7

Discrimination and Homophily

Feldon et al. (2017) asked 336 first-year PhD students in the biological sciences to record their research hours biweekly over the course of a year. At the end of the year, they administered surveys asking, among other things, how many publications these students had been included on as authors. What they found was that, controlling for relevant variables, women students spent significantly more time on research than men students. They also found that for each 100 hours worked, men were 15% more likely to earn an authorship position than women. In other words, the women suffered an inequity in terms of academic credit assigned per hour worked.

This is not the only study to identify gender-based credit inequities in academia. West et al. (2013) and Sugimoto (2013) find that across various disciplines women are less likely to hold first and last author positions. Sarsons (2017) looks at the impact of research publications on the likelihood that economists receive tenure. She finds that men receive an equal boost for co-authored and single-authored publications. Women's chances of tenure, on the other hand, increase by about 8% for a single-authored publication (similar to a man's) or for a paper co-authored with another woman, but by only 2% for a publication with a male co-author (and only 4.5% for a publication with mixed gender co-authors). In other words, even in cases where the collaborators themselves might attempt to give fair authorship credit, the ultimate credit payoffs for collaborative work significantly disadvantage women (at least in economics).

Another set of results indicate that in many academic disciplines women are less likely to choose to co-author, and that when they do co-author, they tend to choose other women as partners. Ferber and Teiman

The Origins of Unfairness: Social Categories and Cultural Evolution. Cailin O'Connor, Oxford University Press (2019). © Oxford University Press.
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(1980); McDowell and Smith (1992); Boschini and Sjögren (2007); West et al. (2013) find these results for women in disciplines where they are underrepresented, including economics. In addition, Del Carmen and Bing (2000) find that black criminologists are less likely to co-author than their colleagues. And Botts et al. (2014) find that black philosophers tend to cluster into sub-disciplines, where those sub-disciplines such as philosophy of race, have lower proportions of white academics.

The goal of this chapter is to use the framework developed thus far in the book to address the question: how do discriminatory conventions and norms influence patterns of interaction? In particular, the models presented will highlight causal processes that can lead to homophily, or disproportionate in-group interaction, as a result of discrimination.

While these models apply generally to the dynamics of strategic interaction, I'll use academic communities as a case study throughout the chapter. This case is a useful one since discrimination with respect to credit sharing in academia has been extensively studied, as have collaboration networks. The models will draw a causal link between the two sets of empirical results from this literature described above. The suggestion is that when women get less credit, they learn to avoid collaborating with men as a result.

I will start by looking at models where those who face discrimination can opt out of scenarios of joint action/division of resources. As we'll see, in these models, those who face discrimination are less likely to collaborate and more likely to work alone as a result of receiving relatively low shares of jointly produced resources. Next, I will turn to models that more explicitly represent interactive structure—network models. Using this framework, I'll explore how interactive network structure and discriminatory behavior are mutually influential, noting especially the emergence of homophily. I'll also look at what happens in these models when social groups have differential access to resources that create asymmetries in their productive abilities. As we'll see, this kind of asymmetry can dramatically change outcomes. I'll conclude by discussing the special relevance of these models to academic communities. It has often been argued that diversity is a boon to scientific research. But discriminatory practices may decrease the effective diversity of scientific teams. In this vein, I will address the possibility of intervening on homophillic collaboration networks, and the potential consequences of such intervention.

7.1 Taking the Outside Option

In O'Connor and Bruner (2017), we consider a case where a community composed of two types (men and women, white and black, etc.) adheres to discriminatory bargaining conventions. This means that when members of the two types divide a resource, it is always the case that the advantaged type receives more than the disadvantaged type. The question we ask is: how does this assumption impact agents' choices about strategic interaction?

In particular, we look at the Nash demand game with an outside option. (See Figure 5.7.) But we twist the interpretation slightly, and take it to represent cases where the resource that is divided is one that actors jointly produce. In general, joint action often improves human productivity, but raises the issue of 1) who will do what work and 2) who will get how much of the resource produced. In other words, situations of joint action are also almost always situations of resource division (Wagner, 2012).

Under this interpretation, we have to change our understanding of the Nash demand game's strategies slightly. In particular, we take them to represent demands for some level of payoff given an amount of work invested.[1] A medium demand, in this version of the game, might correspond to a demand for most of the resource by an individual who also did most of the work to produce it. Or it might correspond to a demand for about half the resource if both actors shared labor fairly. A high demand might be for 70% of a resource that an individual did not contribute much to producing. As mentioned, later I will further discuss an academic interpretation of these models. Under that interpretation, a high demand might represent a researcher who wants to be first author on a research paper where they only did 30% of the work. Notice that this interpretation transforms the question above to: how do discriminatory conventions impact *joint action* between those in different social groups? (And: does discrimination increase homophily in these cases?)

[1] In Cochran and O'Connor (2018) we describe a model that more explicitly represents joint production followed by bargaining. I do not present results from this paper here, since they are more complicated than those from the basic Nash demand game. We find that in this two-stage game the presence of social categories like gender and race also tend to lead to inequitable conventions, even when actors can condition their demands for compensation on the contribution level of their partners.

Remember that in the Nash demand game with an outside option, actors have the option of choosing a low, dependable payoff, rather than risking a bargaining interaction. This model creates a framework where we can investigate whether actors tend to learn to opt out of joint action under discriminatory conditions. That is, if they face discrimination, do they respond by learning to simply work alone?

Consider such a model where the outside option is always 2, and where actors follow a discriminatory norm such that one type always gets L and the other H. Figure 7.1 shows the proportion of outcomes of these models that end up at collaboration rather than solo work.[2] As the inequity between the two groups increases (L gets lower), the likelihood of collaboration also decreases. Notice that this happens despite the fact that collaboration is *always* better from a payoff standpoint, that is, $L > 2$. The relatively low payoff of the disadvantaged type, plus risks associated with collaboration, make them more likely to opt out of collaboration and simply work alone. This effect is stronger for small minority groups. Notice that when the minority makes up only 1% of the population, and when the Low demand is very small (L = 2.2), collaboration only emerges between types about 10% of the time. Again, this is despite the fact that

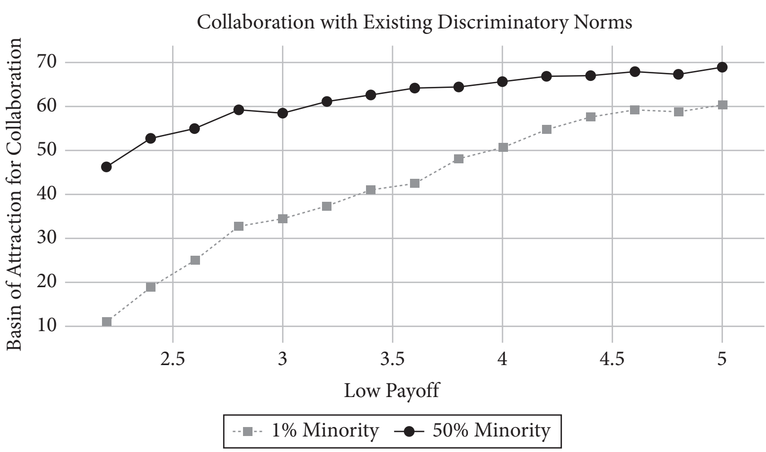

Figure 7.1 Basins of attraction for collaboration for two types playing a Nash demand game with an outside option

[2] As with previous models in the book, we use the discrete time replicator dynamics to generate these results.

the payoffs for the discriminatory collaboration outcomes are better for both parties.

This result suggests that when those in disadvantaged groups are discriminated against, they should be more likely to learn to abstain from joint projects that require bargaining. In other words, based on these results, we might think there is a causal link between the empirical results described in the beginning of the chapter. In particular, when women are subject to credit discrimination, they should also be more likely to single-author. This said, the model just described cannot represent more specific interactive choices (such as to replace an unsatisfactory interactive partner with another who demands less compensation). For that reason, I now move on to discuss network models of similar phenomena.

7.2 Networks and Homophily

In Rubin and O'Connor (2018), philosopher of science Hannah Rubin and I further explore the possibility that discriminatory norms disincentivize joint action between diverse groups. The rest of this section will describe our work together. In particular, we look at *networks* of agents who play Nash demand games with their neighbors on this network. Each *node* of the network represents an individual, and each *edge* an interactive connection. Figure 7.2 gives an example of what such a network might look like. In this figure, we see eight individuals of two different types, with eight links between them.

We use simulations to explore the interactions between discriminatory conventions and network structure. To fully describe these

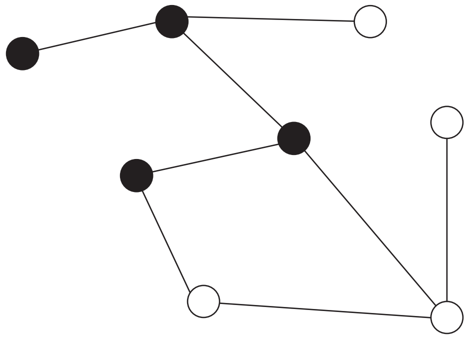

Figure 7.2 A network with two types represented by black and white nodes. Edges represent interactive links between agents

interactions, we break our investigation into three parts. First, we hold one aspect of our model—the network structure—fixed while allowing actors to develop conventions of bargaining. Second, we hold the other aspect of our model—bargaining behavior—fixed and allow actors to choose their network partners. Then we allow both of these elements to vary. As will become clear, in these models (as in the infinite population models from O'Connor and Bruner (2017)) discrimination disincentivizes collaboration between different social groups. The network structure here, though, lets us explore, in particular, the possibility of homophily—preferential in-group interaction—that can arise as the result of discrimination.

7.2.1 Fixed network, evolving bargaining

In this section, I describe models where we assume a fixed network and see how it influences the emergence of bargaining behavior. The question is: on network models, do we see discrimination emerge just as in the infinite population models from the last chapters? And: how does network structure influence this emergence? We begin by specifying networks with two types of actors. In particular, we create random networks using an algorithm where for each possible combination of two agents an edge is formed with some probability, p. We allow the possibility that agents might have different probabilities of linking with those in their in- and out-groups.[3] If the probability of forming each in-group edge p_{in}, is greater than for each out-group edge, p_{out}, the network exhibits homophily.

In the models throughout the rest of the book, I have mostly assumed that actors change strategies according to the replicator dynamics. But in network models, since agents do not interact randomly within their population, one needs an updating rule that takes network structure into account. We assume that agents best respond to the strategies exhibited by their neighbors.[4] We begin a simulation by randomly assigning strategies to each agent. Each round, we assume that the agents collaborate with each of their neighbors on the network. With some small probability, each agent will then update their strategies. They do this by changing to the strategy that would yield the highest payoff given what their neighbors are

[3] This generates a multitype random graph. See Golub and Jackson (2012).

[4] To this point, we have considered a number of models where agents best respond to some set of memories, as in Axtell et al. (2000). Here, we assume agents myopically respond to whatever is happening with their partners at a particular moment.

doing. For example, suppose Suzy has three neighbors who are women, all of whom demand Medium, and four neighbors who are men, all of whom demand Low. Her best response is to switch to demanding Medium of the women, and High of the men. Notice that this is a boundedly rational updating rule—Suzy does not try to predict what her neighbors will do in the next round, or how they might respond to her. She simply myopically responds to her environment. Over time, the agents in these simulations reach stable patterns of behavior, which, again, we take to represent something like a convention for bargaining over joint action.

Reflecting previous work by Poza et al. (2011), we find that these models always evolve to conventions like those described in the previous chapters. In particular, we looked at a Nash demand game with Low, Med, and High demands, so the evolutionary outcomes are that one group demands High, or the other does, or they make fair demands of each other. Payoff details determine how likely these outcomes are, but, as in previous chapters, we find that fair conventions are most likely between groups, but inequitable ones also commonly emerge.

Perhaps surprisingly, the level of homophily in these networks seems to have no effect on the emergence of between-group conventions of bargaining. In other words, discrimination emerges in the same way whether or not agents prefer to interact with those of their own type. Why might this be? In these models, there really are three separate cultural evolutionary processes occurring—one within each in-group and one between groups. A convention develops for each of these—for what actors do in the first in-group, in the second in-group, and between groups. The between-group process is thus insensitive to the level of connectivity within each group.

In Chapter 6 I briefly mentioned that the cultural Red King effect shows robustness across a number of different models, including network models. Hannah and I find that for smaller majority groups, the likelihood that they end up demanding Low at emerged conventions is higher. Figure 7.3 demonstrates this result.[5] As is evident, as one group grows in size, the likelihood that they demand High increases.

[5] This figure averages over a wide set of parameter values. We always considered models with probability .1 that agents updated their strategies in each round, and high demand $H = 6$. We kept $p_{in} = .4$ and varied p_{out} from .2 to .8, meaning that agents went from half as likely to link with out-group members to twice as likely. Network size ranged from 20 to 100 agents. Minority group size ranged from 10% to 50%. Each set of parameter values was run 100 times, in a simulation with 1000 rounds.

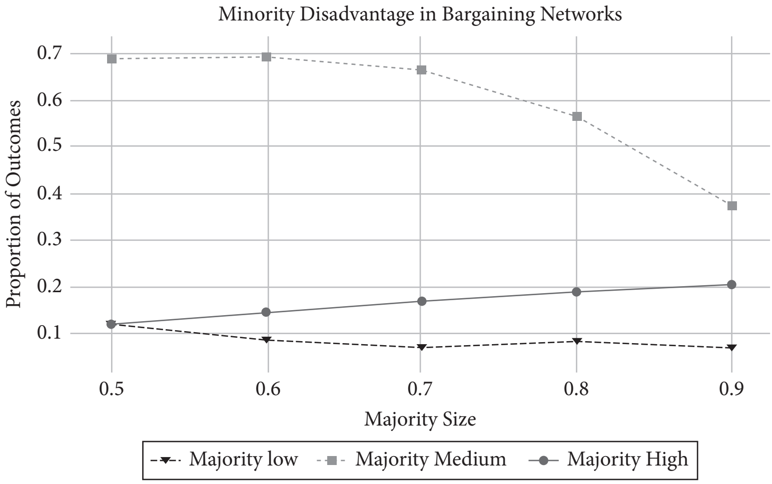

Figure 7.3 An analog of the cultural Red King effect in a network model of agents playing the Nash demand game. Results are averaged over parameter values with H = 6

Perhaps surprisingly, the reason for this trend is actually different from that described in the last chapter. There, minority size caused a difference in learning speed which could lead to disadvantage (or advantage). Here the asymmetry has to do with the average number of between-group network connections for each type. Consider, for example, a community with eight white people and four black people. And suppose that there are eight between-group connections. On average, each white person will interact with one out-group member, and each black person with two out-group members. This sort of asymmetry in out-group connections will exist whenever one group is in the minority.

What this means, for the Nash demand game, is that minority group members will have a greater probability of updating toward lower demands, on average. For example, consider a game with demands 4, 5, and 6. For each white person who has one out-group partner, and for random starting strategies, there is a 1/3 chance that their best response is High (ditto for Medium and Low), because there is a 1/3 chance their single partner starts by playing Low. For each black person with two out-group partners, there is only a 1/9 chance that their best response is High, because this only occurs when both partners demand Low. On the other hand, there is a 5/9 chance that their best response is Low, and 1/3 for Medium. We do not find an analog to the cultural Red Queen in these models, for combinatorial reasons described in Rubin and O'Connor (2018). (The Red King occurs as long as $H < 7$.)

7.2.2 Fixed bargaining, evolving network

Now let us assume a community where discriminatory norms for dividing work and rewards in joint action are already established. In other words, hold bargaining strategies fixed. What happens if we allow the network structure of this model to evolve?

To investigate this question, we consider models where agents use expected payoffs from strategic interactions to update network structure (see Watts (2001)). We assume that agents are making fair demands with their in-group (and so receive a payoff of 5 for each in-group connection) and unfair demands with their out-group. This means that one type gets 6, and the other 4, for each out-group connection. We begin with an empty network. In each round we choose an updater and a potential collaborator. Whenever both of these players are willing to form a link, they do so. Any agent who has not reached their maximum number of links will be willing to form a new one because some payoff from joint action is better than none. For agents who have reached their maximum number of links—essentially the number of interactive partners they can sustain—they consider whether the new potential link will provide more payoff than any of their current ones. If so, agents drop their lowest payoff link and form a new one.[6] Over subsequent rounds of simulation, agents change collaborative partners until the entire network reaches a stable state where no pair of agents is willing to form a new, different link.

We find that these networks always evolve to a state where they are fully homophilous. In other words, each type only interacts with their in-group, and there are no links between the groups. Why? The type that is discriminated against always prefers to interact with their in-group, where they receive a fair payoff. At the beginning of a simulation, links of all kinds form. But once agents reach their maximum number of links, the oppressed type breaks off contact with their oppressors. Once

[6] If the two agents chosen are already collaborators, the updater has the option to break the link and form a new one with another randomly chosen agent. See Watts (2001); Rubin and O'Connor (2018) for more details.

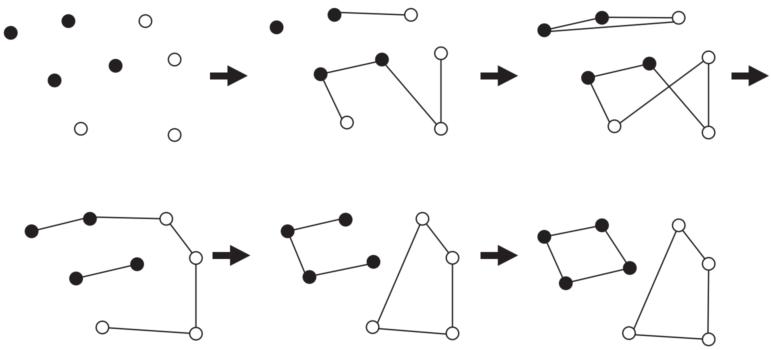

Figure 7.4 An evolving network where eventually agents break all out-group links, leading to total homophily

this happens, the discriminating type forms links with their in-group members, even though they would prefer out-group links that would allow them to get a bigger portion of the pie. Figure 7.4 shows an example of what this might look like in an eight-agent network where the maximum number of links is two. First, agents form links indiscriminately. Once they reach their maximum number of links the oppressed agents (white) break out-group links to form in-group links. The oppressing agents (black) then form in-group links as well.

Returning to academic communities, we see here a potential explanation of why women might tend to collaborate with other women in, say, economics. On the expectation that they will have to do extra work, and receive less credit, should they collaborate with men, they choose a woman partner instead. Notice that one result of homophily in these models is a complete eradication of discriminatory behavior. One group has discriminatory *tendencies*, but since they never get a chance to deploy them, equitable divisions happen across the community. (That sounds unrealistic, and it should. As we will see in the next section, many realistic conditions should shift this picture to one where inequitable behavior is maintained in the group.)

7.2.3 The coevolution of bargaining and network structure

Of course, in real interactive networks, we rarely see complete homophily. The last set of models Hannah and I investigate show what happens when both bargaining and interactive choices update simultaneously. To test this we considered simulation models that began with empty networks, and random strategies. In each round with probability .1 every agent takes one action. The agents either update their bargaining strategy via best response as described above, or else update their network partners as described.[7]

In this model, we observed an emergence of heterogenous strategies throughout the network. Some agents developed discriminatory strategies, and others fair strategies. In response to this, partial homophily emerged at the same time. In particular, agents learned to avoid discriminatory out-groupers, but to maintain links to out-group members who treated them fairly. This meant that there was variety from simulation to simulation as to the level of homophily that emerged in these models. If many agents happened to evolve discriminatory practices, more homophily emerged.

Figure 7.5 shows this trend.[8] As is evident, the greater the level of discrimination, on average, the greater the homophily. To quantify

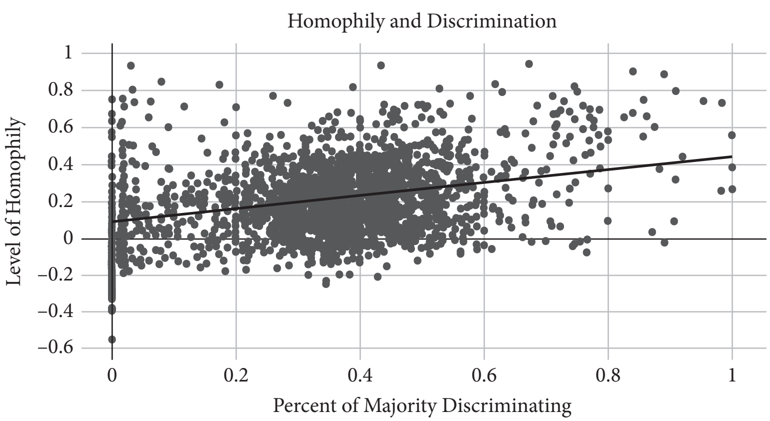

Figure 7.5 Increasing discrimination corresponds to increasing homophily in network bargaining models

[7] Whether an agent updated their bargaining or their network was chosen probabilistically. We considered a .8 probability of updating bargaining strategy and a .2 probability of updating a network link. Similar results emerge for different values.

[8] These results were from simulations with 100 agents and $H = 6$. We varied minority proportion from 10% to 50%. The maximum number of links varied from 3 to 9. We ran 100 simulations for each set of parameter values, running each for 20,000 rounds.

homophily here we use a measure from Currarini et al. (2009) called *inbreeding homophily*. Basically, this measures the proportion of within-group links in the network, controlling for the size of each group.[9]

7.3 Bigger and Smaller Pies

The analysis presented thus far predicts that when two groups engage in joint action, discrimination toward one group should lead to homophily. This does seem to be what we observe in the case of collaboration in academic communities—when women receive less credit for joint work, they are more likely to collaborate with women (as well as to opt out of collaborating). This pattern is not perfect, and the last model we saw predicts that actors will maintain out-group links with those who treat them fairly, while avoiding those who treat them unfairly.

The models discussed thus far, though, also make a key assumption, which is that joint action yields equal amounts of resource, or credit, regardless of who is engaged in it. There are a few cases in which such an assumption will not hold. In Rubin and O'Connor (2018) and Schneider et al. (2019) we consider these cases, and how they impact the results above.

7.3.1 Group privilege

Suppose first that one group generally has special access to resources—social, political, or physical—that increase its productivity. Maybe one group tends to hold greater wealth, and so can get access to the bank loans necessary to start new businesses. Maybe one group has more political capital, and so can use these connections to remove impediments to a joint project, that is, by bypassing slow bureaucratic processes. Maybe one group tends to be more prestigious, and so will tend to get more credit for an academic collaboration by sharing work at prestigious conferences.

We can represent this kind of case by supposing that the size of the "pie" that must be divided between two individuals is biggest if it is produced

[9] Inbreeding homophily (I_i) is defined by:

$$I_i = \frac{H_i - w_i}{1 - w_i}$$

where H_i is the proportion of links for group i that are within-group, and w_i is the proportion of the population that i makes up.

by two members of type A, smallest if produced by two members of type B, and intermediate for one member of each. For instance, maybe two women can generate a resource of value 10, two men one of value 16, and a mixed-gender pairing one of value 12.

What happens in this sort of case? The relative sizes of the pies will define a few different regimes with different interactive outcomes. Consider a model, like those discussed in section 7.2.2, where we assume discrimination happens between groups. Let the Low, Med, and High demands now correspond to demands for .4, .5, or .6 of the resource. And further suppose that those who do the discriminating (type A) are also those with more access to resources.

As we have seen, when the two groups produce similar amounts of resource, homophily occurs because the B types choose to disengage with discriminatory partners. But there are also stable regimes where both types will prefer to interact with their out-group. This occurs, for instance, when the three pie sizes are 15, 14, and 10. Within groups, the expected payoffs are 7.5 and 5, because actors divide their resources fairly. Between groups, the expected payoffs are 8.4 for the A types and 5.6 for the B types. Notice that these payoffs are better than what they would get by collaborating with in-group members, so under an evolving network, we would instead expect actors to maximize their number of out-group connections (Rubin and O'Connor, 2018). Notice also that unlike the models described in the last section, these outcomes are persistently inequitable. The advantages of the A group mean that members of the B group are willing to engage in unfair partnerships to gain access to their partner's extra resources.

If the advantages of the A group are too great, we again expect homophily, but now because A types are unwilling to interact with B types, even though they discriminate against them. Instead, it is better to interact with an in-group member who brings their own special advantages to the table, even if they in turn demand a fair portion of the good that gets produced. In an outcome like this, the groups are homophilic, and B types also receive lower payoffs. Consider, for example, a situation where two As make a pie of value 18, two Bs one of value 10, and a mixed group one of value 13. At stable network outcomes, the A types all receive 9 for each in-group interaction, and the Bs get 5.

To summarize, when one group produces resources of more value, for whatever reason, the picture described in the last section where we expect completely fair treatment, and homophily, breaks down. We sometimes expect homophily, though we do not necessarily expect fair outcomes, and in some cases we expect inequitable between-group interactions to dominate. As an example of this last, think of collaborations between professors and graduate students—in such interactions, the expectation is often that graduate students will perform the lion's share of the work and receive less credit from the community. The opportunity to tap into the personal and monetary resources of an established academic, however, makes the trade-off worth their while. The professor, in the meantime, is willing to collaborate with someone who does not bring as much to the table, but who will do most of the work.

7.3.2 Diversity and synergy

There is one other possibility to consider, which is that in some situations diverse teams may be able to generate resources that homogenous teams cannot. This is often the case when groups interact whose members, by dint of different background training, have complementary skill sets. (See Part I of the book.) In Schneider et al. (2019) we outline several case studies from academia where, by dint of different social training, experience, and access, cross-gender collaboration was especially successful. For example, the early field of sexology, for obvious reasons, benefited from input by both men and women researchers.

There are also empirical results suggesting that in some situations simply combining individuals with different life experiences and social identities can create synergistic effects vis a vis joint production or collaboration. To give a few examples, Sommers (2006) finds that racially diverse juries deliberate more effectively by sharing more information. Phillips et al. (2006) looks at small groups solving problems, and finds that racial diversity improves their decision-making for similar reasons. And, in experimental "markets," Levine et al. (2014) find that prices are more accurate when traders are ethnically diverse because they are more likely to scrutinize the decisions of others. In academia, some authors have found that culturally diverse groups are more productive (Barjak and Robinson, 2008). And Campbell et al. (2013) find that gender-diverse collaborative research is cited more (which they argue is a result of its higher quality).[10]

[10] Freeman and Huang (2015) also find that papers produced by ethnically diverse groups are cited more, but this may result from the relative diversity of their social networks.

Suppose we consider a model where the size of the resource produced between groups is larger than that produced by in-group collaboration. In this case, there is an incentive to drop in-group links, and to form out-group links instead, so as to reap the benefit of this synergy. In other words, we expect negative homophily to emerge. In such models, though, we also expect discrimination between groups to be stable in many cases. For example, suppose one group demands 60% of the resource and the other 40%. If production was the same regardless of group membership, we would expect homophily. If between-group pies are of size 14, while in-group pies are size 10, we expect heterophily (because 5.6 is better than 5). So, again, although one group is disadvantaged with respect to the other group, they still choose out-group partners.

7.4 Discrimination and Academic Progress

Before concluding this chapter, I would like to discuss, in further detail, the interpretation of the models from this chapter as representing bargaining and collaboration in epistemic communities—groups of knowledge-makers such as academics and industry researchers. Philosophers of science are interested in understanding how interactions among members of such communities influence the process of science. This is part of *social epistemology*—the study of knowledge creation emphasizing the role of knowledge-making communities.

In the last few decades, and especially recently, philosophers have used formal models to attempt to understand epistemic communities. Landmark papers by Kitcher (1990), Strevens (2003), Weisberg and Muldoon (2009), and Zollman (2007), for example, have used models to explore questions related to the division of cognitive labor, the role of diversity in science, and how communication networks influence scientific consensus.[11] More recently, in O'Connor and Bruner (2017), Bruner and O'Connor (2015), and Rubin and O'Connor (2018) we've used models to explore not the progress of science directly, but rather the emergence of norms between social categories in scientific communities and the potential impacts of these norms on knowledge.

How do these models translate into an epistemic context? As I have hinted at throughout this chapter, explicit or implicit negotiations are key

[11] Though see Alexander (2013), Thoma (2014), and Rosenstock et al. (2017).

to joint action in academia, and, importantly, to collaborative research projects. This is because in such collaborations academics must decide who will do what work, and also must decide author order on papers produced, which is a proxy for academic credit.[12]

What implications do our results on inequity hold for epistemic communities? Philosophers of science such as Longino (1990), Solomon (2001), and Okruhlik (1994) have convincingly argued that not all knowledge-makers are the same. The experiences and personalities of scientists will matter in how they go about doing science. And in particular diverse communities may be more successful than uniform ones. There are many arguments given in philosophy of science in support of diverse scientific communities. I will not outline them at length here, but will just give an example.[13] Haraway (1989) details how the entrance of women into the field of primatology revolutionized the field, which had previously focused largely on the behaviors of male primates. In this case there is a clear connection between the personal identities of the researchers as women and their research, and a clear benefit to inquiry from this connection.

The implication is that factors that decrease the diversity, or the effective diversity, of scientific fields, may negatively impact science. This seems especially likely in fields where individual experiences impact research choices, like biology and the social sciences. Thus, if discriminatory conventions lead to homophily in academic groups, we might create situations where the benefits to science of diverse collaboration are lost.

7.4.1 Incentivizing collaboration

Given the work just described from philosophy of science, and on the benefits of diverse collaboration more generally, one natural question is: can we incentivize diverse collaborations in science? The framework described in this chapter suggests possible ways to do this. In particular, as we have seen, when individuals expect special benefits from between-group collaboration, we expect them to choose these sorts of interactions.

[12] These models are part of the literature in philosophy of science using a "credit economy" to understand science. The assumption (obviously not always realized in the real world) is that what academics want is credit—recognition from their community, and all that attends it.

[13] Interested readers can find an overview of arguments in support of scientific diversity in O'Connor and Bruner (2017).

In response to this possibility, funding bodies might create special grants for those who wish to form international, or otherwise diverse collaborative groups. Such grants could increase the productivity of these collaborations by, for example, facilitating hiring of research assistants. There is a worry, though, which we raise in Schneider et al. (2019). If discriminatory norms are entrenched between two groups, any initiative to increase interaction between them will also increase the number of discriminatory interactions occurring. Even if we create a situation where the overall payoff outcome is better for both groups (by increasing the between-group pie), we entrench inequities between the groups by incentivizing interaction. As we point out, in the case of academic collaboration, measures intended to improve epistemic outcomes might have unintended social consequences.

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Schelling (1971), in a famous paper, provides an explanation of group-level segregation via appeal to individual discrimination. In particular, his agents prefer to live in neighborhoods where they are not in a small racial minority (less than 30% or so). The result of these preferences is a series of moves that almost inevitably result in spatial segregation by race. While very elegant, this model has been criticized for failing to capture the key causal factors involved in real-world segregation. Among these are a number of structural policies, such as exclusionary mortgage practices and steering by real estate agencies (Galster and Godfrey, 2005; Denton, 2006; de Leeuw et al., 2007). In addition, empirical work indicates that where preferences for racial make up play a role in housing choices, they do not match the minimal discrimination described by Schelling. Instead, Farley et al. (1997) find that black people report hesitation to live in largely white neighborhoods for fear of bias and discrimination. (And, additionally, while black people report preferring mixed neighborhoods, white people's willingness to live in a neighborhood decreases steadily as the proportion of black neighbors increases.)

The framework described in this chapter is not about housing segregation, but rather about interactive segregation—why do people often choose those in their own social identity groups for interaction, and strategic interaction in particular? The answer provided, though, is in line with that developed by Farley et al. (1997). If people are sensitive to the negative effects of discrimination, they should learn to avoid discriminators. This leads to homophily, but also to largely fair patterns of behavior. Where the benefits of out-group collaboration outweigh the detriment of discrimination, we should expect this pattern to reverse, potentially at the cost of equity.

I would like to add one caveat before moving on. All the dynamic network models presented in this chapter assume that actors may freely choose to form and leave collaborative endeavors. In reality, there may be serious constraints to doing so. Actors may be coerced into arrangements that they would not freely choose. Even when actors have freely chosen arrangements, there may be costs to leaving them. A further extension of this work might involve adding such features to these models.