Networks play a ubiquitous role in developing economies. In the absence of well-functioning formal institutions, networks facilitate transactions that otherwise would not take place (Greif 1993; Munshi, 2014). My research in development economics works to improve our understanding of how network structure affects economic interactions. I focus on two fundamental areas:

1) **Social Learning:** How does information spread and how do opinions evolve in a community? The degree to which social learning succeeds or fails has major economic consequences in developing economies. Policymakers in developing economies rely on extension services to encourage take-up of better practices (Beaman et al., 2015), technologies (Conley and Udry, 2010), health products (Kremer and Miguel, 2007), and financial services. Community-driven development such as harnessing social knowledge to target the poor, assumes that members of society know who is needy (Alatas et al., 2012). Job opportunities are passed along networks (Granovetter, 1973; Beaman and Magruder, 2012).

2) **Informal Institutions:** How is a group’s ability to maintain and sustain cooperation affected by the position of its members in a network? Individuals in a developing economy rely on their networks for the smooth exchange of goods and services in the absence of well-functioning formal institutions, limited access to financial products, and poor legal systems. How are networks structured to promote cooperation? How does the introduction of formal markets, like credit, affect the equilibrium informal insurance network (Bramoulle and Kranton, 2007; Bloch et al. 2008; Jackson et al., 2012; Ambrus et al., 2014)? Are there externalities to non-participants?

The language of networks is helpful in studying both social learning and cooperation through informal institutions. Analyzing communication networks helps policymakers choose who best to give information to have it spread, and can inform researchers of misinformation traps. Examining networks elucidates which individuals can sustain cooperation through, say, risk-sharing, even in the presence of frictions such as lack of commitment. The local and global externalities of introducing formal markets (e.g., credit markets) are also better understood through an attention to networks. My research approach is methodologically diverse. I collect novel data, conduct field experiments, conduct lab experiments in the field, and analyze observational data. I use both reduced form and structural methods. I use theory to design my experiments, to analyze data, and to guide my research agenda. I also work on methodological and estimation problems that arise.

I. **Social Learning.** Social learning has two aspects: **diffusion** and **information aggregation.** Diffusion is how information spreads from a small set of agents to the wider, uninformed population. Diffusion models assume all informed agents have the same information. Information aggregation is how rational or boundedly rational agents aggregate different signals. In information aggregation models, every agent is typically informed and the analysis is focused on how quickly agents converge to a limit opinion (if any). My research explores diffusion and information aggregation as they both have an impact on development.

A. **DIFFUSION.** In “The diffusion of microfinance,” joint with Abhijit Banerjee, Esther Duflo, and Matthew Jackson, *Science (2013)*, we studied the spread of take-up of microfinance in 43 villages in India, where we had collected detailed network data. We developed a new model of diffusion that was rich enough to distinguish between theories of peer influence. Yet the model is simple enough to be attached to a number of other economic settings where diffusion is a component (e.g., signaling, risk-sharing). This makes modeling the effects of network structure on standard models easy to do. Further, the model provides a measure of influence in an information passing process on the network, called diffusion centrality, which nests many other measures in the literature as special cases. As we knew which individuals the microfinance institution was likely to seed information with, we used variation in the location of the seeds in each village with patterns of take-up to estimate the model. Diffusion centrality of these seeds predicted take-up.

Targeting diffusion central individuals to spread valuable information is a useful tool for policymakers. However, collecting detailed network data is costly and impractical. In “Gossip: identifying central individuals in a social network,” joint with Abhijit Banerjee, Esther Duflo, and Matthew Jackson, we
address this in an NSF-funded study (co-PI, NSF SES-1156182). Our diffusion model indicated that though diffusion centrality is complicated, individuals in a community are capable of ranking others by diffusion centrality. We checked if this insight could be used empirically. First, we conducted a survey in 33 villages and asked individuals to nominate individuals who, if seeded, could spread information widely. Nominated individuals were indeed more central. Second, in 213 villages we conducted a randomized trial in which we seeded information to villages in three ways: to nominated individuals, to village leaders, and to random villagers. Nominated individuals spread information much further. Thus, our insights from theory provided a blueprint for identifying central individuals, which has important policy implications.

Another important application of diffusion in rural communities deals with reputation. Besley and Coate (1995) and numerous others describe social punishment dependent on reporting poor behavior. Joint liability microfinance, RoSCAs, and peer-driven financial institutions rely on reputation. In “Social networks, reputation, and commitment: evidence from a savings monitors experiment,” joint with Emily Breza, Revise and Resubmit at *Econometrica*, we measure the impact of social reputation. We constructed a financial institution at the pair level: a saver and a monitor. The saver accumulated savings over a six-month period towards a self-set goal; the monitor was notified bi-weekly. We studied whether being randomly assigned a more diffusion central monitor led to higher savings. We followed up 15 months after the end of the experiment and measured if reputational information spread throughout the village. Being assigned a more central monitor increased savings across all accounts and allowed subjects to better cope with shocks.

One example of ongoing work is an experiment I have completed joint with Vivi Alatas, Markus Mobius, Cindy Paladines, and Ben Olken, “Celebrity endorsement and social influence: a nationwide Twitter experiment promoting vaccination in Indonesia.” We used celebrities to promote pro-vaccine messages, designing the experiment to study if central nodes influence diffusion due to their reach or endorsement.

B. INFORMATION AGGREGATION. In “Testing models of social learning on networks: evidence from a lab experiment in the field,” joint with Horacio Larreguy and Juan Pablo Xandri, Revise and Resubmit at *Econometrica*, we study how information is aggregated. We conducted a lab experiment in the field with 665 subjects across 19 villages in Karnataka, India. We designed the experiment to test between two benchmark models: Bayesian and DeGroot learning (see Mobius et al., 2015). We allowed the data to tell us whether all subjects appear to be DeGroot, Bayesian who believe others are Bayesian, or Bayesian who believe others may not be Bayesian with some probability. Our results showed that subjects look to be DeGroot learners. I applied a DeGroot-like model in “Network structure and the aggregation of information: theory and evidence from Indonesia,” joint with Vivi Alatas, Abhijit Banerjee, Rema Hanna, and Benjamin Olken, *American Economic Review* (2016). We used insights from theory to predict which villages would have better information about who is poor and who is rich, in order to assess if community targeting would work there.

The above takes for granted that all individuals are aware that there is something to be learned. However, when a new technology is introduced to a community, often only a few hear about it first. How does this affect information aggregation? In “Naive learning with uninformed agents,” joint with Abhijit Banerjee, Emily Breza, and Markus Mobius, (co-PI, NSF SES-1326661), we study a natural extension of the DeGroot model that can deal with the case where only a few individuals are given signals before social learning commences. Society can end up effectively losing information and make sub-optimal decisions.

I am also interested in the incentives people face to participate in social learning. Consider a farmer who may have low ability and is struggling to figure out how to use a new technology. The farmer may seek advice from a peer, but may worry that doing so signals low ability and therefore refrains from seeking. This mechanism suggests there may be an information poverty-trap, where only the suitably skilled engage in social learning. In “Questions as signals of skill: stigma and silence in social learning,” joint with Benjamin Golub and He Yang, we study the stigma associated with seeking information as a friction in social learning, both theoretically and in a field experiment.

Finally, I have received an NSF grant with Emily Breza to study how affirmative action for disenfranchised castes in India affects information flow of job opportunities (PI, NSF SES-1559469).

II. INFORMAL INSTITUTIONS. As agents rely on their community members to facilitate economic interactions, I study how networks sustain cooperation. I also work on the modeling of network formation.
A. Network Position and Cooperation. I conducted two lab experiments in the field that study how network position affects cooperation. In "Social networks as contract enforcement: evidence from a lab experiment in the field," joint with Cynthia Kinnan and Horacio Larreguy, Revise and Resubmit at AEJ: Applied Economics, we randomly paired subjects and varied their access to commitment contracts. Subjects played a dynamic risk-sharing game (Ligon et al., 2002). We found that lack of commitment did not matter for the socially close, but mattered considerably for the socially distant. Since most pairs are not socially close, lack of contracts impede efficient transactions, which makes third party institutions valuable. In "Network centrality and informal institutions: evidence from a lab experiment in the field," with Emily Breza and Horacio Larreguy, we focus on arrangements between socially distant parties. We ask which network member makes for an efficiency enhancing third party institution.

I have received two NSF grants to conduct experiments on cooperation and risk sharing, with Melanie Morten (PI, NSF SES-1530791) and Attila Ambrus and Matthew Elliott (co-PI, NSF SES-1429959).

B. Network Formation and Evolution. In "Changes in social network structure in response to exposure to formal credit markets," joint with Abhijit Banerjee, Esther Duflo, and Matthew Jackson, we study how introducing microfinance affects network evolution. We use a two-wave six-year panel from 2006-2012 in 75 villages in Karnataka, India, comprising 16476 households where we have network data across relationships across 71% (Wave 1) and 98% (Wave 2) of households. Using demographic and network data from the microfinance villages, along with the microfinance entry strategy and eligibility requirements, we classify households as having a high or low likelihood of joining, if offered. We show that the introduction of microfinance generates systematic losses of social capital, both in terms of direct links and triangles. These losses are more pronounced for those who are ex ante unlikely to join microcredit. Typical models of network formation are inconsistent with this. There is a global externality on others when an agent chooses to endogenously separate. From the perspective of evaluating the impact of microfinance itself, this shows that there are serious external effects that should be considered in policy design and evaluation.

I developed methodological tools to aid the empirical analysis of network data, in part because this is a young field. "Econometrics of sampled networks," joint with Randall Lewis, examines the problems that arise when using sampled network data. In "A network formation model based on subgraphs," with Matthew Jackson, we develop a new class of models for the statistical estimation of network formation while allowing for substantial link correlation. The model is useful to analyze incentives to form cross-caste links in India and risk-sharing models. In addition, I have written a book chapter, "Econometrics of network formation," for the Oxford Handbook on the Economics of Networks that summarizes the state of the literature.

Ben Golub, Matt Jackson and I have received an NSF grant to study network formation through the lens of multiplexing. For example, we are interested in the incentives that a villager may face to distort her information-sharing network to exploit complementarities with her risk-sharing network (PI, SES-1629328).

III. Teaching. I teach two classes on development economics at Stanford. Econ 125 is an upper-division undergraduate class that focuses on microfinance, and Econ 216 is a second-year PhD class. In Spring 2016, I taught a second-year PhD class on the economics of networks (Econ 291), when Matt Jackson was on leave. I have co-organized the development seminar for the last three years (Econ 315).

I designed the syllabi for Econ 125 and Econ 216. Econ 125 focuses on helping students think critically about microfinance. We first cover the financial systems of the poor (savings, credit, informal insurance) and then explore topics of information, social capital, public finance, and firms. As some of the material is technical, I incorporate in-class experiments. For example, students participate in informal risk-sharing experiments where we add in frictions such as lack of commitment, hidden income, or moral hazard, to make these concepts intuitive. Econ 216 is part of our yearlong development field sequence. It begins with an overview of basic applied micro-econometric tools and network economics and then rigorously covers savings, insurance, credit, microfinance, social capital, technology adoption, public goods, redistribution, and firms. I bring a networks-oriented perspective to all of these topics, as network models are useful in thinking about all of these issues. My syllabus for Econ 291 added an emphasis on research that incorporated lab and field experiments as well as econometric methodology, as this is my primary expertise. I expect to continue teaching Econ 125 and 216 and share in teaching Econ 291, as needed, in the future.
IV. REFERENCES BY THE AUTHOR

PUBLISHED PAPERS.

BOOK CHAPTERS.

WORKING PAPERS.
5. “A network formation model based on subgraphs,” (with Matthew Jackson). [submitted]
6. “Network centrality and informal institutions: evidence from a lab experiment in the field,” (with Emily Breza and Horacio Larreguy). [submitted]
8. “Questions as signals of skill: stigma and silence in social learning,” (with Benjamin Golub and He Yang).

V. REFERENCES


