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IS THERE AN IMPLICIT QUOTA ON WOMEN IN TOP MANAGEMENT? A LARGE-SAMPLE STATISTICAL ANALYSIS

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This article advances strategic management by developing a data-driven simulation method to analyze how the characteristics of a group influence the characteristics of the group's components. We apply our method to the underrepresentation of women in the top management of S&P 1,500 firms. Although extant research suggests that the presence of women in top management could be self-reinforcing, we theorize and provide strong evidence that women face an implicit quota, whereby a firm's leadership makes an effort to have a small number of women in top management, but makes less effort to have, or even resists having, larger numbers of women. In consequence, the presence of a woman on a top management team reduces the likelihood that another woman occupies a position on that team.

INTRODUCTION

Women continue to be significantly underrepresented in the top management of corporations, despite evidence that the "pipeline to the top" is well supplied (Helfat, Harris, and Wolfson, 2006), and that women exhibit managerial skills and styles associated with organizational success in contemporary business (Dezsö and Ross, 2012; Eagly, 2007). In the United States, women account for 47 percent of the labor force and 38 percent of all managerial positions (BLS, 2011). Nevertheless, based on regulatory filings from the S&P 1,500 firms, the percentage of top management positions occupied by women has risen only gradually—from 1.6 percent in 1992 to 5.8 percent in 2000 and 8.7 percent in 2011—and in recent years, the trend lines have flattened somewhat and even turned negative in some cases. Women are particularly underrepresented among positions with profit-and-loss responsibility, holding only 3.7 percent of chief executive officer (CEO) positions and 6.1 percent of line officer positions in 2011. In fact, the percentage of line officer positions occupied by women has declined since 2009, when it peaked at 6.5 percent. By contrast, women held 12.8 percent of professional (or staff) positions, which generally do not have profit-and-loss responsibility. See Appendix S1 for more details.

While there are undoubtedly a number of reasons that firms have not made more progress

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promoting women to top management, including overt and implicit discrimination and specific corporate policies (see Oakley, 2000 for a review), we might argue that these problems should be self-correcting, at least at the level of the individual firm. In general, the presence of a woman on a top management team could be expected to reduce the potentially stressful token status of any other woman who might be promoted to the team concomitant with, or shortly after, her (Kanter, 1977). As women rise up the corporate hierarchy, we would then expect stronger networks to emerge for senior women managers, greater accommodation of women managers' parental responsibilities (Bertrand, Goldin, and Katz, 2010; Miller, 2011), less uncertainty about women's suitability for leadership positions by male managers (Aigner and Cain, 1977; Bielby and Baron, 1986; Phelps, 1972) or investors (Lee and James, 2007), fewer gendered behaviors in screening job applicants (Fernandez-Mateo and King, 2011), and more role models and mentors for women at lower managerial levels (Ely, 1994; Ibarra, 1992, 1993; Tsui, Egan, and Oreilly, 1992; Tsui and O'Reilly, 1989; Williams and O'Reilly, 1998). If this intuitive and optimistic perspective were correct, the presence of female top managers in a particular firm would be self-reinforcing, leading women to cluster there. Indeed, one might regard the presence of a female top manager as a good proxy for the degree to which the firm was hospitable to women in positions of leadership.

We cannot be so optimistic. We theorize instead that women face an implicit quota whereby firms seek to maintain a small number of women on their top management team (usually only one). The basic argument is that, while firms gain legitimacy from having women in top management, the marginal value of this legitimacy declines with each woman, whereas the perceived costs, from the perspective of the male majority in top management, may increase with each woman. An implicit quota on women in top management could explain why the self-reinforcing dynamic described above has not materialized. It also implies that women will tend to disperse among firms rather than cluster.

Our research question boils down to whether the presence of a woman on a particular top management team tends to increase or decrease the probability that another woman will occupy a position on the same team. To our knowledge, no previous study addresses our research question, broadly defined, in a statistically rigorous way. As we discuss in detail later, one possible reason is that it is difficult to draw statistically valid inferences from standard regression approaches when investigating whether the characteristics of a group influence the characteristics of the individuals within that group (Manski, 1993). In addition, we are unaware of a good instrument or natural experiment that could be used to establish causality with respect to female representation in top management across a nationally representative sample of publicly traded firms. Even if such an instrument or natural experiment were identified, many of the problems with standard regression approaches would remain.

To overcome these issues, we develop a novel estimation technique and apply it to data on top management teams in the S&P 1,500 firms over a 20-year period. Our technique builds on spatial data analysis, which is used in criminology, epidemiology, geography, urban studies, and environmental sciences. (See Ellison and Glaeser [1997] for a study of firm agglomeration and Haining [2003] for an overview of the field.) The idea is to compare the actual distribution of objects with the null hypothesis that objects are conditionally randomly distributed, given a set of covariates. We establish this null by using both observable and unobservable factors associated with firms, individual positions, and time to predict the probability that a woman occupies a given top management position. We use these probabilities to simulate what the distribution of women across top management teams would be if having a woman in one position on a team did *not* affect the probability that another woman would occupy a position on the same team. We then compare the distribution of female managers in our simulations with their actual distribution among the S&P 1,500 firms. We find strong evidence of negative spillovers: The probability that a woman occupies a top management team position is 51 percent *lower* if another woman holds a position on the same team.

We perform a more fine-grained analysis by calculating how the magnitude of the spillovers varies by the type of top management position. The strongest spillovers are associated with professional positions, which are generally more supporting, lower in status, and less integral to a firm's operations than line officer or CEO positions. We argue that a firm's managers have greater latitude to use professional positions to satisfy an implicit quota on women in top management. Thus, these results

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provide further support for our theory. We also find that the weakest negative spillovers are from female CEOs, as if female CEOs partially mitigate the negative spillover arising from their presence.

THEORETICAL BACKGROUND

A theory of an implicit quota on women in top management

It is well documented that dominant status groups, like men in the upper echelons of corporations, may enact exclusionary strategies of social closure designed to limit or restrict the access of competing groups to resources and opportunities for status attainment (Collins, 1971; DiTomaso, Post, and Parks-Yancy, 2007; Karabel, 1984; Parkin, 1974; Tomaskovic-Devey and Skaggs, 2002; Weber, 1968; Weeden, 2002). Discernible surface-level attributes, such as race, religion, and notably, gender are frequently the basis for social closure, which may range from explicit quotas, such as those implemented by leading U.S. universities on Jewish college applicants during the twentieth century (Kalman, 2010; Karabel, 1984, 2005) to more covert strategies, such as discriminatory licensing, credentialing, or certification (Weeden, 2002).

We theorize that women in top management face an implicit quota enacted through the recruitment and promotion process. We describe the quota as "implicit" rather than "explicit" or "tacit" because our theory does not require that managers publicly or privately acknowledge the existence of a gender-based quota. Rather, our theory posits that firms make significant organizational efforts to achieve and maintain a low target number of women in top management (usually one woman), but that the effort to promote and maintain women in excess of this target is lower or even in opposition. An implication is that the population of female top managers tends to be fragmented across firms.

Our starting point is that firms clearly face a strong norm of promoting diversity within their ranks (Dobbin, Kim, and Kalev, 2011). Organizations such as Catalyst lobby for greater female representation at senior corporate levels. Some large investment companies overtly promote gender equity across their investment portfolio and in specific funds (Dezső and Ross, 2012). Direct pressure from sex discrimination lawsuits and negative press can exert coercive pressure to hire women into highly visible positions (Skaggs, 2008; Williams, Kilanski, and Muller, 2014). Another source of pressure may be from a firm's own managers. Female managers are especially likely to agree that "because of past discrimination, employers should make special efforts to hire and promote qualified women" (Cohen and Huffman, 2007: 682), and many senior male managers may agree. While many of these influences are hard to observe, one potential exception is provided by women on boards, who may act to influence their firms to hire women into senior management (Bilimoria, 2006; Matsa and Miller, 2011); we provide evidence of this in our analysis (see below). It follows that making a public demonstration of progress toward gender equity in senior management is important for firm legitimacy in the eyes of internal and external constituents (Meyer and Rowan, 1977).

While equal numbers of women and men on the top management team may be normative in an aspirational sense, even a single female top manager could be perceived as a symbol of successful firm-wide gender equity policies (Blalock, 1967; Wajcman, 2013: 32), act as a female representative of the firm to the media and other external constituencies, and generate positive press coverage (Singh and Vinnicombe, 2004). Thus, from the standpoint of organizational legitimacy, female top managers would exhibit declining marginal returns for their firm. Field work also suggests that senior managers who subscribe to the aspirational norm of gender equity feel greater urgency to promote one woman to the top management team than they feel to promote multiple women since having even one female top manager can be enough to surpass peer firms (Kanter, 1977; Thomas and Roosevelt, 2004).

A firm's male majority may even actively resist the ascension of more than a small number of women to the top management team. In general, majority resistance to a minority is increasing in the degree to which the majority perceives the minority to be a threat to its attainment and well-being (Riek, Mania, and Gaertner, 2006), which would frequently be an increasing function of the minority's relative size (Blalock, 1967). Accordingly, studies have found a strong positive relationship between African-American population and hostility in the attitude and behavior of Southern white Americans (Giles, 1977; Orey *et al.*, 2011; Quillian, 1996; Reed, 1972). Likewise, xenophobia in Europe increased with the size of the local foreign

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population (Scheepers, Gijsberts, and Coenders, 2002; Semyonov, Raijman, and Gorodzeisky, 2006). Research on gender finds that as the representation of female managers increases, male managers may perceive them as a greater threat (Beaton, Tougas, and Joly, 1996), try to set them against one another (Kanter, 1977), and provide them with less social support and encouragement for promotion (South *et al.*, 1982). The degree of majority resistance often appears to increase at a convex rate when a minority grows to as little as 20 percent (Blalock, 1967), that is, roughly the percentage of one woman on a typical five-person top management team.

Thus, the impetus to devote firm resources toward satisfying the aspirational norm of gender equity in top management is likely to be greatest with respect to low numbers of women and to decrease or perhaps even reverse with respect to larger numbers of women. A woman who is not among the "chosen few," meaning that she is deprived of her firm's best efforts to promote women to top management, is more likely to remain stuck at a lower level, pursue an alternative career, or leave for another firm (where she could become one of the "chosen few" to advance to top management). The implication is that, all else equal, the presence of a woman on the top management team of a given firm will have negative spillovers for the possible presence of other women on that same team in that same year. Formally, we have:

Hypothesis 1: The presence of a woman in a given top management position in a firm will be negatively associated with the contemporaneous presence of another woman in a top management position in that firm.

The implicit quota by position

Not all positions on a top management team are equal in power or status. The CEO has profit and loss responsibility for the firm as a whole. Line positions such as the chief operating officer or the head of a subsidiary generally have profit and loss responsibility, too, and may act like CEOs for the parts of the firm they run. In contrast, professional positions such as chief accounting officer or head of human resources, while undoubtedly important, have more of a supporting role. The CEO and line officer positions are thus more integral to the operation of the firm than are professional positions.

Of the more than 6,400 first-time CEOs in our data, we can confirm that about 47 percent were promoted from a line officer position, versus 4 percent from a professional position. Thus, one would expect that CEO would be the most desirable, highest status position, and that the category of line officer would be, on average, more desirable and higher in status than the professional category. Indeed, when we ranked each manager in terms of salary and bonus from lowest to highest, the mean ranks were 1.32, 3.36, and 3.89 for CEOs, line officers, and professionals, respectively.

It follows that male managers would be more supportive of promoting a woman to a professional position than to a CEO or line position, and that enacting an implicit quota on women in top management would play a particularly large role among promotions to professional positions. If so, the largest negative spillovers predicted by Hypothesis 1 should be associated with professional positions in two distinct but related ways. First, if there is a woman in a top professional position, it would be especially likely that she was promoted to that position because there would otherwise not have been enough other women on the firm's top management team, that is, the presence of a woman in a top professional position would be especially likely to imply the absence of a woman in another top management position. Formally, we have:

Hypothesis 2A: The presence of a woman in a top professional position in a firm will have a particularly strong negative association with the contemporaneous presence of another woman in a top management position in that firm.

Second, if a firm has identified a woman for a position on its top management team and so has less impetus to identify other women for promotion to that team, professional positions would be disproportionately affected. We thus have:

Hypothesis 2B: The presence of a woman in a top management position in a firm will have a particularly strong negative association with the contemporaneous presence of another woman in a top professional position in that firm.

Alternative explanations

There are other theoretically grounded explanations for the negative spillovers predicted by Hypothesis 1.

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Operational efficiency

Diversity in a surface-level characteristic such as gender can trigger expectations that informational differences may be present and can legitimize the expression of divergent perspectives (Phillips, Liljenquist, and Neale, 2009; Phillips and Loyd, 2006), leading a top management team to consider a more comprehensive set of solutions and make better decisions (Hoffman and Maier, 1961; Wiersema and Bantel, 1992). However, diversity may become excessive, causing problems with communication (Wiersema and Bantel, 1992). Perhaps, the decision-making of a top management team is most efficient when women are a small but extant minority. We consider this explanation by building on Dezső and Ross (2012), who made the foregoing argument and used similar data to show that (1) having a woman on a top management team improved firm performance, but (2) only to the extent of a firm's innovation intensity as measured by spending on research and development. It follows that if firms seek female representation in top management to maximize operational efficiency, then such representatation should be more prevalent the greater the benefit it confers, that is, the greater the firm's spending on research and development.

The "queen bee syndrome"

Some admittedly controversial accounts suggest that women may be resistant to supervisory relationships with other women, the so-called "queen bee syndrome." A token woman in top management may be given preferential access to resources (Blalock, 1967) or benefit from being different in an environment in which success is associated with being known (Kanter, 1977). If so, a token woman on a top management team may regard another woman on the top management team as a threat (Staines, Tavris, and Jayaratne, 1974). In addition, members of a disadvantaged minority (here, women) may affiliate psychologically with the ideology of the advantaged majority (here, men) (Chattopadhyay, Tluchowska, and George, 2004). A woman in top management may have to demonstrate an ongoing commitment to the male majority's norms to be accepted (Nieva and Gutek, 1981). Her membership in such a high status group might be threatened if she exhibits favoritism toward other women or if other women either bring higher qualifications or reinforce negative stereotypes about women's management qualifications (Duguid, Loyd, and Tolbert, 2012). As a result, relationships among women in male-dominated environments may be more competitive than supportive (Ely, 1994; Mavin, 2006). These postulated behaviors could be responsible for the negative spillovers predicted by Hypothesis 1.

We consider this explanation by noting that CEOs have more influence than other top managers on the composition of the top management team. If negative spillovers arise due to the "queen bee syndrome," they should be strongest running from a female CEO to other women in top management positions, and strongest of all to women in line officer positions. This would be true because a female line officer would represent a more credible internal replacement for the CEO than a woman in another position, and because poor performance on the part of the line officer would be more likely to reinforce negative stereotypes about female managers (Duguid *et al.*, 2012), and thereby, undermine the CEO's credibility.

EMPIRICAL ANALYSIS

Data

In general, U.S. public companies are required to report information on the CEO and four other most highly paid managers. We use Standard & Poor's ExecuComp, which provides data on these executives for the S&P 1,500 firms, an index of public companies designed to reflect the overall U.S. equity market. Following previous research, we take the managers reported in ExecuComp to be a firm's top management team (Dezső and Ross, 2012). The size of these top management teams is in line with studies in the upper echelons literature, which typically report an "inner circle" of top management with between three and seven people (Carpenter and Sanders, 2002). The sample period is 1992–2011.

ExecuComp contains information on gender and job title, but job title is missing for 67 percent of the managers in one or more years, or for about 22 percent of the observations. We accordingly supplemented ExecuComp using BoardEx, which provides career histories for board members of U.S. public companies, many of whom are top managers in ExecuComp. To match managers between ExecuComp and BoardEx, we first used

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three common company identifiers—Central Index Key, CUSIP, and ticker symbol—and then matched managers within each firm by name, year of birth, and years of entry and exit. Ambiguous cases were manually confirmed with extensive web queries. After the matching procedure, the number of managers with any missing titles for any year was reduced to 43 percent.

Inspection of the data revealed that approximately 100 female managers were improperly coded as male because the managers in question had the female honorific "Ms." and obviously female first names. (The number of men improperly coded as female appeared to be much lower.) We accordingly coded a manager as a woman if either ExecuComp coded the manager as a woman or the manager had the honorific "Ms." (Our results do not qualitatively change if we use ExecuComp's gender coding as is.)

We used S&P's CompuStat database for firm financial information and the Center for Research in Securities Prices for firms' initial public trading date. Additional information on boards of directors came from ISS, which contains data on board members of S&P 1,500 companies from the early 1990s to today.

Variable definitions

The subscript $t-1$ refers to lagged values, and the Greek letter Δ refers to the change from year $t-1$ to year t.

Dependent variable

We define the dummy variable *Female*, which takes the value 1 if a given top management position in a given firm in a given year is occupied by a woman. This variable serves as the equivalent of a dependent variable in our estimation methodology as described below.

Job categories

We extend the taxonomy of job categories of Helfat *et al.* (2006). *Chief executive officer* is coded using the CEO flag field in ExecuComp. For more than 99 percent of the firm-years in our sample, ExecuComp identifies one and only one CEO. *Line officer* denotes senior managers with profit-and-loss responsibility; these include a second-in-command after the CEO, like the President or COO (Hambrick and Cannella, 2004) and the head of a division or subsidiary. *Professional* denotes a manager with responsibility for a staff area; examples include chief accounting officer, chief administrative officer, chief compliance officer, chief financial officer, chief marketing officer, chief technology officer, general counsel, head of human resources, and head of research and development. *Ex CEO* is a small category for managers who served as CEO, and subsequently, shifted to an advisory capacity. All other managers are classified as *Miscellaneous*, which is the omitted category in all statistical analyses and accounts for about 20 percent of the observations; these managers' titles are either missing or do not indicate the nature of the manager's job (e.g., EVP, VP, or SVP, but without any additional information). Some managers have titles that span categories; the most common example is a CEO who is also COO or President. To resolve these instances, we establish a status hierarchy of *Chief executive officer* > *Line officer* > *Professional*, and assign managers to the highest category for which they have an appropriate title. About 71 percent of *Chief executive officer*–years and 28 percent of *Line officer*–years have titles from a lower-ranking category.

Female representation in other positions

One natural but econometrically problematic way to test for gender spillovers among top management team positions is as follows: For each top management position, use a measure of the count or frequency of female managers on the rest of that team as an independent variable of interest. To illustrate why this approach is problematic, we present regressions with such a measure below and provide a more formal discussion in Appendix S1. Specifically, for each observation, we define the dummy variable, *Other woman*, which takes the value 1 if any of the other managers on the same top management team in the same year is also a woman and is otherwise 0.

Other control variables

We include a number of control variables, many of which have been linked to female representation in top management in the literature. We primarily use lagged values to mitigate concerns of endogeneity, although we acknowledge that, in principle, all of these variables are influenced by firm strategy. We

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include (untabulated) year fixed effects to control for time trends.

Firm performance factors include *Advertising intensity*$_{t-1}$, a log transformation of the ratio of advertising expenses to assets, which encodes firms' orientation toward consumer sales; female managers' potentially superior understanding of women's tastes may be important if a firm is focused on selling to consumers (see, e.g., Hillman, Shropshire, and Cannella, 2007: 944, and the references therein). Research dating at least from Stinchcombe (1965) argues that societal norms at a firm's founding affect organizational characteristics later, so we include *Firm age*, a log transformation of the firm's age in years measured as the difference between the current year and the earlier of the firm's first year in CompuStat or CRSP. *Leverage*$_{t-1}$ is the ratio of debt to the market value of a firm's assets. Dezső and Ross (2012) found that innovation intensity makes female participation in top management more valuable. Thus, we control for this with *R&D intensity*$_{t-1}$, a log transformation of the ratio of R&D expense to assets. *Size – assets*$_{t-1}$, a log transformation of the book value of a firm's assets, and *Size – employees*$_{t-1}$, a log transformation of the size of a firm's workforce, provide two proxies for the possibility that women may be averse to workplace environments characterized by steep promotion tournaments (Matsa and Miller, 2011; Niederle and Vesterlund, 2007). *Tobin's* q_{t-1}, a log transformation of the ratio of the market value of a firm's assets to their replacement value, controls for a possible relationship between firm performance and the presence of women in the top management team. If R&D expense or advertising expense is not material, a firm is not required to disclose it. Accordingly, we impute the value of 0 to these items if they are missing.

Female board members may act to influence their firms to hire women to top management (Bilimoria, 2006; Matsa and Miller, 2011). We proxy for this possibility using *Board women*$_{t-1}$, which measures the number of women on a firm's board. We measure overall board size with *Board members*$_{t-1}$. We log transform both these variables to reduce their skewness. We only have board data for about 60 percent of our firm-years. Where board data are missing we set these variables to 0 and set the dummy variable *Board data missing* equal to 1. The *Number of executives* reported by the firm in ExecuComp controls for the possibility that the number of managers a firm reports in its public filings is endogenously related to the gender composition of its top management team. *Number of women*$_{t-1}$, that is, the subset of *Number of executives*$_{t-1}$ who are women, dynamically controls for persistence in female representation in a firm. We consider Δ *Number of women* as a possible dependent variable, as described below.

Table 1 reports summary statistics and correlations.

Estimation challenges

We face a number of econometric challenges in testing our research question. First, we have explicitly theorized the existence of simultaneity in the sense that the probability that a given top management team position in a given firm in a given year is occupied by a woman is affected by whether another position on the same team is occupied by a woman, and vice versa. Second, our data are not a proper panel because the jobs comprising a firm's top management team change from year to year. Third, some managers change job categories from year to year, both in reality and because the language of their job title description changes, allowing us to code them precisely in some years, but only as *Miscellaneous* in other years. Fourth, we have persistence in the sense that having a woman on a top management team in a given year makes it more likely she will be on that team in subsequent years, although not necessarily in the same position. Fifth, it is almost certainly true that unobservable heterogeneity at the firm level influences the propensity for a top management position to be occupied by a woman. Sixth, female representation on a top management team is bounded both at the individual level (*Female* is either 0 or 1) and at the team level since a firm cannot have fewer than 0 women on its top management team or more women than there are members. Seventh, mean reversion creates a downward bias if we use the number of women on a team to predict changes to that number of women. Eighth, *Other woman* (or any similar measure) is mechanically related to *Female* by construction. To our knowledge, there is no existing methodology that successfully addresses all of these issues.

Analysis at the position level

We now discuss how some of these challenges create problems for standard regression methodologies, with further details provided in

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Table 1. Descriptive statistics and correlations

	Mean	Std. dev.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13
1. *Advertising intensity*$_{t-1}$	0.01	0.03	0.00	1.13													
2. *Board data missing*	0.39	0.49	0.00	1.00	0.01												
3. *Board members*$_{t-1}$	1.42	1.15	0.00	3.87	−0.01	−0.98											
4. *Board women*$_{t-1}$	0.49	0.72	0.00	3.26	0.04	−0.55	0.60										
5. *Chief executive officer*	0.16	0.37	0.00	1.00	0.00	−0.02	0.02	0.00									
6. Δ *Number of women*	0.03	0.36	−4.00	4.00	0.00	−0.01	−0.01	0.00	−0.02								
7. *Ex CEO*	0.02	0.13	0.00	1.00	0.00	−0.04	0.04	0.02	−0.06	0.00							
8. *Female*	0.06	0.23	0.00	1.00	0.03	−0.04	0.04	0.03	−0.08	0.13	−0.03						
9. *Firm age*	2.85	0.80	0.69	4.13	−0.03	−0.29	0.33	0.30	0.01	0.01	0.02	−0.02					
10. *Leverage*$_{t-1}$	0.16	0.15	0.00	0.97	−0.10	−0.03	0.06	0.05	0.00	−0.01	0.00	−0.02	0.18				
11. *Line officer*	0.28	0.45	0.00	1.00	0.02	−0.05	0.05	0.04	−0.27	−0.01	−0.08	−0.03	0.03	0.00			
12. *Other woman*	0.25	0.43	0.00	1.00	0.06	−0.10	0.10	0.08	0.02	0.29	0.01	0.08	−0.02	−0.03	0.00		
13. *Number of executives*	6.28	1.42	1.00	15.00	0.01	−0.02	0.04	0.07	−0.08	0.16	0.03	0.00	0.07	0.05	0.01	0.13	
14. *Number of women*$_{t-1}$	0.34	0.64	0.00	7.00	0.08	−0.11	0.10	0.08	0.00	−0.21	0.00	0.38	−0.03	−0.04	0.00	0.70	0.06
15. *Professional*	0.34	0.47	0.00	1.00	0.00	−0.06	0.05	0.02	−0.31	0.00	−0.09	0.10	−0.01	0.00	−0.44	0.02	−0.07
16. *R&D intensity*$_{t-1}$	0.03	0.06	0.00	2.76	−0.02	0.06	−0.09	−0.07	0.00	0.00	0.00	−0.01	−0.16	−0.28	0.00	−0.01	0.02
17. *Size – assets*$_{t-1}$	7.39	1.79	0.43	14.63	−0.08	−0.28	0.35	0.43	0.00	0.00	0.02	−0.01	0.41	0.31	0.04	0.01	0.12
18. *Size – employees*$_{t-1}$	1.96	1.26	0.00	7.65	0.08	−0.19	0.25	0.41	0.00	0.01	0.02	0.00	0.40	0.14	0.05	0.01	0.16
19. *Tobin's q*$_{t-1}$	1.01	0.37	0.26	4.66	0.12	0.07	−0.09	−0.04	0.00	0.01	0.00	0.01	−0.27	−0.50	0.00	0.02	−0.02

	14	15	16	17	18
15. *Professional*	0.05				
16. *R&D intensity*$_{t-1}$	−0.03	0.02			
17. *Size – assets*$_{t-1}$	−0.01	−0.03	−0.30		
18. *Size – employees*$_{t-1}$	0.00	−0.06	−0.24	0.66	
19. *Tobin's q*$_{t-1}$	0.02	0.00	0.37	−0.32	−0.13

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Table 2. Preliminary analysis of gender spillovers among top management positions

	Linear probability *Female*				Ordinal logit Δ *Number of women*
Dependent variable	1	2	3	4	5
Other woman	3.59***	−20.14***	−15.91***	−27.80***	
	(0.47)	*(0.59)*	*(0.65)*	*(0.66)*	
Chief executive officer	−4.88***	−4.34***	−4.30***	−4.12***	
	(0.31)	*(0.26)*	*(0.28)*	*(0.26)*	
Ex CEO	−6.21***	−5.19***	−5.65***	−5.26***	
	(0.33)	*(0.33)*	*(0.38)*	*(0.37)*	
Line officer	−2.09***	−1.94***	−1.94***	−1.86***	
	(0.27)	*(0.21)*	*(0.28)*	*(0.22)*	
Professional	2.34***	1.67***	1.93***	1.49***	
	(0.30)	*(0.25)*	*(0.28)*	*(0.26)*	
Advertising intensity$_{t-1}$	16.60***	2.92	−1.74	−8.00	0.89
	(4.25)	*(2.20)*	*(7.89)*	*(6.34)*	*(0.61)*
Board data missing	0.86	1.60*	−1.64	0.45	0.54*
	(1.51)	*(0.97)*	*(1.83)*	*(1.48)*	*(0.28)*
Board members$_{t-1}$	0.43	0.58	−0.53	0.11	0.19
	(0.69)	*(0.43)*	*(0.80)*	*(0.65)*	*(0.12)*
Board women$_{t-1}$	0.51	0.24*	0.71**	0.42**	0.07*
	(0.21)	*(0.14)*	*(0.25)*	*(0.19)*	*(0.04)*
Firm age	−0.68***	−0.21**	−1.68**	−1.64***	−0.09***
	(0.18)	*(0.11)*	*(0.81)*	*(0.54)*	*(0.03)*
Leverage$_{t-1}$	−1.62**	−0.44	−1.79	−0.74	−0.26
	(0.88)	*(0.57)*	*(1.52)*	*(1.16)*	*(0.16)*
Number of executives	0.18**	0.30***	0.97***	1.11***	0.42***
	(0.07)	*(0.08)*	*(0.10)*	*(0.09)*	*(0.02)*
Number of women$_{t-1}$		23.19***		19.81***	−1.33***
		(0.51)		*(0.46)*	*(0.52)*
R&D intensity$_{t-1}$	−9.47***	−2.91**	−5.66	−0.95	−1.50***
	(2.22)	*(1.35)*	*(4.60)*	*(3.00)*	*(0.36)*
Size – assets$_{t-1}$	−0.40***	−0.10	−1.07**	−0.45	−0.08***
	(0.11)	*(0.07)*	*(0.48)*	*(0.31)*	*(0.02)*
Size – employees$_{t-1}$	0.26	0.06	−0.73	−0.45	0.01
	(0.16)	*(0.09)*	*(0.69)*	*(0.41)*	*(0.02)*
Tobin's q_{t-1}	0.26	0.57**	−0.30	0.69*	0.09
	(0.39)	*(0.25)*	*(0.51)*	*(0.40)*	*(0.07)*
Firm fixed effects	N	N	Y	Y	N
Year fixed effects	Y	Y	Y	Y	Y
Observations	184,467	184,467	184,467	184,467	30,841

*, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.
Standard errors are in parentheses and are clustered at the firm level. The subscript *t – 1* refers to the prior year. Δ indicates a change in value from *t – 1* to *t*. Coefficients and standard errors in Models 1–4 are expressed in percentage terms.

Appendix S1. Consider an OLS regression with *Female* as the dependent variable and *Other woman* as the independent variable of interest as depicted in Table 2, Model 1. (Table 2 uses linear regression to make interpretation easier; discrete choice models yield qualitatively the same results.) The positive coefficient on *Other woman* seems to indicate that the probability of having a woman in a given top management position is positively affected by having a woman in another top management team position in the same firm in the same year. But this inference is unwarranted because of unobservable firm-level factors (e.g., related to history, location, type of business, etc.) that make some firms more likely to have female managers than others. Absent a control for these

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factors, *Other woman* may proxy for them, thereby serving as a measure of the probability that the top management team has a woman in any position, which would be positively correlated with *Female*. If so, the coefficient on *Other woman* would have a positive omitted variable bias.

Two standard ways of controlling for unobservable firm-level factors are to include *Number of women*$_{t-1}$, which dynamically controls for the propensity of a firm to have a female top manager, and firm fixed effects, which control for the time invariant characteristics of a firm, including its propensity to have a female top manager. Models 2–4 add *Number of women*$_{t-1}$, firm fixed effects, or both, respectively. In each regression, *Other woman* is negative and highly statistically significant, as if to indicate that the probability of having a woman in a given top management position is negatively affected by having a woman in another top management position in the same firm in the same year. However, this inference, although consistent with the results we report later, is not warranted. First, the relationship between *Other woman* (or any similar measure) and the group mean of *Female* induces a mechanical negative bias. (See Appendix S1 for a formal proof.) The bias disappears asymptotically in the number of observations used to calculate the mean of the dependent variable with respect to each group of observations. In Model 1, the group is the entire dataset, so the negative bias is vanishingly small. In the fixed effects regressions, each group of observations corresponds to a firm, so the negative bias is potentially much larger. In fact, based on the analysis in Appendix S1, the number of observations we have per firm is small enough for the bias to be large. Second, *Number of women*$_{t-1}$, has a similar effect because of persistence, that is, managers tend to have multi-year tenures on their top management teams. Consider a firm for which *Number of women*$_{t-1}$ equals 1. There is likely to be one and only one woman in year *t*, too, making the combination of *Number of women*$_{t-1}$ and *Other woman* a negative determinant of *Female* in year *t* without actual gender-related spillovers among top management positions.

In addition, because for a given observation, *Other woman* is a contemporaneous function of the dependent variable *Female* in other observations, all the regressions in Table 2, Models 1–4 suffer from a simultaneity bias, which usually grows rather than shrinks asymptotically. The direction and size of this bias is unknown, but the analysis in Appendix S1 suggests it may be meaningful here.

Analysis at team level

Another potential approach is to analyze changes at the team level by using an ordinal logit model to regress Δ *Number of women* on *Number of women*$_{t-1}$ and other controls, as depicted in Table 2, Model 5. If there are positive (negative) spillovers, then large values of *Number of women*$_{t-1}$ should be associated with positive (negative) changes and small values with negative (positive) changes. The negative and highly statistically significant coefficient on *Number of Women*$_{t-1}$ suggests a strong negative spillover; we confirm this by examining the (untabulated) marginal effects of *Number of women*$_{t-1}$, which are −0.067 vis-à-vis the outcome +1 woman and 0.045 vis-à-vis the outcome −1 woman, in each case highly statistically significant. Again, however, making such an inference is unwarranted because the coefficient on *Number of women*$_{t-1}$ is biased downward. Due to mean reversion, large (small) values of *Number of women*$_{t-1}$ are more likely to be followed by negative (positive) values of Δ *Number of women*. Another downward bias arises from the implicit bound on the size of each top management team. Imagine that a five-person top management team has no woman in year *t – 1*. Possible changes range from [0,5]. Conversely, if that top management team has one woman in year *t – 1*, the range of possible changes shifts down to [−1,4].

A simulation-based approach

Because to our knowledge there is no existing regression methodology that addresses these issues, we developed an alternative approach. We use the data to predict as precisely as possible the probability that each top management position in a given firm in a given year is filled by a woman, while ignoring gender spillovers, that is, that the probability may be influenced by whether other positions on the same team are filled by women. We then use these predicted probabilities to generate simulated populations of top management teams across our data. If the simulated populations, which are, in principle, free of spillovers, exhibit more fragmentation of women across top management teams than exists in the actual population, then we conclude that women tend to cluster in reality

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and that the probability that a woman occupies a given top management position is higher if other positions on the same team are filled by women. Conversely, if the simulated populations exhibit more clustering of women in top management teams than in the actual population, then we conclude that women are more fragmented in reality, that is, that the probability that a woman occupies a given top management position is lower if other positions on the same team are filled by women.

Roughly 44 percent of our observations are accounted for by firms that never had a woman on their top management team in the sample period. For these firms, we impute a value of 0 to the probability that a woman occupies any given position. This imputation and our use of firm fixed effects (see below) bias our results against finding negative spillovers because, in fact, the *ex ante* probability that a woman would have occupied a senior management position in one of these firms in any given year is perforce larger than zero, and the firm fixed effects incorporate some portion of whatever spillovers exist in reality. For the remaining observations, we proceed by running the following conditional logit regression:

$$y^*_{ijt} = \alpha + \beta_C C_{ijt} + \beta_X X_{jt} + \varphi_t + \zeta_j + \varepsilon_{ijt}$$

$$Female_{ijt} = \begin{cases} 1 & y^*_{jt} > 0 \\ 0 & \text{otherwise} \end{cases}, \qquad (1)$$

where y^*_{ijt} is a latent variable representing the underlying propensity for top management position i in firm j in year t to be filled by a woman; α is a constant; C_{ijt} is a vector of job category indicator variables; X_{jt} is a vector of firm level controls; φ_t is a year fixed effect; ζ_j is a firm fixed effect; and ε_{ijt} has the standard logistic distribution. Because we have too many firms to estimate the firm fixed effects directly, we condition on the sum of *Female* across each firm so that we can generate estimates of $\alpha, \beta_C, \beta_X, \varphi_t$.

The first column of Table 3 reports the estimated coefficients and the second column reports marginal effects (which, following standard protocol, are unconditioned on the group effects). Women are more likely to be in professional positions and less likely to be in line positions. Women are especially unlikely to be CEO, and even less likely to be a former CEO kept on in an advisory capacity. *Board women*$_{t-1}$ is significant and positive, even though *Board members*$_{t-1}$ has no explanatory power. Firms accordingly seem to hire more women to senior management in response to actions by their female board members, illustrating the power of social forces that motivate a firm to maintain some level of female representation in top management.

As discussed when we considered operational efficiency as an alternative explanation for our

Table 3. Simulation regression

	Conditional logit *Female*	
Dependent variable	Coefficients	Marginal effects
Chief executive officer	−1.64***	−32.24***
	(0.12)	*(2.44)*
Ex CEO	−2.45***	−48.10***
	(0.27)	*(5.24)*
Line officer	−0.56***	−10.92***
	(0.06)	*(1.20)*
Professional	0.21***	4.20***
	(0.06)	*(1.10)*
Advertising intensity$_{t-1}$	−0.58	−11.49
	(0.70)	*(13.76)*
Board data missing	0.24	4.81
	(0.18)	*(3.52)*
Board members$_{t-1}$	0.10	1.90
	(0.08)	*(1.57)*
Board women$_{t-1}$	0.05**	0.90**
	(0.02)	*(0.46)*
Firm age	−0.30***	−5.95***
	(0.07)	*(1.41)*
Leverage$_{t-1}$	−0.13	−2.52
	(0.14)	*(2.81)*
Number of executives	0.02	0.30
	(0.01)	*(0.19)*
Number of women$_{t-1}$	0.89***	17.47***
	(0.03)	*(0.65)*
R&D intensity$_{t-1}$	−0.11	−2.07
	(0.27)	*(5.40)*
Size – assets$_{t-1}$	−0.02	−0.44
	(0.04)	*(0.79)*
Size – employees$_{t-1}$	−0.06	−1.27
	(0.05)	*(0.97)*
Tobin's q$_{t-1}$	0.10**	1.92**
	(0.05)	*(0.89)*
Firm fixed effects	Y	Y
Year fixed effects	Y	Y
Observations	184,467	184,467

*, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.
Standard errors are in parentheses and are clustered at the firm level. The subscript *t – 1* refers to the prior year. Marginal effects are expressed in percentage terms and are unconditional on the firm fixed effects. Because 81,519 observations are accounted for by firms that never had a female top manager, 102,948 observations were used to fit the model.

findings, prior research suggests that the positive performance benefits from female representation in top management increase with a firm's spending on R&D. If the extant pattern of female representation in top management arises because firms are rationally maximizing their own performance, we would expect to see a positive relationship between $R\&D\ intensity_{t-1}$ and the probability that a woman occupies a given top management position. In fact, $R\&D\ intensity_{t-1}$ is insignificant and negative. We conclude there is no support for operational efficiency as an explanation for the negative gender-related spillovers in top management that we document below.

The insignificance of $Advertising\ intensity_{t-1}$ is also intriguing given that this variable proxies for what is viewed in the literature as a potentially important benefit of female representation in top management. *Number of executives* is not significant either, suggesting that firms do not report a larger top management team to create the impression of greater gender equity. $Number\ of\ women_{t-1}$ is positive and highly significant, reflecting the fact that individual managers tend to spend several consecutive years on a firm's top management team. *Firm age* is negative and significant, perhaps reflecting the imprinting of social norms from an era when women were not as active in the professional workforce. Firm performance, as measured by *Tobin's* q_{t-1}, is positive and significant, consistent with the twin propositions that female representation in top management both engenders and is engendered by good organizational performance. None of the other controls are significant.

The next step is to use the estimated coefficients in Table 3 to calculate an offset with respect to each observation. We then run separate logit regressions for each firm, where *Female* is the dependent variable and the independent variables are the offset, whose coefficient is set to 1, and a constant, which identifies the firm fixed effect. Formally, we have the following, where "^" represents an estimated value.

$$\begin{aligned}&\text{logit}\left\{\Pr\left(Female_{ijt}=1|C_{ijt},X_{it},\varphi_t,\zeta_j\right)\right\}\\&=\overbrace{\text{offset}_{ijt}}^{\hat{\alpha}+\hat{\beta}_C C_{ijt}+\hat{\beta}_X X_{jt}+\hat{\varphi}_t}+\zeta_j\end{aligned}\tag{2}$$

We use the predicted probabilities from these firm-by-firm regressions in our 100 simulations. In each simulation, we draw a random number from a uniform distribution on [0,1] for each observation. If the random number is less than the predicted probability that *Female* equals 1, then we impute a value of 1 to *Female*. In this way, we generate 100 simulated populations of top managers across firm-years.

The results of these simulations are depicted graphically in Figure 1, which is a bar chart showing the distribution of women across top management teams. (A firm's top management team appears exactly once in Figure 1 for every year the firm is in our data.) The dark bars represent the actual data, and the clear bars represent the median of the simulations. (Using the minimum or maximum instead of the median yields qualitatively the same results.) Vis-à-vis the simulations, the actual data have far more singletons and far fewer zeroes or teams with multiple women.

Specifically, the mean number of women in a top management team is 0.35 in the actual data, versus 0.34–0.36 in the simulations. Thus, the total number of women in the actual data and the simulations is almost exactly the same. However, the variance of the number of women per team is only 0.42 in the actual data, versus 0.59–0.64 in the simulations. The discrepancy arises because the actual data have over 2,200 more singleton women than the simulations, which have more teams with multiple women. The implication is that having a woman in a given top management position lowers the probability that another position on her team will be filled by a woman, relative to a conditionally random allocation, providing indicative support for Hypothesis 1.

The magnitude of the gender-related spillovers is not clear from Figure 1 since there are few teams with multiple women. The marginal effect of a regression coefficient in OLS measures how much the dependent variable changes due to changes in an independent variable. The equivalent in our context is how much the expected probability that a woman occupies a top management position changes because another position on the same team is occupied by a woman. We calculate this by comparing the expected number of women on a top management team in the actual and simulated data, conditional on the team having at least one woman. We subtract one from these averages, which are calculated once per team, because a female manager cannot have a spillover effect on herself. Thus, we are asking, "If a top management team has one

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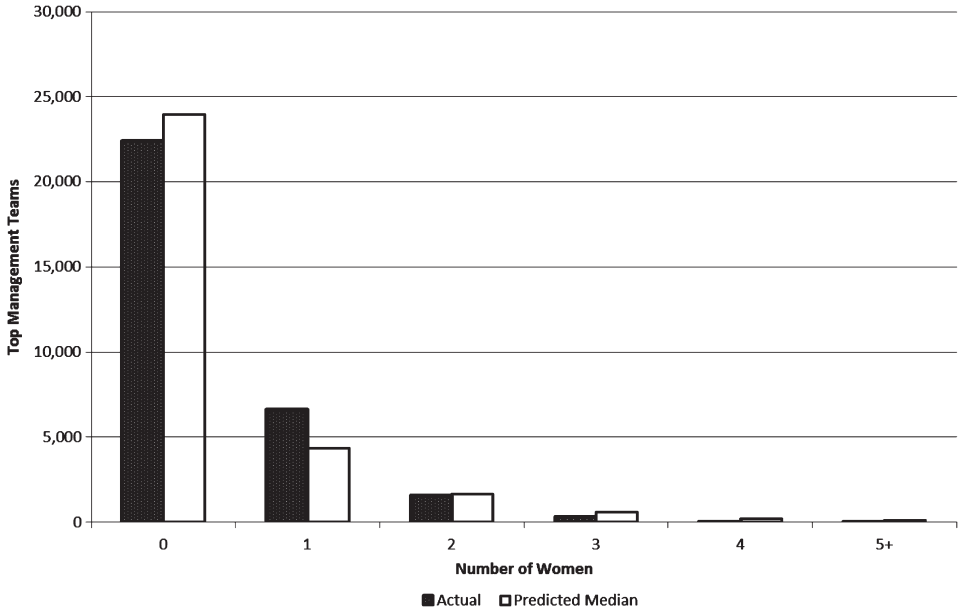

Figure 1. Actual and predicted distribution of women among top management teams

woman, how many *additional* women does it have on average?"

As shown in the Panel A of Table 4, if there is at least one woman on a top management team, there are on average 0.277 additional women in the actual data and 0.570 additional women using the medians in Figure 1, implying a marginal effect from negative spillovers of $0.277/0.570 - 1$ or about -51 percent. (The maximum and minimum of the marginal effects are very similar.) This result provides strong support for Hypothesis 1. To address concerns that the job categories could be endogenously related to gender, we reran our analysis without them and obtained a nearly identical marginal effect.

To test Hypotheses 2A and 2B, we refine our measure of marginal effects as follows: Given a woman in a given category of top management position, how many additional women does the team have in each of three categories of position: CEO, line officer, and professional? (Again, each statistic is calculated once per team.) See Table 4, Panel B. The small absolute size of the within-category conditional means reflects the fact that the remaining positions on a top management team are less likely to be in the same category as the focal position. The relatively high expectations conditional on having a female CEO reflect the intuitive fact that female CEOs are more often found in companies that, for observable and unobservable reasons, tend to have more women in general.

The greatest marginal effects are associated with professional positions: (1) if a woman occupies a top management position in any of the three categories, then the probability a woman occupies a professional position goes down by the greatest amount; and (2) a female in a professional position reduces the probability that a woman occupies a position in each of the three categories by more than does a female line officer or CEO. These results are quite robust. The same ordering of marginal effects was obtained in all 100 simulations. Thus, Hypotheses 2A and 2B are strongly supported. By contrast, female CEOs have the smallest negative spillover on each of the other two categories and the smallest negative spillover on female line officers. These results are the opposite of what the "queen bee syndrome" would predict.

DISCUSSION

We theorized that women in top management face an implicit quota whereby firms make organizational efforts to achieve and maintain a low target number of women in top management, but that the effort to achieve or maintain a greater number of women is lower or even negative. On the basis of our theory, we predicted and found strong

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Table 4. Conditional average number of women on top management team

Panel A: Expected number of additional women overall			
Actual	0.277		
Predicted median	0.570		
% difference: actual from predicted median	−51.39		
Panel B: Expected number of additional women by category			
Focal woman's job category	Chief executive officer	Line officer	Professional
Actual			
Chief executive officer	–	0.265	0.438
Line officer	0.057	0.089	0.285
Professional	0.038	0.109	0.116
Predicted median			
Chief executive officer	–	0.379	0.809
Line officer	0.076	0.144	0.606
Professional	0.065	0.237	0.285
% difference: actual from predicted median			
Chief executive officer	–	−30.05	−45.88
Line officer	−24.94	−37.98	−52.97
Professional	−41.28	−53.92	−59.29

evidence for negative gender spillovers, whereby the probability a given position in a top management team is occupied by a woman is lower if another position on the same team is occupied by a woman. An implication is that the population of female top managers tends to fragment rather than cluster across top management teams, relative to what a random allocation—conditional on observable and unobservable factors—would produce. We also predicted that the largest effects would be associated with professional positions because they are of lower status and less integral to the firm than are the CEO position or line positions, and hence, could more readily serve to achieve a quota on women in top management. We found strong support for this prediction as well. The "queen bee syndrome" would predict particularly large negative spillovers from the CEO position, but we did not find this. Likewise, if firms were maintaining a quota on women in top management to maximize operational efficiency, prior research suggests that spending on R&D should predict female representation in top management, but we did not find this.

Strengths and limitations of our estimation methodology

Conventional econometric techniques frequently do not allow for valid inferences when studying how the characteristics of a group influence the characteristics of the individuals that comprise that group or vice versa. We overcame these limitations by developing a simulation-based methodology that compared the actual distribution of female top managers in our data with what their distribution would be in the absence of gender-related spillovers. Our method allowed us not only to determine that gender-related spillovers exist, but also to estimate their sign, their magnitude, and how they vary by type of position.

While our conventional regressions in Table 2 (see above) appeared to provide a qualitatively similar answer in this case, this appearance is misleading for two reasons. First, because of the conflicting and *a priori* unquantifiable biases inherent in those regressions, we cannot take the magnitude of those effects at face value. Second, if we used conventional regressions to analyze gender-related spillovers by type of position, then the coefficients measuring within-category spillovers (e.g., line officer on line officer) would suffer from a particularly strong version of the downward mechanical bias on variables that are a positive function of their group means (see Appendix S1 for details). Coefficients measuring cross-category spillovers (e.g., line officer on professional) would only suffer that bias to a limited extent, reflecting the propensity of women to shift position categories in the same top management team across time. It could thus be impossible to compare position-by-position spillovers with each other.

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Our methodology has clear strengths. First, although developed to test specific predictions, it could be adapted to a broad range of topics of interest to strategy scholars, including the consequences and antecedents of top management team characteristics; dynamics between boards of directors and their members; the diffusion of practices among firms in the same network, geographic region, or industry category; network tie formation; and any research question that can be characterized with spatial dimensions. Second, our methodology allowed us to determine the magnitude of the effects (using a conditional expectation) and their statistical robustness (by analyzing the consistency of the simulations). Third, we were able to consider the contingency represented by the type of top management position.

The primary limitation of our methodology is that researchers may have to devise test statistics that fit their particular context. A researcher studying how a set of actors of different types in a network at time $t - 1$ influences network configuration at time t would probably want to measure marginal effects with reference to common descriptive statistics for networks (e.g., centrality, structural holes). A researcher studying firm agglomeration perhaps would want to measure marginal effects with reference to measures of co-location. The needed adaptation may place more burden on researchers than conventional statistical techniques.

Implications for research and practice on female representation in management

Much other work suggests that women generate positive spillovers for each other in a corporate setting. Hultin and Szulkin (1999) found that women who worked in establishments with more female managers received higher wages. Cardoso and Winter-Ebmer (2010) found that female CEOs pay their female employees higher wages than do male CEOs, and that the gender wage gap is 1.5 percent lower in female-led firms. Similarly, women with influence over the hiring process may reduce workplace gender segregation at nonmanagerial levels (Huffman, Cohen, and Pearlman, 2010), or increase participation by women at lower levels (Kalev, Dobbin, and Kelly, 2006). It is possible that the effects we observe in our data are largely confined to the same or nearby levels within a managerial hierarchy. It is also possible that the spillover effects of female participation depend on the level of the managerial hierarchy. Cohen, Broschak, and Haveman (1998) found that the proportion of women at a given level in a California savings and loan establishment is positively associated with the probability that a hire at that level is a woman. We also found that having more female board members is positively associated with female representation in top management. However, we obtained qualitatively different results among top managers, perhaps because men's willingness to work toward the betterment of women within their organizations is lower in top management, where each job is so valuable both to the individual who holds it and to the dominant male coalition inside the organization.

Since our results suggest that the paucity of women in top management may not be self-correcting, one might ask whether nonmarket mechanisms should be considered. A number of European countries, starting with Norway, have imposed or are considering quotas mandating a minimum percentage of women on their corporate boards. It is important to note that our study focuses not on firm boards, but on top management teams, which are much more involved in firm management than are boards. A legal quota for women in top management would impose a much higher level of interference in internal firm affairs. Nonetheless, one implication of our analysis is that stakeholders who would like their firms to have more female top managers should increase, rather than decrease, the pressure they bring to bear as their firms make progress toward greater gender equity in top management. Another implication is that, absent such proactive behavior by stakeholders, women may remain an isolated minority in top management.

Overall, this study provides insight into the composition of work teams, especially with regard to gender in top management, and also offers a rigorous methodology for using large datasets to study how the characteristics of management teams influence the characteristics of the individuals comprising those teams. There is a growing need to understand the antecedents and consequences of the composition of management teams, and this study offered a starting point for such research.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix S1. Is there an implicit quota on women in top management? A large-sample statistical analysis