* be Rational
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Quotes

While mass media play a major role in alerting individuals to the possibility of an innovation, it seems to be personal contact that is most relevant in leading to its adoption. Thus, the diffusion of an innovation becomes a process formally akin to the spread of an infectious disease.

– Arrow (1969)

An idea is like a virus. Resilient. Highly contagious. And even the smallest seed of an idea can grow. –Cobb

– The movie Inception (2010)

Expectational heterogeneity

Handbook of Microeconomics, Browning, Heckman, and Hansen 1999, wrote that the most universal lesson of micro economics is that "people are different in ways that importantly affect their economic behavior."

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OK, heterogeneity also importantly affects "macroeconomic" behavior

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OK, heterogeneity also importantly affects "macroeconomic" behavior

Even for things like inflation or stock returns

- Giglio, Maggiori, Stroebel, and Utkus (2021)

... but not yet (regularly; as a normal practice) in "structural" models:

- Rational Expectations
- Diagnostic Expectations
- Sparsity (Gabaix)
- ...
- Fading Memory (v 1.0)

Why Epidemiology?

- Other attempts ('different info sets') have not worked
- Vast literature outside of economics with methods, data
- Lots of reduced-form evidence in economics
- Cool new social network evidence!

Network Theory/Graph Theory Toolkits

Like DYNARE for heterogeneous agent network modeling

- `NetworkX`
- NDLib

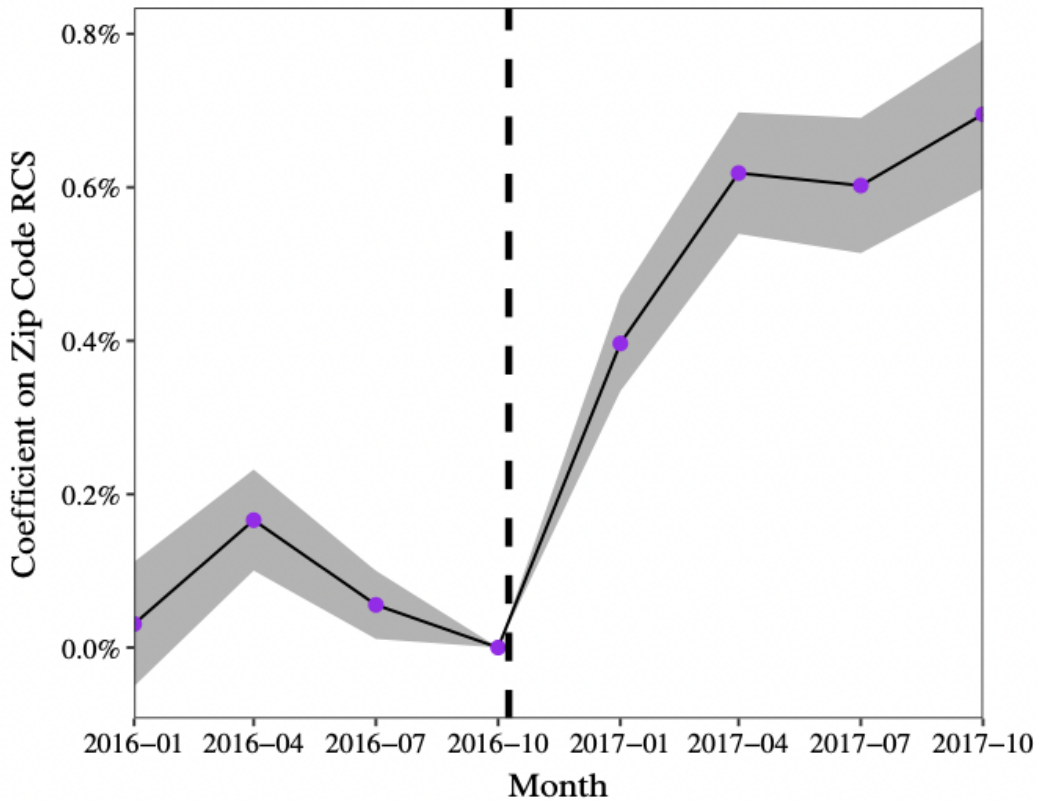
These very powerful tools have been used in huge literatures outside of economics.

Two results in some tension

- 'Small World'
  - 6 Degrees of Separation – everybody is interconnected
- Many ways to get persistent heterogeneity/disagreement/polarization

Expectational tribes

Figure: Portfolio responses to 2016 U.S. election



Common Source S-I Model

Table: Common Source SI Model

Date	Susceptible	Infected
0	1	0
1	$(1-p)$	$1-(1-p)$
2	$(1-p)^2$	$1-(1-p)^2$
$\vdots$	$\vdots$	$\vdots$
n	$(1-p)^n$	$1-(1-p)^n$

Personal Contact S-I Model

Table: Transmissible SI Model

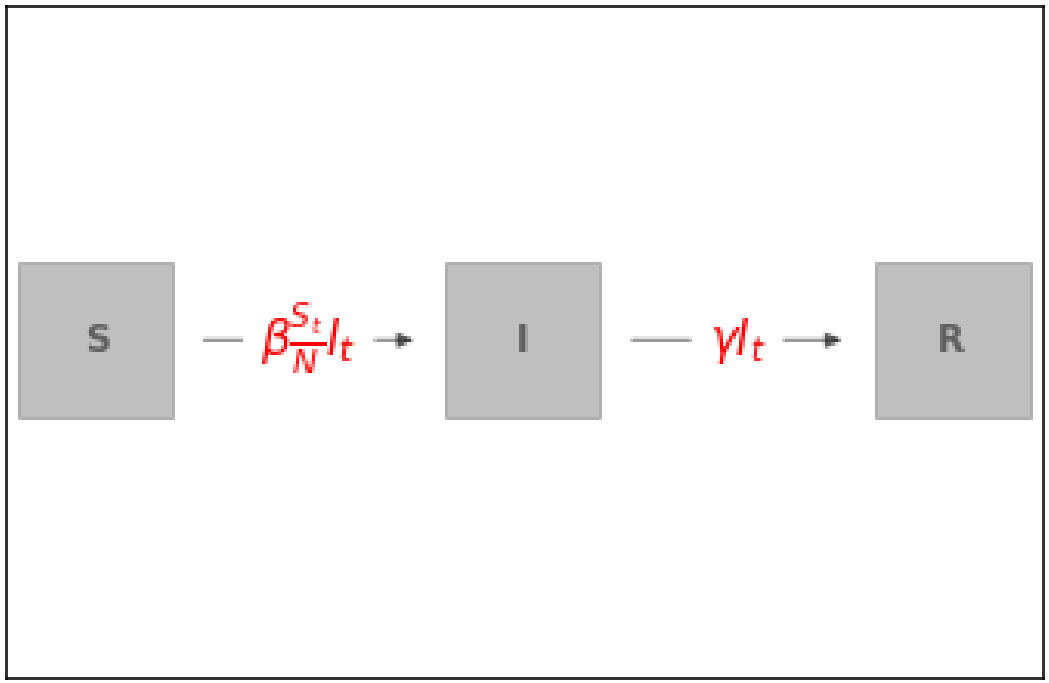
Date	Susceptible	Infected
0	S_0	I_0
1	$S_0 - \beta S_0 I_0$	$I_0 + \beta S_0 I_0$
2	$S_1 - \beta S_1 I_1$	$I_1 + \beta S_1 I_1$
$\vdots$	$\vdots$	$\vdots$
n	$S_{n-1} - \beta S_{n-1} I_{n-1}$	$I_{n-1} + \beta S_{n-1} I_{n-1}$

Other States

- Recovered/Removed (Dead)
- Exposed (which might affect future infection risk)
- Immune

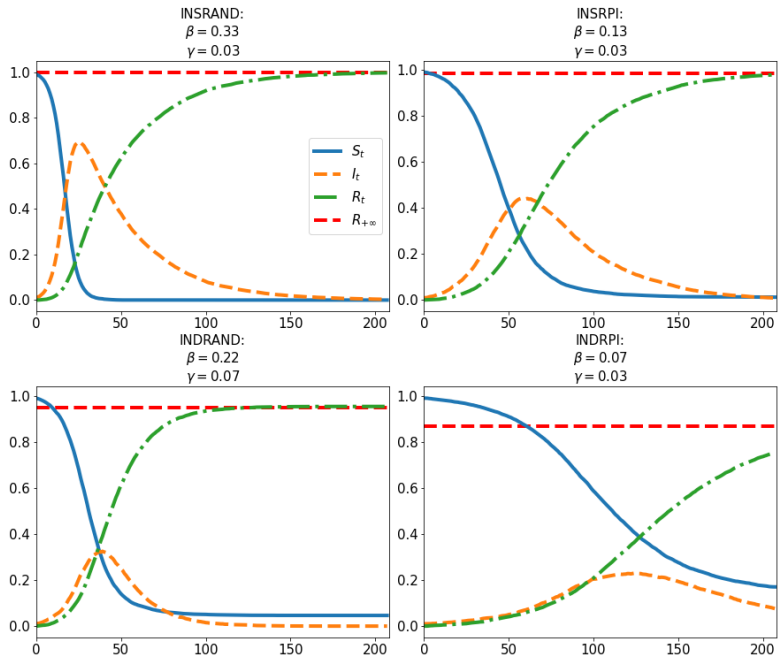
A SIR Model of stock investors (Shiller and Pound, 1989)

Figure: A SIR model of stock investors



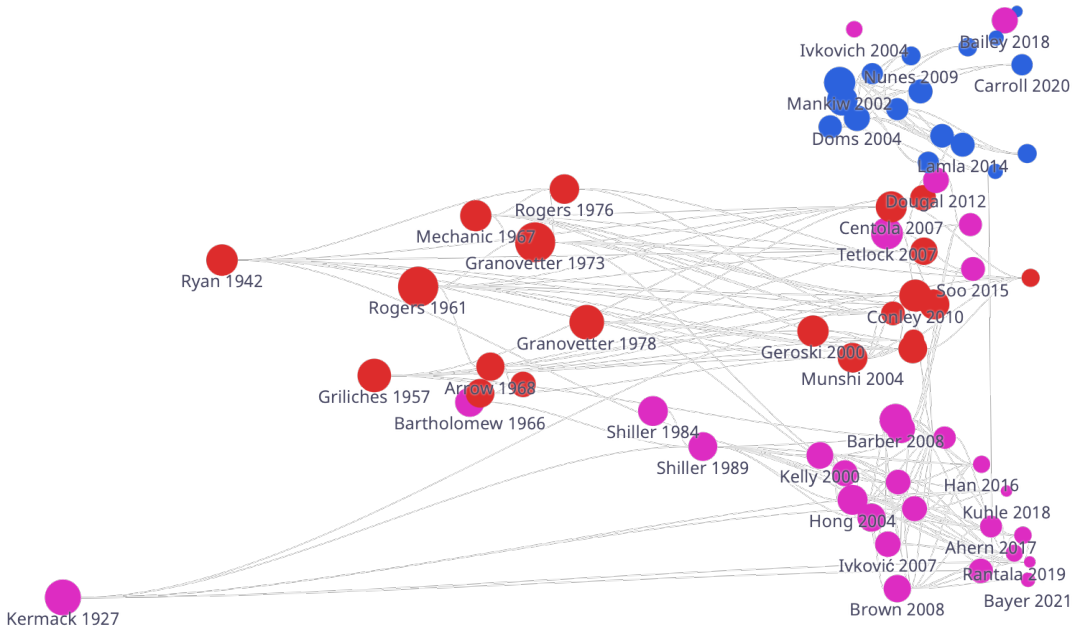
A SIR model of stock investors

Figure: Simulated trends from a SIR model of stock investors



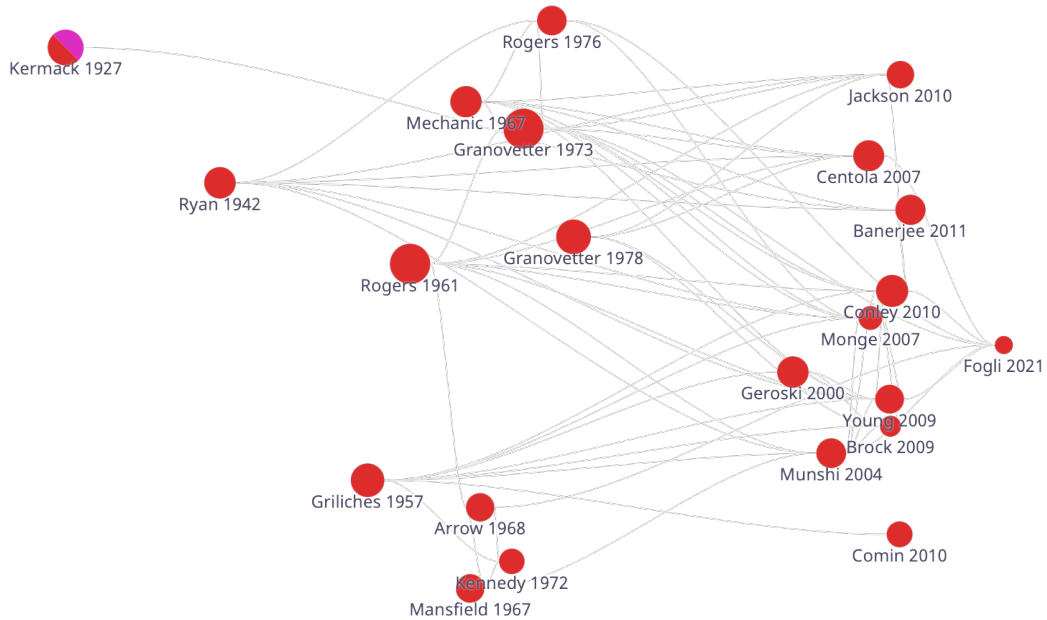
Three substantial fields of EE models

Figure: Literature map of EE models in economics



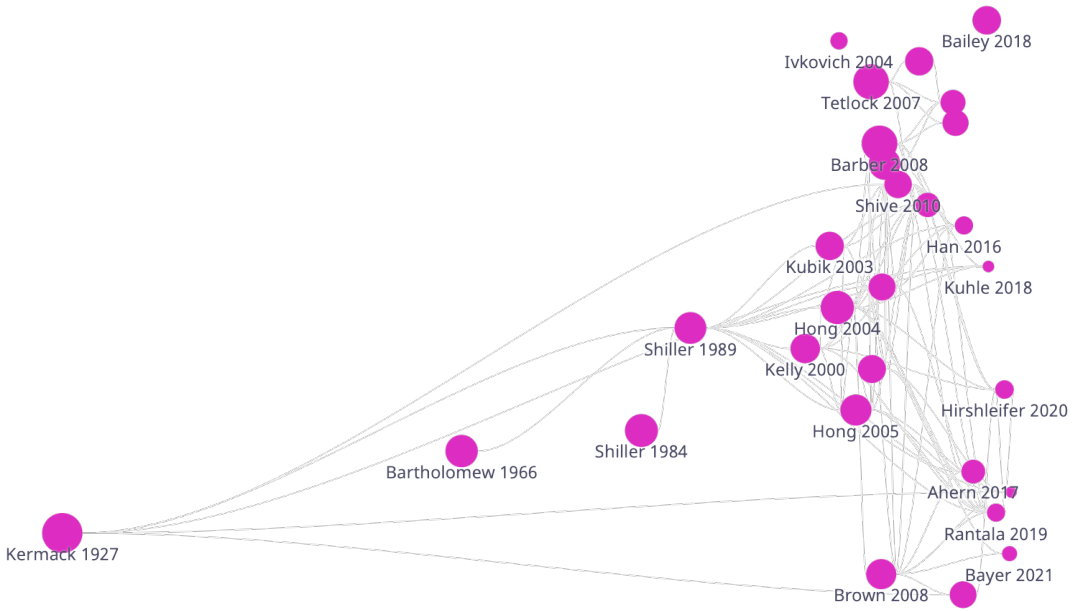
EE models of technological diffusion

Figure: Literature map of models of technological diffusion



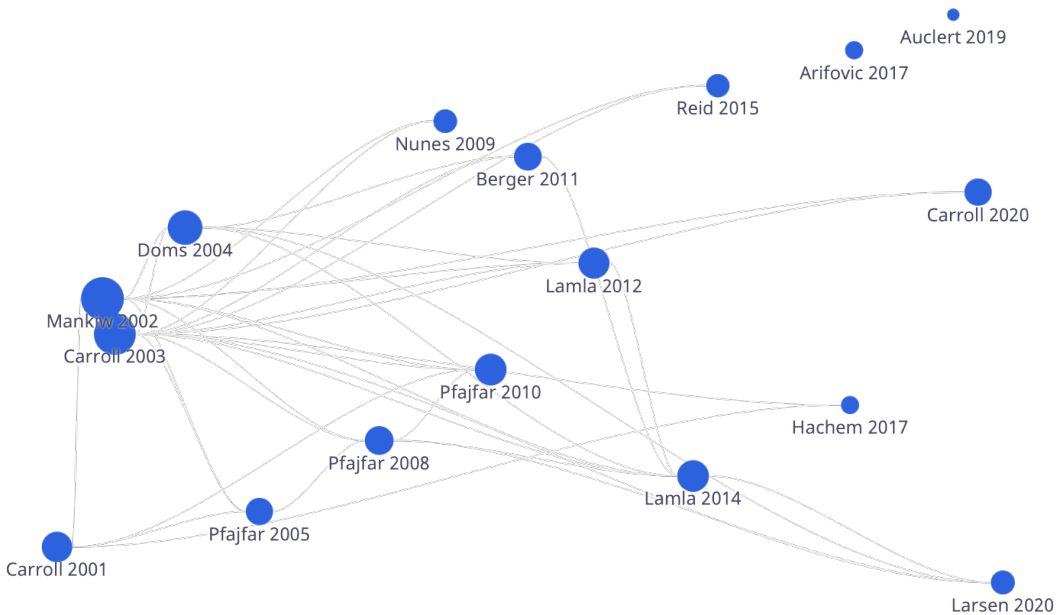
EE model of asset investment

Figure: Literature on epi models of financial market investment



EE model of macroeconomic expectations

Figure: Literature on epi models of macroeconomic expectations



Micro Evidence

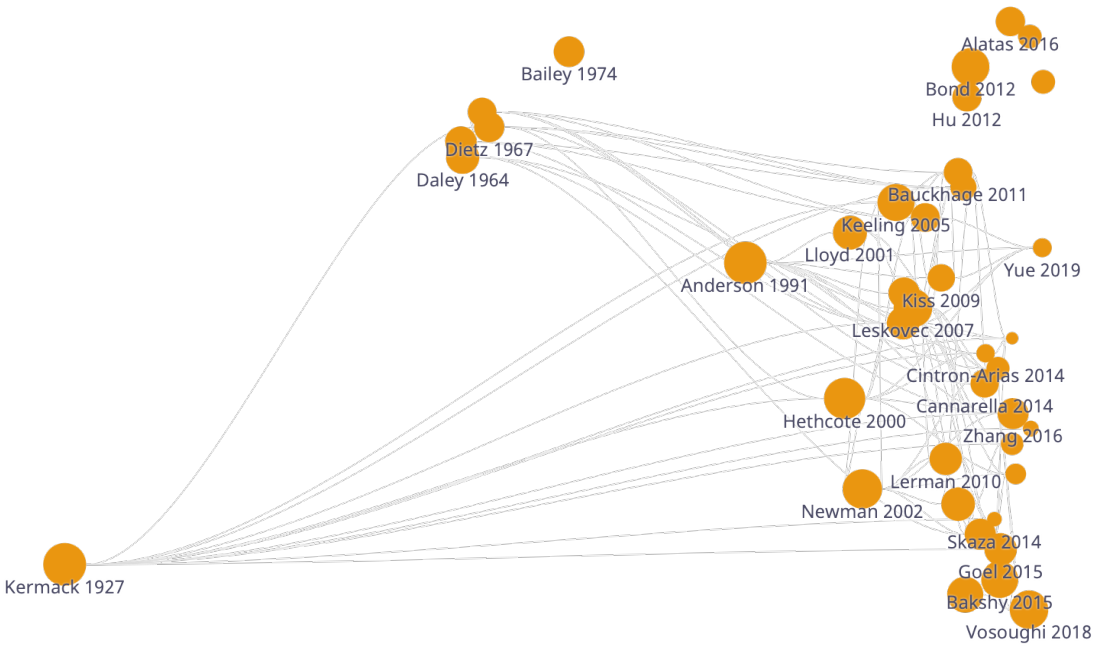
1. What are the characteristics of source and recipient of the infection
2. Under what conditions and through which media do communications take place
3. What kinds of information/expectations are more infectious?
4. Are economic choices truly affected by identifiable socially transmitted beliefs

Non-economic applications of epi models

1. the spread of news, fake news, and rumors
2. the diffusion of scientific ideas
3. the dissemination pattern of internet content such as memes

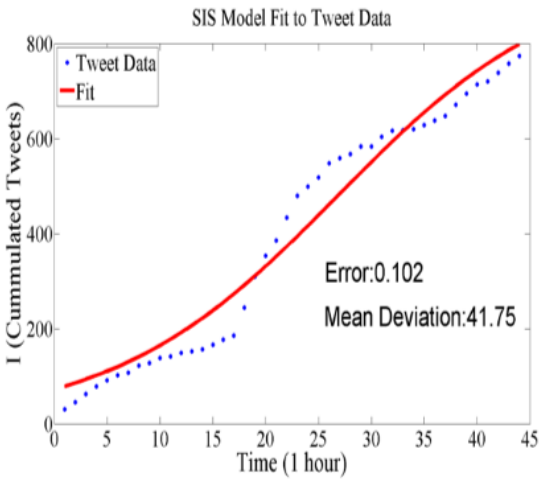
Other Epidemiological models

Figure: Other fields related to epi models

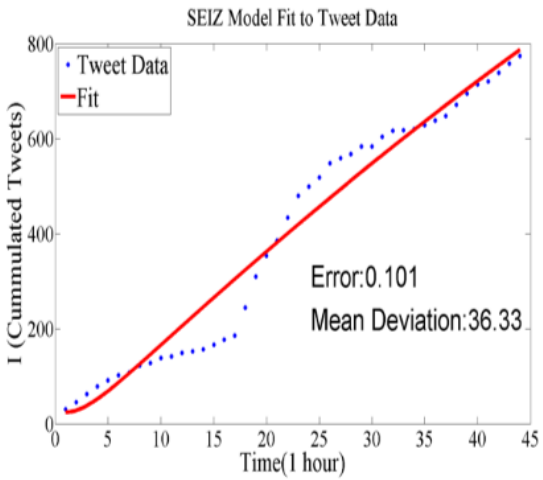


An Epi model of news /rumor spreading

Figure: Jin, Dougherty, Saraf, Cao, and Ramakrishnan (2013)



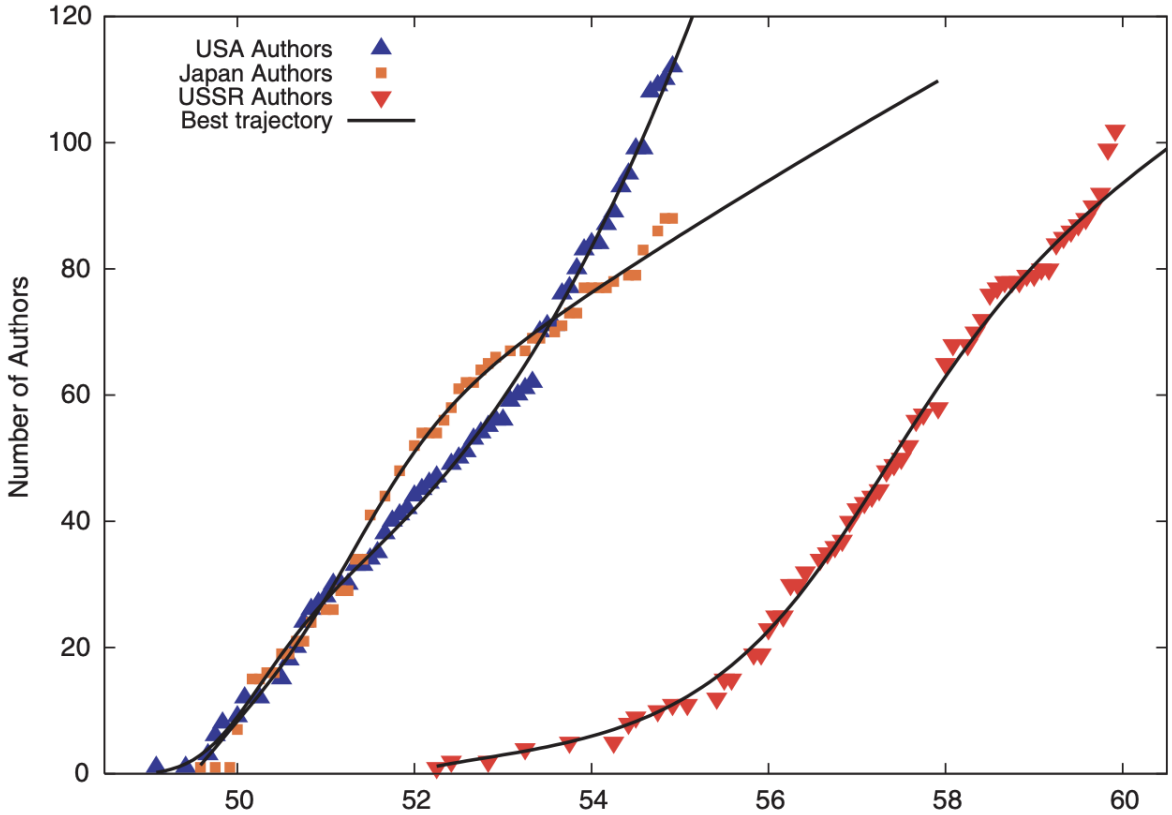
(a) SIS



(b) SEIZ

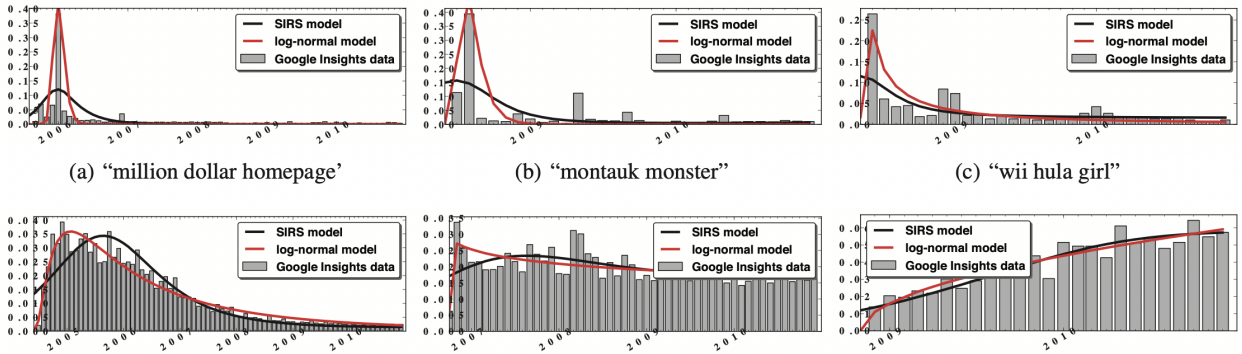
An Epi model of scientific ideas

Figure: Bettencourt, Cintrón-Arias, Kaiser, and Castillo-Chávez (2006)



An Epi model of "memes"

Figure: Bauckhage (2011)



(a) "million dollar homepage' (b) "montauk monster" (c) "wii hula girl"

(d) "salad fingers" (e) "laughing baby" (f) "so much win"

Figure 6: Examples of SIRS and log-normal fits to Google Insights time series that characterize the evolution of interest in different Internet memes. The examples in the top row show pathological cases that are not well accounted for by either model. This occurs if a meme is characterized by a single burst of popularity or by a sequence of such bursts. The bottom row shows more accurate fits for memes of slowly declining, or almost constant, or even constantly growing popularity.

Conclusion

Time is ripe for EE modeling to take off:

- Data on expectations and social networks now exist!
- Expectations affect measured choices
- Mature, powerful, easy modeling `NetworkX/NDLib` tools exist
- HA modeling is cutting edge –
  - expectations are new frontier

Arrow, Kenneth J. (1969): "Classificatory Notes on the Production and Transmission of Technological Knowledge," *The American Economic Review*, 59(2), 29–35.

Bauckhage, Christian (2011): "Insights into internet memes," in *Proceedings of the International AAAI Conference on Web and Social Media*, vol. 5.

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