12 Social capital and faculty network relationships

If a man can write a better book,
preach a better sermon,
or make a better mousetrap than his neighbor,
though he builds his house in the woods
the world will make a beaten path to his door.

Ralph Waldo Emerson (1855)

In Chapter 6, we argued that differences in the network of contacts that a person has for exchanging resources and learning – their social capital – explain why and how women students are socially isolated and limited in their opportunities to form relationships, produce science, and gain support for their careers. In Chapter 8, we extended the argument to explain the experiences of newly minted women scientists who experience many of the same biases they did as graduate students, compounding the negative effects of their graduate school relationships and laying the groundwork for a perpetuation of the status quo. In the complex and political world of science, exclusion not only decreases a person's ability to acquire the knowledge needed to build a better mousetrap, but also decreases the ability of others to learn about and adopt it.[1]

In this chapter, we use original survey data on the social networks of men and women faculty members to further explicate our argument

[1] The 'Waldo' hypothesis is interesting in that it so squarely places human capital at the seat of innovation and success. Yet Emerson's own success appears to have been greatly shaped by his accumulation of social capital. Burt (1998) notes that Emerson was born into a poor family and through cultivated ties became noticed by Harvard's ministerial studies department. After graduation, he changed his name to Waldo, built his connections through lectures and the minister's association, and married the daughter of a well-to-do family whom he met at a speaking engagement. The question is would an equally qualified person who did not go to Harvard, have access to the minister's association, or marry well have enjoyed equal success?

and show that exclusion and access measurably affect not only perceptions of difference, but also career performance. Our research strategy triangulates our qualitative findings with survey data from a sample of male and female faculty members of science departments at an elite Midwestern university, a setting in which gender differences should be least likely to matter (Sonnert and Holton, 1994). By examining data on men and women faculty members who work side-by-side we can directly compare their experiences and the consequences of their experiences and explore the representativeness of conclusions.

We demonstrate that the cumulative effects of negative graduate school experiences and tenure-track positions that we described earlier shape attainment and work experiences, even among the select women scientists who have been able to cross the threshold from graduate student to untenured professor. We show that women experience more exclusionary and tokenistic practices in their collegial relationships than their male peers, that their networks are more isolated and alienating, and that these differences are associated with barriers to performance, even when no differences in human capital exist.

The chapter is organized as follows. First, building on the social capital concepts introduced previously, we review how social capital and network structure influence the careers of current female and male faculty members. Second, we describe the differences in the social capital of female and male faculty members. Third, we test the argument and show social capital's effect on the success of scientific careers in the 'publish or perish' world of contemporary science (Cole, 1992; Pfeffer, 1993).

SOCIAL CAPITAL AND DEPARTMENTAL RELATIONSHIPS

In previous chapters we argued that men and women faculty members experience separate scientific worlds. The male world is characterized by stronger social and professional ties than is the female world. Typically, men form close social ties with other male colleagues

within and beyond the department that facilitate access to collegial resources and information, which in turn help them to identify promising studies, manage labs, or learn the politics of tenure and publishing. In contrast, women typically report the obverse: their relationships with male colleagues tend to lack the close personal relationships and high levels of reciprocity they observe in male-to-male relationships within their departments. In this sense, the scientific worlds of women and men faculty who work side-by-side creates an ironic duality. Whereas male faculty work in closely knit social networks of exchange – in 'kula rings' – that belie the conception of the lone scientist finding truth in isolation from outside influences, this lone scientist conception is imposed on women, undermining rather than enhancing their ability to succeed.

In earlier chapters, our interviews with women faculty members discovered that men's and women's relationships varied along two dimensions, which we might broadly refer to as 'colleagueship' and 'reciprocation' – dimensions similar to those found in other professional environments (Podolny and Baron, 1997: 675–6). *Colleagueship* affected a person's sense of exclusion or isolation from their department and colleagues and was manifested in two ways. One indicator of colleagueship was the level of *social support* or friendship in the relationship. Did colleagues form friendships and exchange non-professional or private information in social settings that helped to manage the stress of publishing, teaching, and office politics? The other indicator related to how important the relationship was for conferring a positive *professional identity*. Did colleagues reflect expectations and sentiments that reinforced a positive image of one's ability to be a good scientist and to do good scientific work? Relationships high in colleagueship were reported to be important because they tended to reduce stress and provided a second opinion in a world where the quality and value of one's work is subjectively evaluated and commonly takes years to have a visible impact. The qualitative research suggested that men tend to have ties that are more socially supportive and confer more positive social identity

than women, creating feelings of empowerment and inclusion in male faculty, and estrangement and resignation in women faculty.

Reciprocation affected a person's ability to access and exchange tangible professional resources. It also was manifested in two ways. One symptom related to the degree to which the relationship was characterized by an imbalance of exchange of resources. In particular, we found that women scientists were typically tokens in departments and often experienced 'token overload', meaning that women often had to shoulder tasks and responsibilities that their male peers did not. For example, did colleagues expect their papers to be proofed, exams to be proctored, or grants to be reviewed but not expect to do the same in return? Did women have to take on more committee work for the purposes of providing 'female' representation? The other symptom related to the degree to which the relationship was characterized by *power imbalances.* Did colleagues view the person as a professional equal or unequal? Did women have to work harder to prove their worth and gain the favor of colleagues than did male peers? In the next section, we reveal the results of our survey of male and female faculty members, with special attention to how the qualities of their department relationships differ.

GENDER DIFFERENCES IN QUALITY OF DEPARTMENT RELATIONSHIPS

To examine the differences in the relationships of male and female academics and their effect on attainment, we surveyed faculty members in six hard science departments (biology, biochemistry, chemistry, computer science, engineering, and physics) at a top-ranked, elite U.S. university. The questionnaire provided systematic data on the quality of the departments relationships along the dimensions of colleagueship and reciprocation. A social network was defined as the 'people you go to for vital professional advice or social support regarding work related activities.' Our constructs of Social Support, Professional Identity, Token Overload, and Power Imbalance were measured using the following items and a five-point Likert scale respectively.

(1) 'How important to your personal feelings of well-being is [contact's name]?'
(2) 'To what extent does this contact [name of contact] understand your particular needs as a faculty member?'
(3) 'If the following person [name of contact] asked you to do an activity that had no direct benefit to you (e.g. doing committee work, running an experiment, or proofing a manuscript), would you?'
(4) 'Do you agree or disagree with the following statement? I sometimes exaggerate the qualities (e.g. experience or expertise) of [contact] to show that I value their relationship.'

Other characteristics of the sample, design, and methods used in the survey are described in the appendix.

Consistent with our arguments and field data, we found that women report lower levels of colleagueship and reciprocation in the department relationships than do their male peers. Table 12.1 shows the means of our four measures of relationship quality. We present the relevant comparisons by three categories: all faculty, untenured

Table 12.1 *Quality of department relationships*

	All faculty		Untenured faculty		Untenured women faculty	
Department relationships	Men	Women	Men	Women	Critical mass	Tokens
Social support	3.7*	3.2	3.7*	3.2	3.4*	2.8
Professional identity	4.0	4.1	4.5*	4.2	4.2	4.0
Token overload	3.9*	4.3	3.9*	4.3	4.3	4.5
Power imbalance	3.7*	4.3	3.8*	4.4	4.7*	3.7

Note: An asterisk indicates significant differences in men's and women's responses by category and relationship type.

faculty, and untenured women in departments of critical mass and token status. Departments of critical mass and token status were defined in accordance with prior research (Kanter, 1977; Ibarra and Smith-Lovin, 1997). A department has a critical mass of women faculty if women compose more than 15% of faculty members. A department has a token status if women make up 15% or less of the faculty. (A department has a majority status if women make up more than 60% of the faculty.) Table A1 in the Appendix shows the exact percentage of women in each of the departments we sampled and indicates that biology and biochemistry have a critical mass, whereas chemistry, computer science, engineering, and physics have token status.

The results reveal that on average untenured men experienced their contacts as being more supportive of their psychological well-being than did untenured women. Similarly, untenured men scored their contacts as more enhancing of their professional identity than did women. These results suggest that within the department, male faculty members maintain relationships that provide more social support as well as conferring greater levels of professional identity than do women, a finding that reinforces the conclusions of our fieldwork. Furthermore, these differences suggest that men have more outlets for reducing stress and are empowered to achieve higher goals. Moreover, while these effects may be intangible their importance is hard to overstate because of the unique character of academic careers. The intense stress of tenure and the postponed feedback one receives about one's work means that these factors can both ease the psychological costs as well as maintaining aspiration levels of a serious scientific career.

The results also reveal that women report lower levels of reciprocation in their relationships. This finding is consistent with our interview data and suggests that the problems of colleagueship are compounded by relationships that provide few tangible resources. First, in terms of token overload, women report that they dedicate more resources to their contacts than are likely to be received in return. This finding is consistent with our interview data, which suggests that women faculty are expected to dedicate more resources to their

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relationships to compensate for the false perception that their intellectual contributions are lower than their male peers. Second, the data reveal that women are more likely than their male peers to have unequal power relationships with their colleagues. Women are statistically more likely than their male peers to experience the need to work relatively harder to prove their worth and gain the favor of colleagues.

Like the results regarding the level of colleagueship, these findings suggest that women's department relationships provide fewer of the tangible resources that are important for academic success. Their relationships required more time and resources to sustain than do those of their male peers, with apparently no offsetting level of resource inflows. Thus, they allot more time or effort to communicating and explaining their accomplishments and failures than do the men who are part of the demographic majority (Kanter, 1977). The implications of these findings are that women carry a double burden of meeting the requirements of academic success as well as the added provisions of token overload and unequal power relationships.

We also found that these problems were most acute for women in departments where they had token status (Kanter, 1977), and that a critical mass of women faculty members improved these problems but failed to reduce them to a level where male and female faculty members rated their ties similarly. This is an important extension of our findings and suggests that critical mass has positive effects on women's experiences in science, even though an increase in size may result in divided subgroups of women who are at odds with one another (Kanter, 1977). Indeed, this dividedness is partly suggested by the fact that critical mass improves women's perceptions of relationships but not up to the level of male faculty.

Finally, Table 12.1 shows the relevant comparisons by token versus critical mass status. Consistent with our argument, the data show that women in departments of critical mass are more likely to report relationships that have higher levels of social support and identity enhancement than are women in departments where they are a token

minority. Similarly, their contacts provided more reciprocation than in departments where women were tokens, but were still less positive than men's. Conversely, the results suggest that women in departments where they have token status have a double disadvantage: they are less likely to receive either social support or important productive resources via their relationships. This suggests that while critical mass may be one factor that can overcome the barriers to success of women, other interventions are needed. We return to this in Chapters 13 and 14 where we compare different models of graduate education and their relative successes in reducing gender-related barriers.

GENDER DIFFERENCES IN DEPARTMENT NETWORKS

Our comparison of department relationships also contrasts the number of department ties that men and women faculty members report having for professional or social work-related advice. This analysis supplements our analysis of perceptual measures of relationships with a behavioral indicator – the assumption being that perceptions should correspond with actions (Marsden and Campbell, 1984; Ibarra and Andrews, 1993).

Our fieldwork suggested that faculty who named an intermediate number of contacts tended to have relationships with these contacts that were characterized by high levels of colleagueship and reciprocation. At first blush, this view seems counter-intuitive because more ties are normally assumed to provide better connectedness and access to information and resources. Our research and that of others on scientific careers suggests, however, that although a large network of ties *beyond* a department may be uniformly beneficial, a network of ties within the department that is too small or large may signal problems of integration into the department (Powell *et al.*, 1998). This is because an intermediate number of department ties strikes a requisite balance between having a set of collaborative relationships on the one hand and the ability to sustain meaningful relationships on the other hand.

As we argued in earlier chapters, a network of department contacts that is few in number lacks a wide enough base of social and professional resources to be effective even if the ties within the network are close, giving, and supportive. These kinds of networks are too insular. Our fieldwork suggests that women are more typically in these kinds of department networks than are men. Conversely, a network of strong department contacts that is too large requires a large investment in time and energy to maintain – draining important resources away from other productive activities (Uzzi, 1998). For instance, these processes were exemplified by a woman professor who commented on the compromise between forming many close attachments within department and the need to spend time and resources on other professional activities or building ties to people in other departments. She said, 'The bigger concern is whether energies I spend here are energies I don't spend somewhere else. And somewhere else being things that affect the nurturing outside [relationships].'

Table 12.2 displays the number of strong department contacts named by our respondents. Strong ties were measured by asking respondents, 'What faculty in the department would you feel comfortable approaching for important personal or professional advice?' Table 12.2 suggests that men and women untenured faculty members have similar distributions of strong ties in their departments. Consistent with theory, men tend to have an intermediate number of strong ties – the modal number is three. Somewhat surprisingly, the women in our sample also reported having an intermediate number of strong department ties. However, when these results are disaggregated by critical mass and token status, they suggest that a critical mass of women promotes the development of a well balanced network of strong ties, a finding consistent with our expectations about the role of critical mass. Although the actual numbers make unambiguous inferences troublesome, they suggest, in line with our fieldwork, that in departments with critical mass, women's strong tie networks look like those of their male counterparts. They have neither too few nor too many strong ties within the department. In contrast, women in

Table 12.2 *Number of strong department contacts named*

Ties in the dept.	All faculty				Untenured faculty				Untenured women faculty			
	Men		Women		Men		Women		Critical mass		Tokens	
Number	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
1	11	13	0	0	4	15	0	0	0	0	0	0
2	10	11	3	23	0	0	3	27	3	43	2	50
3	39	46	3	23	16	59	3	27	1	14	0	0
4	9	10	0	0	2	7	0	0	0	0	0	0
5	15	17	7	53	5	19	5	45	3	43	2	50
Total	84	100	13	100	27	100	11	100	7	100	4	100

departments of token status tend to have either too few or too many strong ties – suggesting that their networks may lack the capacity for collaboration or have high maintenance and opportunity costs. Thus, the patterns of results from our interviews, the quantitative data on the perception of the quality of department ties, and the quantitative data on the number of close department ties converge on a similar theme. Women in departments of token status, as opposed to women in departments of critical mass, lack the strong tie networks that promote empowerment and opportunities for academic success within the department.

GENDER DIFFERENCES IN INTERDEPARTMENTAL NETWORKS

Our fieldwork also argues that interdepartmental ties play an important role in the careers of women faculty. While departmental ties are important for colleagueship and the reciprocal exchange of information and resources, interdepartmental ties are important for subfield visibility as well as access to novel or specialized information,

tacts named

ılty	Untenured women faculty			
	Critical mass		Tokens	
·men q. %	Freq.	%	Freq.	%
0	0	0	0	0
27	3	43	2	50
27	1	14	0	0
0	0	0	0	0
45	3	43	2	50
100	7	100	4	100

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needed for research breakthroughs but not represented in the backgrounds of local faculty specialists. Consequently, interdepartmental ties are critical for building reputations and accessing expertise that is unrepresented at the department level. Our fieldwork suggests that women's networks of ties beyond the department were significantly smaller and less diverse than men's faculty – a consequence of the accumulated disadvantages experienced in graduate school and their faculty experiences after graduation – and a barrier to their attainment.

In Chapter 2, we illustrated the importance of interdepartmental ties for gaining information when we described how they promoted Watson and Crick's discovery of the microstructure of DNA. In contrast, the absence of interdepartmental ties inhibited a similar accomplishment by Rosalind Franklin despite the fact that her laboratory had produced the first photos of DNA's structure. Specifically, Watson and Crick's interdepartmental ties to chemists in other laboratories (in particular the chemist who found the mistake in the chemistry text) opened up new opportunities for discovery by providing channels by which to import exciting new ideas and methods from other fields. And while the discovery of DNA's microstructure is an extraordinary case, the same principle holds in many ordinary cases that are arguably as consequential because of their prevalence. For example, a female graduate student recounted her experience of forming a tie with someone outside the department and described how it became a unique and valuable source of professional knowledge and advice.

> [I] . . . went to a grant writing workshop and saw a woman [from another department] there who actually stood up and asked questions. I actually went up and asked her, how do you do this? I'm fine on a one to one, but not in a big group . . . She said, "I sit in the front of the room. Then . . . It's just me and the other person talking." What a great idea. Later on I called her and I told her I was feeling very isolated and I'm wondering if you're feeling the same

> way. She took the time to help. That makes me more likely to help someone else. I felt very touched by it and very lucky.

Our arguments explain the benefits of interdepartmental ties by building on and extending research on the social networks of professionals and entrepreneurs. Consistent with our fieldwork, these approaches have found that the social networks of professionals are made up of two types of connections that can be called *strong ties* (i.e., intradepartmental) and *bridging ties* (i.e., interdepartmental).[2] As noted above, strong ties are characterized by frequent interaction and usually involve collaboration (e.g., reading papers, doing conferences together, sharing committee assignments, co-authoring) or sensitive information (e.g., hidden dress codes, department politics, secrets). Unlike strong ties that require substantial resources to maintain, bridging ties require relatively infrequent contact and usually involve professional acquaintances. The key characteristic of bridging ties is that they are more likely to exist between persons in different professional circles, thereby becoming bridges over which new ideas flow between two otherwise disconnected research teams that could benefit from one another's knowledge. Moreover, bridging ties access information widely because they are likely to link local department networks together, and thus provide crucial viaducts to resources in

[2] A fuller treatment of these theoretical concepts can be found in Granovetter (1973), Burt (1992), Bian (1997), Podolny and Baron (1997), and Uzzi (1997; 1999). Readers from the hard sciences should see D.J. Watts and S. H. Strogatz's 1998 article in *Nature*, which explores the mathematics of networks in biological oscillators, Josephson junction arrays, excitable media, neural and genetic control networks, spatial games, and other self-organizing systems. Their insight is that connections between persons are ordinarily assumed to be either completely regular or completely random. But many types of networks lie between these extremes. On the basis of this assumption, the authors explore simple models of networks that can be attuned to this middle ground: regular networks 'rewired' to introduce increasing amounts of bridging ties. They call these reworked systems of local and bridging ties 'small-world networks', by analogy with the small-world phenomenon popularly known as six degrees of separation. The small-world phenomenon suggests that two strangers anywhere on the planet, such as a falafel maker on a street corner in Jerusalem and Marlon Brando, can be connected by a minimum of just six intermediaries (e.g., a friend of a friend and so on). This notion underscores the social network principle that the right contact can help individuals gain access to resources and information circulating in worlds very distant from their own.

fields like science where knowledge is fragmented and dispersed among many persons.

Our fieldwork suggested that bridging ties position a researcher to learn of new breakthroughs, to get important papers before they are published, to learn where competing researchers are investing their resources, or to import techniques from other disciplines into their own. A large network also generates channels for presenting work, educating users about its importance, and disseminating ideas prior to formal review. Finally, because bridging ties, unlike strong ties, require only modest amounts of resources to maintain, the larger the number the higher the faculty member's social capital. Faculty members who have only strong local ties to members of the department are likely to be cut off from these important channels of information and knowledge because their local department contacts share comparable viewpoints and resources.

A women professor approaching her tenure review revealed a sharp and vivid example of the benefits of a rich network of bridging ties. She commented on the importance of having a social network composed of both strong local ties as well as numerous bridging ties to faculty in other departments who would referee her case.

> So there are two issues, one what the inside letters would look like and what the paper case would look like; that is, the vita. But then there is also what the outside letters are going to look like . . . The way that I am supposed to decide officially from whom to solicit letters is by who knows my work well. I actually have a friend who came up for promotion who picked the seven most important people in his field. Needless to say he didn't get promoted. You just don't do that. You pick people to whom you have been sending your publications; you pick people who really know your work. My sense of how you do this is you have a sense from these people whether they are going to write you good letters. That is, at least you know that they think your work is good. You don't have to walk up to someone and say what kind of a letter will you write me, you know what that person thinks.

PATTERNS OF MEN'S AND WOMEN'S INTERDEPARTMENTAL TIES

Table 12.3 shows the distributions of the number of bridging contacts outside the department. Bridging ties were measured by asking respondents to name the individuals outside the department that they could call if seeking professional information. In line with the previous section we break down the analysis by gender, untenured, and critical mass categories. Consistent with our fieldwork and qualitative interviews, we find that women cite fewer bridging contacts than men do for both the full faculty category and untenured faculty category. Women in departments of token status also report fewer contacts than women in departments with critical mass. These findings show that women, especially in departments of token status, have fewer bridging ties than men, suggesting that they are weak on a key dimension of professional success.

Taken together, a comparison of male and female faculty network within the department and outside the department converge on a

Table 12.3 *Bridging ties: Number of faculty contacts named outside the department*

	All faculty		Untenured faculty		Untenured women faculty	
Number of bridging ties	Men	Women	Men	Women	Critical mass	Tokens
Mean	9.2*	6.3	4.7	4.4	7.0*	4.7
Standard deviation of mean	15.7	6.4	4.9	3.2	7.7	1.2
Minimum	0.0	0.0	0.0	0.0	0.0	3.0
Maximum	99.0	25.0	20.0	10.0	25.0	6.0

Note: An asterisk indicates significant differences in men's and women's responses.

similar and crucial finding: women's networks tend to be poorer in social capital than those of their male peers. While this finding is expected given the fieldwork, the quantitative analysis reveals the sources and patterns of difference along gender lines. Moreover, it demonstrates that the self-reports of women faculty members capture their reality as well as their view of the reality of their male peers. Finally, the triangulation of results reinforces our fundamental conclusions about the sources of women's disadvantage in the hard sciences, and establishes pointers to underlying biases and strategies for overcoming them. In the next section, we examine the consequences of social capital.

ARE GENDER DIFFERENCES IN SOCIAL CAPITAL EXPLAINED BY DIFFERENCES IN OUR HUMAN CAPITAL?

Table 12.4 presents the mean differences between women and men faculty members along our three analytical categories: (a) all faculty by gender, (b) untenured faculty by gender, and (c) untenured women faculty by critical mass of women faculty in the department. Table A2 in the Appendix shows that men and women differ little in their human capital, a finding consistent with prior research on gender stratification in the professions (Pfeffer and Ross, 1982; Davis-Blake and Uzzi, 1993; Schneer and Reitman, 1993; Stroh and Brett, 1996; Uzzi and Barsness, 1998). Age and education level of the sample does not differ significantly when broken down by gender, tenure, or critical mass. The ages of the men and women show no significant differences, except for the difference between untenured women in departments with a critical mass and token status. Our three measures of work experience – years since the Ph.D. (professional age), number of years employed, and number of years in a post-doctoral fellowship position – show no significant differences. Both untenured men and women faculty members have had approximately five to six years of work experience and have spent two or three years as a post-doc before starting their present tenure-track position. Similarly, this sample of untenured women and men are approximately one to two years from

their tenure decision which suggests that their understanding of their department is comparable and unlikely to change significantly before their tenure decision.

Several comparisons of the backgrounds of the women and men were also conducted. As expected, the education levels show no statistical differences by gender. The schools where faculty members received their doctorates are of similar status, and their Ph.D.s are usually from an institution within the top-ranked 15 universities. This is most likely a consequence of the fact that the hiring institution is a prestigious school. Married male faculty members are more likely to have children than are their female faculty peers (no single or divorced faculty members reported having children). Eighty-three percent of the untenured men versus 55 percent of the untenured women ($p < 0.8$) have children. The average age of the untenured women in this sample (41 years) suggests that these women have chosen not to have families, if they do not already have them. One reason for this effect may be that the sample represents 'survivors' (i.e., all women who wanted to start a family have left the sample). Another interpretation is that this sample

Table 12.4 *Respondent's human capital characteristics*

	All faculty		Untenured faculty		Untenured women faculty	
Variables	Men	Women	Men	Women	Tokens	Critical mass
Age	49	46	45	42	36*	45
Professional age	21	18	16	15	9	18
Years employed	14	10	6	6	7	5
Years in post-doc	3	2	3	2	3	2

Note: An asterisk indicates significant differences in men's and women's responses by category and characteristic.

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42	36*	45	
15	9	18	
6	7	5	
2	3	2	

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of women have self-selected themselves into positions predicated on the assumption that they would forgo raising a family.

Finally, 83% of the untenured women in departments with critical mass ($p < 0.005$) have children versus zero percent among untenured women in departments without a critical mass. In sum, there are no significant differences in human capital among members of the same sample. They are all talented and well educated, and share similar work histories. However, there is an important difference between men and women in that a significant larger number of women than men participate in the tenure race without having children.

SOCIAL CAPITAL AND RESEARCH PRODUCTIVITY

The final question we explore is whether differences in social capital translate into differences in research productivity, holding constant human capital. We review the results of a regression analysis that linked social capital differences to research productivity using the popular convention of number of publications. While this measure does not account for conditions of work and job fulfillment, it is the dominant measure used to study career attainment and plays a disproportionately large role in promotion decisions (Zuckerman and Merton, 1972; Seashore *et al.*, 1989; Cole, 1992; Pfeffer, 1993).

In organizing our analysis, we look at three aspects of women's and men's networks that follow from our above examination of the quality of collegial relationships, number of strong ties, and number of bridging ties. First, we examine the predictive effects of *token overload* and *power imbalance* on publication rates, two empirical indicators of our underlying relationship constructs of collegiality and reciprocity respectively. We expect both of these factors to decrease a faculty member's publication success because both represent a lack of reciprocity in exchanges of tangible resources that are crucial for producing research. Following previous research, we do not hypothesize effects for social support or identity enhancement because these factors have been found to affect job turnover and job fulfillment rather than productivity per se (Podolny and Baron, 1997). (In analyses not shown,

these variables did not have a statistically significant association with productivity.) Second, we examine the effects of the number of *strong* ties in the department. We expect faculty members who have insular or expansive department ties to have less attainment than those who keep an intermediate number of department ties. Our argument is that faculty members who keep too few ties are marginalized socially and/or politically in the department. Those who maintain large numbers of contacts experience alienation because their relationships tend to be shallow and low in trust. Third, we examine the effects of bridging ties and expect that bridging ties will be positively associated with publication success. We also include in our analysis standard control variables for human capital and department characteristics to isolate the net effects of social capital on research performance. The Appendix provides a full description of our statistical model and measures.

Table 12.5 reports the results of our regression of research productivity on social and human capital. Model 1 is the control model and contains variables that measure an individual's human capital and control for the statistical properties of their networks. It is presented to demonstrate that the predicted variables hold net of controls. Model 2 contains all the network, human capital, and statistical control variables. A positive and significant coefficient for an independent variable in these models indicates that it is positively associated with the level of research output.

Consistent with our expectations, we found that relationships high on power imbalance tend to reduce academic productivity. We also found that too few or too many strong ties negatively affect attainment, while an intermediate number of department contacts is positively associated with attainment. This suggests that either an under-investment in strong ties or an over-investment in strong ties hurts research productivity. Having too few strong ties decreases possibilities for collaboration and support, while too many strong ties have maintenance costs that override their benefits. Finally, we found that measures of both weak ties (number of contacts beyond the department) and number of co-authors are positively associated with

Table 12.5 *Ordered logit regression of social and human capital on research productivity*

	Model 1	Model 2
Social capital		
Token overload		–0.2542
		(0.3412)
Power imbalance		–0.5258*
		(0.270)
No. of strong ties		30.140***
		(10.080)
No. of strong ties squared		–0.615***
		(0.1712)
No. of bridge ties		0.0880**
		(0.0420)
No. of co-authors		0.0696***
		(0.0206)
Human Capital		
Gender (1=Male)	1.05*	0.0939
	(0.616)	(0.6938)
Tenure (1=Yes)	10.54***	10.062*
	(0.497)	(0.5726)
Professional age	0.036	0.1197*
	(0.056)	(0.0690)
Age	–0.009	–0.0899
	(0.054)	(0.0728)
Controls		
Network turnover	–0.019	0.1588
	(0.149)	(0.1673)
Average duration	–0.006**	–0.0068
	(0.003)	(0.0042)
Research budget	0.001	0.0008
	(0.000)	(0.0012)

Table 12.5 *(cont.)*

	Model 1	Model 2
Post-doc (1=Yes)	0.128	–0.0898
	(0.462)	(0.5362)
Model log likelihood	–930.452	–680.668
Pseudo R^2	0.1232	0.3557
Low productivity cut point	–20.28	–50.047
	(10.82)	(30.279)
Medium productivity cut point	–0.015	–20.004
	(10.76)	(30.259)
High productivity cut point	10.60	0.558
	(10.76)	(30.248)

$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$. Standard errors are in parentheses. N=97.

research success. Consistent with our arguments, these results suggest that a large network of bridging ties aids timely access to intellectual capital.

These effects suggest that one of the underlying barriers to the success of women scientists is the structure of their social networks. Results of both structure and relations point in the same direction. Network structures composed of an intermediate level of strong department ties and a large network of bridging ties beyond the department are consistently associated with publishing by improving the ability of a researcher both to gain access to novel information that is circulating in other networks and to collaborate productively with close ties within the department on research projects.

Model 2
−0.0898
(0.5362)
−680.668
0.3557
−50.047
(30.279)
−20.004
(30.259)
0.558
(30.248)

:ors are in parentheses. N=97.

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SUMMARY

The role of kula rings outlined in earlier chapters is symbolic of the structure of relationships in contemporary science. Like kula rings that are founded on exclusivity and selective access to critical resources, relationships among faculty members follow the same principles of exchange and produce similar outcomes. In the popular parlance of science, the kula ring creates and allocates, through connections among scientists, the social capital that transforms their human capital into productive assets and conditions the experience of their work lives.

This chapter reinforces our conclusions about the social structural conditions that prevent women's full participation in scientific careers, even for those select women who attain faculty status despite having endured the barriers of gender socialization, overt discrimination, and conflicts between work and personal lives. A next step is to focus on the sources and consequences of social capital, and the strategies that can overcome its dark side and increase its benefits for women. Younger male faculty members express an understanding and interest in building more productive cross-gender and gender-inclusive networks, yet new strategies are needed and other problems exist. While women fare better in departments with a higher proportion of women, an increase in the number of women in a department sometimes, paradoxically, does not automatically produce positive effects when women split on key issues, some allying themselves with traditional male faculty members. Next, we examine what strategies have been used, what strategies furnish new possibilities, and what strategies are likely to overcome the problems we have identified.