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Social isolation, survey nonresponse, and nonresponse bias: An empirical evaluation using social network data within an organization

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Abstract
Survey researchers have long hypothesized that social isolation negatively affects the probability of survey participation and biases survey estimates. Previous research, however, has relied on proxy measures of isolation, such as being a marginalized group member within a population. We re-examine the relationship between social isolation and survey participation using direct measures of social isolation derived from social network data; specifically, instrumental research and expressive friendship connections among faculty within academic departments. Using a reconceptualization of social isolation, we find that *social network isolation* is negatively associated with unit response. Among women (a numerical minority group within the organization), we further find that *social group isolation* (i.e., lacking instrumental network connections to men, the majority group in the organization) is negatively associated with survey participation. Finally, we show that some survey estimates are systematically biased due to nonparticipation from socially isolated people.

Keywords: Survey nonresponse, Nonresponse bias, Social isolation, Network analysis, Organization

1. Introduction

Social isolation, or lack of connectedness with other people, has long been hypothesized as a cause of unit nonresponse in sample surveys (Brehm, 1993; Goyder, 1987; Groves and Couper, 1998; Voogt, 2004). Under this hypothesis, people who are disengaged from society or the dominant groups within a society do not share common norms and are less compliant with survey requests. Isolated persons lack the "common cause" of civic engagement that underlies helping behavior and participation in civic events or prosocial organizations (Brehm, 1993; Verba, 1996; Toppe and Galaskiewicz, 2006). Therefore, a request from "society at large" is rejected by those who feel rejected by society (Groves and Couper, 1998).

The purpose of this research is to test this common hypothesis for why individuals do not participate in social surveys. It is important to examine the effects of social isolation on survey nonresponse because our knowledge relies heavily on survey methods to understand how populations think, feel, and act. Survey estimates can be biased when respondents and nonrespondents differ on the characteristics being measured in the survey, resulting in nonresponse bias on estimates related to these characteristics (Groves, 2006). One notable limitation to previous research is that 'social isolation' is not directly measured on both respondents and nonrespondents. Rather, it is inferred from the distribution of responses to questions about social participation or friends among respondents (e.g., Abraham et al., 2008) or based on observable status characteristics of the sample indicating marginalized groups, such as racial minorities or the elderly (e.g., Goyder, 1987).

This study uses a different way of measuring 'social isolation' or 'connectedness' to further understand the relationship between social isolation and unit nonresponse. Specifically, collecting full rank social network data (Wasserman and Faust, 1994)[1] within the context of an organization (a university) makes it possible to directly measure social isolation. All people within the organization are sampled and asked to identify their connections to all the other people in the department, including actors who ultimately do not participate in the survey. Thus, we have a measure of social integration for each sampled person that is independent of whether or not that particular person participated.

Moreover, using social network data allows us to further develop the concept of social isolation. A central focus in social network theory pertains to how network characteristics shape a person's perceptions and behaviors (Borgatti et al., 2009; Wellman, 1988). Most network theories take either a structural or a compositional approach. Structural theories focus on the characteristics of network ties (e.g., Coleman,1988; Granovetter,1973), such as network size. Compositional theories focus on the attributes of a person's connections (e.g., Bourdieu and Wacquant, 1992; Lin, 1986), such having connections to individuals similar or different from oneself (i.e., homophily). Drawing from both theoretical traditions and integrating survey methodological theories on nonresponse, we re-conceptualize the general idea of social isolation into two basic forms: social network isolation and social group isolation. *Social network isolation* pertains to a lack of social connections overall, whereas *social group isolation* identifies a lack of connections to particular social groups. We further examine two different types of social connections or relational tie networks: instrumental research and expressive friendship networks. As such, we can assess variation in the *relational context* of isolation on survey nonresponse.

Integrating research on methods and networks, this study reformulates and tests the social isolation hypothesis for survey nonresponse in Science, Technology, Engineering, and Math (STEM) departments at a large research-intensive Midwestern university. We expect to find that social network isolation in an academic context will predict lower probabilities of survey participation. Within research networks, we further predict the effect of social group isolation to operate differently for the numerical majority group (men) compared to the numerical minority group (women). Finally, because nonresponse bias in survey estimates only occurs when respondents and nonrespondents differ on survey variables of interest (Groves, 2006; Kreuter and Olson, 2011), we combine information from two different surveys on the same sample of faculty to examine nonresponse bias on a diverse set of indicators of faculty work life such as collegiality and work-life balance. We expect a lower survey participation propensity among socially isolated faculty to upwardly bias mean estimates of faculty work life, particularly for concepts related to social interaction among faculty.

2. Social isolation and survey participation

A commonly posited cause for survey nonparticipation is social isolation (Goyder, 1987; Groves and Couper, 1998), also called by its converse social engagement, social involvement or social participation (Voogt, 2004; Brehm, 1993). According to the social isolation hypothesis, socially disconnected individuals are likely to lack a sense of obligation to cooperate in surveys (Brehm, 1993; Groves and Couper, 1998; Toppe and Galaskiewicz, 2006; Verba, 1996). Specifically, social isolates tend to be less influenced by the dominant culture, and thus less influenced by commonly invoked survey recruitment themes, such as the norm of reciprocity and power of authority, compared to those who are in more socially integrated positions (Groves and Couper, 1998). Despite the expectations of social isolation reducing the probability that an individual will participate in a survey, tests of this hypothesis rely largely on proxy measures of social isolation.

Two forms of social isolation have been considered with survey participation. First, there is isolation from other individuals (Abraham et al., 2008; McPherson et al., 2006, 2008). For this form of isolation, the primary concern is about *how many connections* a person has, regardless of the personal characteristics of those connections. The lack of social connections to others represents what we call social network isolation. The second form pertains to isolation from dominant social groups and/or society in general (Keyes 1998; Putnam, 2000; Toppe and Galaskiewicz, 2006). In this instance, the main concern is with the *attributes of the respondent*, such as being a racial minority.

2.1. Social network isolation

Previous research uses various indirect proxy measures to tap into social network isolation. Typically, social network isolation is measured by questions about social participation, such as involvement in political activities (Brehm, 1993; Groves et al., 2004), neighborhood organizations and neighborhood watch activities (O'Neil, 1979), volunteering (Abraham et al., 2008), and church attendance (Woodberry, 1998). There are three problems with this approach. First, these characteristics only indirectly measure social isolation. Second, little of this work has information for both respondents and nonrespondents (for an exception, see Abraham et al., 2008, which used data from the Current Population Study to predict non-response to the American Time Use Survey). Rather these studies rely on comparing reports to survey questions between cooperative and reluctant respondents, but such an approach does not consistently reflect the characteristics of nonrespondents (e.g., Lin and Schaeffer, 1995; Smith, 1984). Third, questions about social participation have known measurement errors related to social desirability. For example, people overreport voting, volunteering, and other forms of social participation (e.g., Tourangeau et al., 2000).

The number of self-reported friends or confidants is also used to evaluate the relationship between survey nonresponse and social network isolation (Hampton et al., 2011; McPherson et al., 2006, 2008; Bergman et al., 2010). This personal (ego) network measure improves on previous measures of social network isolation by measuring actual social connections rather than social participation. However, it also has two weaknesses. First, this measure is generally only available for respondents and is missing for nonrespondents. One study on attrition, however, found that wave one respondents who reported no confidants were less likely to participate in wave two (Bergman et al., 2010). Second, self-reported personal networks are prone to recall bias as respondents forget to mention people in their networks leading to the under-reporting of network size (Brewer and Webster, 1999; Killworth and Bernard, 1976).

With full-rank network data, alternative measures are possible. One network measure that taps into the social network isolation concept is in-degree, the total number of nominations a person receives from other members of the network (Wasserman and Faust, 1994).[2] For example, in an organizational setting, an employee may receive friendship nominations from coworkers. By focusing on received network nominations or in-nominations, we have the same network information on both respondents and nonrespondents. Following the social isolation hypothesis, we expect persons with a low in-degree to have a lower probability of survey participation. It is also possible that survey participation may decrease for people with a large number of nominations (higher in-degree). Thus, the association between network size and survey participation may be curvilinear. Faculty with multiple nominations (higher in-degree) could be a sign of higher time demands or "busy-ness", which is a competing theory for why individuals do not participate in surveys (Abraham et al., 2006; Fricker and Tourangeau, 2010). For these reasons, we test for non-linear effects of in-degree on survey participation.

2.2. Social group isolation

With the incorporation of social network theory and data into this paper, we introduce a second form of social isolation: *social group isolation*. In this conceptualization, the status characteristic of the sampled individual *and* the individuals to whom the individual has connections is of primary importance. The network measure that helps us tap into social group isolation is status homophily (Lazarsfeld and Merton, 1954; Brashears, 2008). A network connection is considered homophilous if both the sender and receiver of the nomination share the same status characteristic. For each person, an aggregate score is created to identify whether a sampled person's received nominations overall come from homophilous or heterophilous actors.

To fully capture the concept of social group isolation, status homophily must be considered in conjunction with the composition of status groups. In an academic context, men make up the overwhelming majority of STEM faculty (National Science Foundation, 2015). As such, the opportunity structure for forming homophilous versus heterophilous ties varies by gender (Ibarra, 1993; Blau, 1977). Specifically, the network connections of men (i.e., the numerical majority group) should be primarily homophilous, whereas for women (i.e., the marginalized status group) network connections should be primarily heterophilous. For majority group members, we predict that a lack of social connections to one's status group (i.e., having primarily heterophilous connections) is likely to lead to feelings of social group isolation. Thus, we expect men with heterophilous networks to have lower probabilities of survey participation. For marginalized groups, in contrast, we predict a lack of connections to the majority group (i.e., having primarily homophilous connections) is likely to lead to feelings of social group isolation. In this instance, one's status group is excluded from full participation within the organization. Therefore, we expect women with homophilous networks to have lower probabilities of survey participation.

2.3. The relational context of social isolation

Within an organization, individuals can be connected to one another in a number of different ways. In general, network connections are classified as expressive or instrumental (Ibarra, 1993). Within the workplace, instrumental ties involve interactions within the work role and exchanges of job related-resources, such as information and advice, whereas expressive ties entail personal interaction and exchanges of sentiments, such as trust and liking. In the current study, research and friendship connections among faculty serve as instrumental and expressive ties, respectively. Traditional conceptualizations of social isolation are closely linked to expressive connections through the idea of emotional support (House, 1987; Thoits, 1995). At the same time, research is the primary role of faculty jobs within a research-intensive institution (Jacobs and Winslow, 2004; Park, 1996), and as such, should also be important for survey participation (Donald, 1960; Tourangeau et al., 2009). Thus, we expect *social network isolation* within either relational tie context to lead to feelings of social isolation and, thus, lower survey participation.

In contrast, the *social group isolation* hypothesis may primarily apply to instrumental rather than expressive network ties. The tendency to form connections to similar others who share the same status characteristic is commonplace in all types of relational ties (Maccoby, 1998; McPherson et al., 2001). It may, however, be more socially acceptable and expected within expressive than instrumental connections. For example, cross-gender expressive ties are often viewed as inappropriate or suspect outside the context of marriage or other family relationships (Rubin, 1990; Williams, 2000). Previous studies suggest that women have a stronger tendency to form homophilous ties in expressive networks compared to instrumental networks (Ibarra, 1992). As such, the predicted interaction effects between marginalized status and gender homophily might only materialize within the instrumental research network. Specifically, within research networks, gender homophily will be positively associated with survey participation for men and negatively associated for women.

3. Social isolation and nonresponse bias

Nonresponse bias threatens the validity of knowledge derived using survey methods. In particular, nonresponse bias of a respondent mean ($\bar{y}_R$) can be expressed as the nonresponse rate (M/N) times the difference between mean for the respondents ($\bar{Y}_R$) and the mean for the nonrespondents ($\bar{Y}_M$) on the survey variable of interest (Lessler and Kalsbeek, 1992):

$$Bias(\bar{y}_R) = (M/N)\ (\bar{Y}_R - \bar{Y}_M)$$

Alternatively, we can express nonresponse bias of a respondent mean as a function of the covariance of the survey variable, Y and the unobserved propensity to respond to the survey request, P, divided by the average response propensity ($\bar{P}$, equivalent to the response rate) (Bethlehem, 2002):

$$Bias(\bar{y}_R) = cov(Y,P)/\bar{P}$$

A correlation between P and Y, leading to differences between respondents and nonrespondents on a survey variable of interest (Y), arises when a common cause influences both the probability of response (P) and Y, or arises when the survey variable itself is a cause of nonresponse (Bethlehem, 2002; Groves, 2006).

Our measure of in-degree serves as both a survey variable of interest and potential common cause. For example, we expect that mean in-degree will be *overestimated* when estimated on respondents alone if the socially isolated fail to participate; if both the socially isolated and highly socially integrated fail to participate, then we expect that mean in-degree may be unbiased, but the variance of in-degree will be *underestimated*.

Additionally, more socially isolated faculty have worse perceptions of faculty work life compared to better connected faculty (MIT, 1999; Smith and Calasanti, 2005). Ties to other faculty members facilitate communication about workplace norms (e.g., regarding tenure and promotion and research collaborations) and positively contribute to feelings of belonging and satisfaction with the job in general (Moody, 2004; Realff et al., 2007). As such, we expect that survey questions related to these constructs will be *overestimated* when estimated on respondents alone because of the common cause of in-degree. On the other hand, not only work-related factors but also family-related factors interact with each other and have complex effects on perceptions of work-family balance (Voydanoff, 2005). Because the degree of social isolation is not strongly associated with a faculty member's satisfaction with work-family balance, we expect smaller nonresponse biases on mean estimates related to the construct of work-family balance.

4. Data and methods

4.1. Survey on promoting faculty success [SPFS]

The first part of the study focuses on examining the relationship between network ties and unit nonresponse. The data for the first part of this study come from the 2008 Survey on Promoting Faculty Success [SPFS], a web survey conducted at a research-intensive Midwestern university. Between March and July 2008, 451 full-time tenure-line faculty in 26 STEM departments were asked to participate in the survey. We identify full and partial completes as survey participants, with a partial complete defined as someone who answered at least 70% of the questions in the survey.[3] About 61% of the surveyed faculty were either a full (n = 268) or partial (n = 5) complete (AAPOR RR2; AAPOR, 2015).

When conducting a network analysis, the network level response rates are critically important. Ideally the relational response rate for the network (i.e., department) will be above 70% in order to calculate reliable social network measures (Knoke and Yang, 2008). The formula for the relational response rate of a directed network is:

$$RR = 1 - [M!/2!(M-2)!] \,/\, [N!/2!(N-2)!]$$

where M is the number of missing actors and N is the network size. Although survey response was high overall, three departments in the sample had relational response rates lower than 70%. The relational response rates for the remaining 23 departments ranged between 72% and 100% with an average of 89%. Since departmental level response rates will influence the focal independent variable in the study, we conducted sensitivity analyses where the three departments are dropped from analyses. All of the study conclusions were identical.[4]

The network survey instrument measured relational ties (i.e., connections) among faculty within their primary (i.e., tenure home) department. In our study, we use a positional strategy to bound the network and identify network actors (Knoke and Yang, 2008). That is, we examine academic departments as the bounded network and full-time, tenure-line faculty within departments as network actors. We use reports from respondents to obtain measures of social ties on both respondents and nonrespondents. The sample frame contained administrative demographic and other data (e.g., race, gender, and years working at the institution) provided by the university for all respondents and nonrespondents. One case, however, is lost due to missing data on demographic characteristics, and two cases were dropped because they were mistakenly invited to participate in the survey even though their appointment was part-time. As a result, our analytic sample consists of 448 faculty in 26 STEM departments.

4.1.1. Network questions, adjacency matrices and focal independent variables

The network mapping component of the survey measured two distinct relational ties among faculty — research exchange and friendship — using a roster method. The use of a roster method (i.e., list of network members) rather than a name generator approach generally reduces recall and self-report biases (Brewer, 2000; Kumbasar et al., 1994). Respondents were provided a list of all faculty names in their tenure home department and asked to identify how often they interacted with each faculty member on the list during the 2007–2008 academic year. The response choices were: 1 = never, 2 = once a semester or less, 3 = a few times a semester, 4 = a few times a month, and 5 = once a week or more. Fig. 1 illustrates the network question for friendship within a fictional department. Friendship ties among faculty were measured with one network question asking faculty to think about non-work related interactions and report how often they spent free time together or discussed personal matters with each faculty member. A single research exchange network was created from two network questions. Respondents indicated how often helpful research-related information, advice, or equipment was (1) received from or (2) provided to the other faculty members listed on the questionnaire. These network questions were combined by taking the union of the response; such that, a research exchange tie exists if the connection entailed giving or providing support.

From the network roster questions, asymmetric binary adjacency matrices for friendship and research exchange were created for each department. In an adjacency matrix, the number of rows and columns is equal to the number of full-time, tenure-line faculty in the department. So, in the Fictional Department shown in Fig. 1, there are seven rows and seven columns, one for each member of the department. For an asymmetric adjacency matrix, each actor's row in the network identifies ties they send to other actors in the network, whereas their column identifies ties received from other actors in the network. Thus, it is possible for a person to report having an interaction with a particular member of the department (that is, to nominate them as a tie), but for the other individual not to reciprocate the nomination. For a binary adjacency matrix, the value of 1 indicates the presence of the relational tie and 0 indicates its absence. Within the five response choices for the network questions, we chose the response option "a few times a semester" as the cut-off to create binary matrices for two reasons. First, we wanted to mitigate the potential over-reports of ties caused by using a roster-based method (Brewer, 2000). Second, we did not want to measure "weak" connections and strong ties are often characterized as having a higher frequency of interaction (Granovetter, 1973). From these asymmetric binary adjacency matrices, measures of *in-degree* were created by summing down the columns of the matrix to identify the number of received nominations from other actors.

Gender in-homophily is measured using the point bi-serial correlation (PBSC). The PBSC is a homophily measure for categorical attributes represented by the following equation (Everett and Borgatti, 2012):

$$PBSC = (ad - bc) / [(a + c)(b + d)(a + b)(c + d)]^{1/2}$$

In this study, the PBSC is calculated based only on received network nominations; thus, a is the number of received ties from actors who share the same attribute, b is the number of received ties from actors with a different attribute, c is the number of network actors who did not send a tie but share the same attribute, and d is the number of network actors who did not send a tie and have a different attribute (Borgatti et al., 2002). The value of –1 on in-homophily identifies a completely heterophilous network in terms of the attribute (i.e., a faculty member only receives ties from faculty who do not share his/her gender). For example, a woman only receives ties from men. A value of +1 on in-homophily indicates that the faculty member receives network ties only from homophilous actors (*i.e.*, a faculty member only receives ties from faculty who share his/her gender).

Since our network measures (in-degree and in-homophily) are calculated using the responses from other members in a given faculty member's department, they can be subject to nonresponse bias if other faculty members with whom an individual interacts systematically fail to respond to the survey. For two reasons, however, we do not believe nonresponse bias on these measures to be of great concern as predictors in our analytic models. First, we have conducted our analyses on subsets of departments with increasingly higher response rates and find the same results. Second, the other nonrespondents in each department would need to interact with only each other. Although this could be the case in one or two departments, it is highly unlikely to happen in all departments with a wide range of department-level response rates. To the extent that nonrespondents have ties with responding members of the department, we assume that the sorting of the ties in the department is largely correct, but that the number of ties will be lower than actually present for some persons in the department. This measurement error in the number of ties should attenuate the relationship between our network measures and survey participation (Fuller, 1987; Biemer and Trewin, 1997).

The measure of social isolation used in this study came from other person's reports of their interactions with a faculty member. Admittedly, this might have caused some measurement errors. Our measurement of interactions between faculty members, however, used a rating scale, generally found to be more reliable than a simple question of whether or not the respondent interacted with the alter (i.e., the other faculty member) (Ferligoj and Hlebec, 1999). Additionally, we dichotomized the ratings, collapsing neighboring categories. Thus, errors that arise in this dichotomous measure will be those in which a respondent mistakenly selected “a few times a semester” rather than “once a semester or less” (or vice versa).

4.1.2. Dependent variable

The dependent variable in the study is a dichotomous variable indicating *unit response* to the survey. Sampled subjects are coded ‘1’ (n = 273, 60.9%) on this if they were a full or partial complete. In sensitivity analyses, we varied the definition of survey participation: defining a partial as whether or not the sampled person answered at least one question on the survey (n = 306, 68.3%) and excluding the five partial completes, restricting “respondents” to full completes (i.e., whether or not the person answered the last question on the survey) (n

= 268, 59.9%). The results from the sensitivity analyses were similar to the results reported in this paper.

4.1.3. Marginalized status and alternative explanations

The information for the variables described in this section was provided by the university and is, therefore, available on all sampled persons. Previous research uses status characteristics as indirect proxy measures of isolation to measure and identify marginalized group members. For example, research on general population surveys shows that racial/ethnic minorities, immigrants, people with lower education, and the elderly tend to have lower response rates (Collins et al., 2000; Holbrook et al., 2007; Goyder, 1987; Green, 1996; Groves and Couper, 1998; Smith, 1984; Voogt, 2004). This study focuses on one marginalized status group for our social group isolation hypothesis (gender) and controls for another (race).[5] *Female* is a dummy variable where women are coded one (15%). *Nonwhite* is a dummy variable where nonwhite faculty members are coded one (19% within the analytic sample).

We also consider other plausible explanations of survey participation. First, time demands or “busy-ness” is often also considered as an alternative explanation for survey nonresponse; however, in this organizational study of highly educated, employed persons, we assume faculty are generally busy. Previous research has documented long work hours (typically over 50 h per week) among faculty (e.g., Jacobs and Winslow, 2004; Misra et al., 2012). Second, the level of involvement with the survey organization might affect the probability of participating in surveys (Goyder, 1987). For example, those working at an organization for a long time or who are administrators or managers may feel more connected to the organization, and thus more obliged to meet the survey participation request by the organization compared to those with weaker connections to the organization. We approach involvement with the organization with three measures: years working at the institution, academic rank, and being an administrator. *Years working at the institution* is a continuous variable measured in years that was calculated based on the faculty member's start date at the university. We developed a series of dummy variables for *academic rank* (assistant, associate, and full professors). *Administrator* is a dummy variable identifying faculty who hold a primarily administrative appointment (e.g., department chairs and associate deans).

Third, salience of the topic, especially when the topic has a positive valence, plays a crucial role in an individual's decision to participate in a survey (Goyder, 1987; Groves et al., 2004; Groves et al., 2006; Voogt, 2004). The survey focused largely on research, but faculty have appointments that vary in the amount of time dedicated to research versus teaching. In particular, the survey topic may be less salient for faculty with a high teaching appointment. Therefore, *teaching appointment* is included as a control variable and represents the percentage of a faculty member's official appointment that is devoted to teaching. Fourth, persons who view a survey sponsor positively, either due to positive affiliation with the sponsor or viewing the sponsor as a trusted authority figure, are more likely to participate in the survey than people who view the sponsor negatively (Donald, 1960;

Goldberg et al., 2001; Jones, 1979; Edwards et al., 2002; Faria and Dickenson, 1996; Goyder, 1987; Groves and Couper, 1998; Jones and Lang, 1980; Jones and Linda, 1978; Perneger et al., 2005; Sudman and Ferber, 1974; Wu and Vosika, 1983). In some instances, the sponsor may have provided resources for the sampled individual, potentially also invoking a social or economic exchange relationship (Dillman et al., 2009; Goyder, 1987). In the current study, the cover letter indicated that the results from the survey would support a National Science Foundation (NSF) grant application at the university. As funding for agricultural research tends to come from the US Department of Agriculture, not NSF, there may be different levels of affiliation toward the sponsor across departments and, as such, a series of dummy variables identify *academic area*: 1) physical or biological sciences (24%), 2) agriculture or natural resources (30%), and 3) engineering or math (46%). There are five, seven, and fourteen departments in each category, respectively.

4.1.4. Data analysis strategy

We explored whether there are significant relationships between the network measures of social isolation and unit response using multivariate models that included alternative explanations of nonresponse. Due to the high correlations between the research exchange and friendship measures (e.g., $r = 0.54$, $p < 0.001$ between in-degree in the research exchange networks and in-degree in the friendship networks), we estimated the models separately for the research exchange and friendship networks. The data used in this study comprise individual faculty ($N = 448$) nested within academic departments ($N = 26$). Therefore, we estimated multilevel mixed-effects logistic regression models. The structure of the network data (autocorrelation within each network matrix) further violated the assumption of independence across cases (Dow et al.,1982; Krackhardt, 1988). For this reason, we also ran models with 1000 permutations to deal with potential biases in the variance estimates and significance tests (Good, 2000; Hubert, 1987). For this paper, we report the results from the multilevel models without permutations, as the results were consistent with and without permutations.

4.2. COACHE

The second part of this study focuses on the implications of the findings related to social isolation for nonresponse bias of survey estimates. Using data from the Collaborative on Academic Careers in Higher Education (COACHE) survey (COACHE, 2008), we explore the role of social isolation in leading to nonresponse biases in survey estimates. COACHE data were gathered via a Web survey in Spring 2008, roughly two months after the SPFS targeting the same STEM faculty at the same large Midwestern university. The response rate was 48% (N = 215). The COACHE data have been merged with the SPFS data using identification numbers that were randomly assigned to all of the faculty in the sampled 26 STEM departments; both respondents and nonrespondents to the SPFS participated in the COACHE survey.[6] Thus, this survey provides an additional source of information about the effects of social isolation on survey estimates. The COACHE survey asked faculty to assess their experiences regarding the nature of their work, the work culture within their primary departments, promotion and tenure, and so on. We focus on five measures within the COACHE survey that represent a diverse array of faculty experiences.

4.2.1. Faculty work life measures

Three measures assessed satisfaction with various aspects of faculty work life. For *overall workplace satisfaction*, COACHE asked faculty, "All things considered, how satisfied or dissatisfied are you with your department as a place to work?" Faculty also reported on their level of satisfaction or dissatisfaction with "the value faculty in your department place on your work" (*work valued by colleagues*) and with "the balance between your professional time and your personal or family time" (*work-life balance*). All three questions were asked on a five-point scale (1 = very dissatisfied; 2 = dissatisfied; 3 = neither satisfied nor dissatisfied; 4 = satisfied; 5 = very satisfied). Two additional measures about *collegiality* and *tenure/promotion fairness* were asked on an agreement scale (1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = strongly agree). Specifically, the COACHE survey asked faculty "On the whole, my department is collegial" and "In my opinion, tenure (or promotion from associate to full professor) decisions here are made primarily on performance-based criteria (e.g., research/creative work, teaching, and/or service) rather than on non-performance-based criteria (e.g., politics, relationships, and/or demographics)."

4.2.2. Data analysis strategy

For this set of analyses information on in-degree from the SPFS is merged with measures of faculty work life within the COACHE survey. The analysis goal is to evaluate the risk for nonresponse bias due to nonresponse from the socially isolated. To examine this, we conduct a series of regression analyses demonstrating that the respondents and nonrespondents to the SPFS are different on estimates strongly related to social isolation within the department, but not on an estimate that is not as strongly related to the degree of social isolation. Then, we show that in-degree explains this nonresponse effect (i.e., the differences between respondents and nonrespondents are mediated upon controlling for in-degree). This analysis permits us to demonstrate that in-degree is a common cause for survey participation and some key survey estimates. For simplicity, we only report in-degree for the friendship network, but our findings replicate using research in-degree. We conducted one-tailed tests as we were testing directional associations.

5. Results

5.1. Social isolation and survey nonresponse

Table 1 shows basic information about faculty research and friendship networks. On average, faculty are nominated as a friend by 3.2 faculty in their department and exchange research with 3.6 other faculty. The range for nominations is from zero nominations (complete isolates) to a maximum of thirteen nominations. Overall, 6.5% (N = 29) of faculty had no research exchange nominations and 10.9% (N = 49) had no friendship nominations from anyone else in their department. Finally, the means for gender in-homophily across both relational ties measures are close to zero, ranging from 0.06 for gender in-homophily in research exchange networks to 0.11 for gender in-homophily in friendship networks. With the homophily measure, the value of 0 means that alters with the same attribute and alters with different attribute are equally represented in the ego network. Thus, on average, faculty were nominated by an equal mix of individuals who shared and did not share their gender. As expected, women, who are a numerical minority group among STEM faculty, are more likely to have heterophilous networks compared to men in both the research exchange and friendship networks (results available from authors on request). As the majority group members, men have more opportunities to form homophilous ties to other men.

Overall, 27.6% of complete social isolates in the research exchange networks participated in the survey, compared to 63.3% among persons with at least one research exchange tie. Similarly, for those who were complete social isolates in the friendship networks, 36.7% participated, compared to 63.9% among persons with at least one friendship tie. This bivariate analysis provides initial support for the network isolation hypothesis.

In Tables 2 and 3, we estimated a series of models separately for the research exchange and friendship networks, respectively. The first model in each table shows the linear effect of in-degree on survey participation. Specifically, in-degree had a significantly positive association with unit response for both research exchange (Model 1 in Table 2: $b = 0.27$, odds ratio [OR] = 1.32, $p < 0.001$) and friendship (Model 1 in Table 3: $b = 0.26$, OR = 1.29, $p < 0.001$). Faculty who had a larger number of research exchange ties or friendship ties within the department were more likely to participate in the survey compared to faculty who were less integrated in these networks. These results from Model 1 indicate that social network isolation had a significantly negative effect on the probability of survey participation concerning both instrumental and expressive networks, controlling for alternative explanations of nonresponse.

In the second models, we tested for curvilinear effects with a squared in-degree term. The squared term was significant for friendship (Model 2 in Table 3: $b = -0.03$, OR = 0.97, $p < 0.05$) but not for research exchange (Model 2 in Table 2). Fig. 2 shows the predicted probability of unit response that we calculated based on the results for the friendship networks (Model 2 in Table 3). The positive returns of having more friendship ties diminishes when in-degree reaches roughly eight. Thus, Fig. 2 shows diminishing returns to having more expressive ties. On the other hand, the insignificant squared term for instrumental ties suggests that the relationship between instrumental ties and probability of unit response was linear. Therefore, we dropped the squared term for the final model in Table 2.

Regarding *social group isolation,* the interaction effect between gender and gender in-homophily was significant for the research exchange networks (Model 3 in Table 2, $b = -2.15$, OR = 0.12, $p < 0.05$) but not for the friendship networks (Model 3 in Table 3). Fig. 3 provides the graphical representation of this interaction effect. For women (solid line), having higher levels of gender in-homophily (i.e., having connections primarily to other women) in the research exchange networks is associated with lower probabilities of unit response. For men (dashed line), on the other hand, the probability of unit response was relatively stable across all levels of gender in-homophily.

5.2. Nonresponse bias

Combining information on in-degree with faculty work life questions in the COACHE survey, the final analysis component of this study examined how reduced survey participation among the socially isolated may affect survey estimates. The odd numbered models in Table 4 clearly show that faculty who responded to the SPFS have more positive perceptions of the department than faculty who did not respond to the SPFS. Significant differences exist for overall work satisfaction, work being valued by colleagues, collegiality, and tenure/promotion fairness. The even numbered models in Table 4 show that in-degree is also significantly and positively associated with these same variables. Having more connections to others in the department led to more positive perceptions of faculty work life. Only the work-life balance concept, which has less bearing on workplace interactions, did not differ between respondents and nonrespondents to the SPFS and was not associated with in-degree.

In analyses not shown (results available from authors on request), SPFS respondents had a significantly larger in-degree than SPFS nonrespondents. This helps account for why in-degree explains differences in perceptions of faculty work life between SPFS respondents and nonrespondents as demonstrated in the odd numbered models of Table 4. Specifically, the differences in overall workplace satisfaction, work valued by colleagues, and collegiality between SPFS respondents and nonrespondents became smaller and statistically non-significant once we added in-degree to the models. In-degree did not, however, explain away the significant nonresponse effect for tenure/promotion fairness, although in-degree did explain some of the effect. Nevertheless, our regression analysis demonstrated that in-degree served as a common cause for participation in SPFS and three measures of faculty work life. Our results show that the mean of survey variables that are negatively influenced by social isolation may be overestimated due to persons with fewer ties participating in surveys (Groves, 2006).

6. Conclusions

In this paper, we conducted the first examination of the relationship between social isolation and survey participation in which social isolation was directly measured within a network. The results show a clear relationship between participating in a survey and social network isolation, measured by the number of connections an individual has within a department. Within instrumental and expressive networks, having fewer ties was significantly associated with lower odds of survey participation controlling for marginalized statuses and several other alternative explanations of survey nonresponse. Within expressive friendship networks, on the other hand, there were diminishing returns to having more ties. Thus, our findings provide initial direct support to the long-time hypothesis that more socially isolated individuals are less likely to participate in surveys compared to individuals who are better connected to others.

This study also adds to the literature by examining the impact of social group isolation on survey participation. For instrumental networks only, we found that women who were more isolated from men (the majority group in the organization) had lower odds of unit response. For men, gender in-homophily did not predict survey participation.

The findings from this research have several implications. Most important, the results suggest that researchers using survey data should consider potential nonresponse bias on estimates related to social isolation or lack of network ties. Previous research using surveys within institutions has found that social isolates tend to have less positive perceptions of organizational conditions and work (Ibarra and Andrews, 1993; Roberts and O'Reilly, 1979). The nonresponse bias analysis confirmed these previous findings. Scholars who are interested in conducting institution-level surveys to measure attitudes or perceptions about the organization (e.g., organization climate, job satisfaction, and organizational commitment) should be particularly sensitive to the risk of a nonresponse bias to the extent that socially isolated individuals do not participate.

With finding support for the isolation hypothesis and the common cause model of nonresponse biases, it will be also important not to ignore nonresponse among socially isolated individuals within general population surveys. Drawing on somewhat contested research based on the General Social Survey (GSS) (Brashears, 2011; Fischer, 2009; McPherson et al., 2006, 2008, 2009; Paik and Sanchagrin, 2013), social isolates are rated as less cooperative by interviewers after the interview. This finding has potential implications for both nonresponse bias and nonresponse error variance. First, for nonresponse bias, to the extent that individuals with fewer ties in the general population are also less cooperative, they will be less likely to be recruited into the survey interview overall without extensive follow-up efforts.

General population surveys without extensive follow-up attempts and recruitment efforts thus are likely to be systematically missing people with fewer network connections in general and social isolates in particular, thus leading to biases in variables that have been shown to be related to network connections, such as educational and occupational attainment (Paldony and Baron, 1997; Thomas, 2000), political participation (Knoke, 1990), religious attendance (Rote et al., 2013), aggression (Faris and Felmlee, 2011), and physical and mental health (Cornwell et al., 2012; Litwin, 2012). This finding also means that analysts should, where possible, consider the number of network connections to account for this differential nonresponse. Ideally, a measure of network connections would be part of weighting or imputation models. As a measure of network connections is nearly impossible to obtain for both respondents and nonrespondents in most studies, it is unlikely to be available for weighting adjustments, although possibly for imputation models. Alternatively, analysts may want to consider adding a measure of network connections to their analytic models, if available, as a control variable to account for the differential participation probabilities for individuals with varying network sizes (Winship and Radbill, 1994).

Second, for nonresponse error variance, there is striking variability across interviewers in the reports they obtain on network size (Paik and Sanchagrin, 2013). Our findings suggest that these recent findings about variability in network size across GSS interviewers could be due to differential nonresponse biases across interviewers in recruitment of people with fewer social connections (e.g., West and Olson, 2010) as well as differential probing methods and other interviewer behaviors during the interview. That is, to the extent that different interviewers follow up with less cooperative respondents differentially (O'Muircheartaigh and Campanelli, 1999), and that those individuals have different network sizes, the observed interviewer variance effect in network size will occur.

Finally, our findings have an important implication for studies that utilize full-rank social network data. There is an increasing attention to the effect of missing relational data on biases in measures of network structure (Borgatti et al., 2006; Huisman, 2009; Kossinets, 2006; Smith and Moody, 2013). Thus far, research has shown that missing data on actors with a small number of connections has a lower impact on network measures compared to missing data on actors with more connections (Moody and Smith unpublished results; Huisman, 2009). Through empirical analyses, the current study supported the association between social isolation and survey nonresponse. In other words, our results imply that network studies are likely to be missing data on socially isolated actors who have relatively low impact on network measures. This is good news for network scholars who are concerned about potential biases in network measures due to nonresponse.

As with any analysis, this study has limitations. The most obvious limitation is potential nonresponse bias on the focal independent variables. It is plausible that an individual is not socially isolated within a department or a particular social group, but rather that their department and/or similar other connections chose not to participate in the survey. Departments with higher response rates have more people within the network who participated and thus lower risk of the people who failed to participate being the 'missing link' for the nonrespondent in the network measures. To address this limitation, we conducted a sensitivity analysis and dropped departments with lower response rates from each of the analyses. None of the findings changed.

Additionally, this study examines 26 departmental networks within one large Midwestern research-intensive university. Although we have replication over multiple departments in the university (with differing sizes and departmental cultures), we do not know whether these findings will generalize to other contexts. We suspect that the findings about the number of received connections for work-related tasks (e.g., instrumental research connections) being predictive of survey participation will translate to other organizational settings. That is, we would expect that other university-based studies and other studies in organizations that permit collaboration partners selected by members of a division will systematically underrepresent people who are not connected to others in the respondent pool, especially minority group individuals who are not connected to members of the majority group. For general population studies, we suspect that the expressive ties, based on friendship networks, are more informative about lack of survey participation, consistent with prior studies using ego-based measures of discussion or friendship networks.

Furthermore, our measure of social isolation was based on in-degree because this is a measure that we can calculate for all respondents and nonrespondents. Other network measures, such as out-degree, may be a better measure of social isolation as it affects survey nonresponse, reflecting the respondent's perceived (lack of) research and friendship connections. Finally, consistent with having a marginalized status the number of women and nonwhite faculty members in the sample is small. As a result, we have limited power to detect differences in survey participation for these groups.

Despite these limitations, the current study makes several key contributions to the current literature. First, to our knowledge, this is the first direct examination of social isolation and survey participation measured by full rank network data, with information collected on both respondents and nonrespondents. Second, our network measures pertained to two different forms of social isolation: social network isolation and social group isolation. We also looked at social isolation within two different relational tie networks: the research networks for instrumental connections and the friendship networks for expressive connections. Furthermore, we were able to take into account the effects of marginalized statuses and the alternative explanations of unit nonresponse in our analysis because the university provided us with the administrative demographic and other data for all respondents and nonrespondents.

Future research should include the number of network connections as a key outcome to monitor during data collection, as in a responsive design (Groves and Heeringa, 2006). To the extent that nonrespondents tend to be individuals with fewer network connections, then successful data collection strategies that bring in less connected people would result in the mean number of connections decreasing over the course of the field period. Explicitly tailoring follow-up efforts to those with fewer connections could be fairly easily done in longitudinal studies where network connections are collected at wave *t*, and that information is used for targeting resources in wave *t*)1. What those tailored efforts should be, however, requires additional experimental work.

Have you spent free time together (such as eating dinner, working out, or other leisure activities) or discussed personal matters (such as family celebration s or difficulties) with each of the following faculty members in the FICTIONAL Department during the 2007-2008 academic year? *Please indicate your answer by checking the appropriate column to the right of each faculty member's name on the list. Please leave the column next to your own name marked 'no answer.'*

	Never	Once a semester or less	A few times a semester	A few times a month	Once a week or more
Linda Bolling	☐	☐	☐	☐	☐
Patrick Brown	☐	☐	☐	☐	☐
Michael Johnson	☐	☐	☐	☐	☐
Robert Jones	☐	☐	☐	☐	☐
Pablo Lopez	☐	☐	☐	☐	☐
James Smith	☐	☐	☐	☐	☐
John Williams	☐	☐	☐	☐	☐

Fig. 1. Network mapping question for friendship (fictional department).

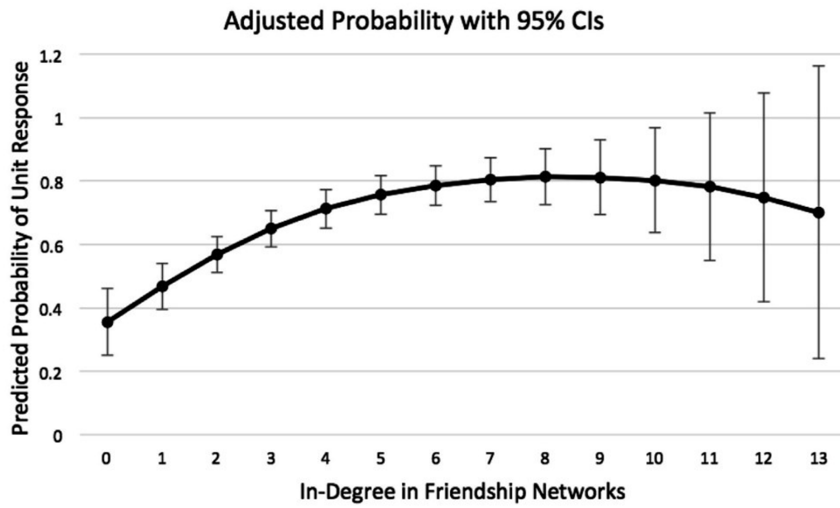

Fig. 2. Predicted probability of unit response by in-degree in friendship networks.

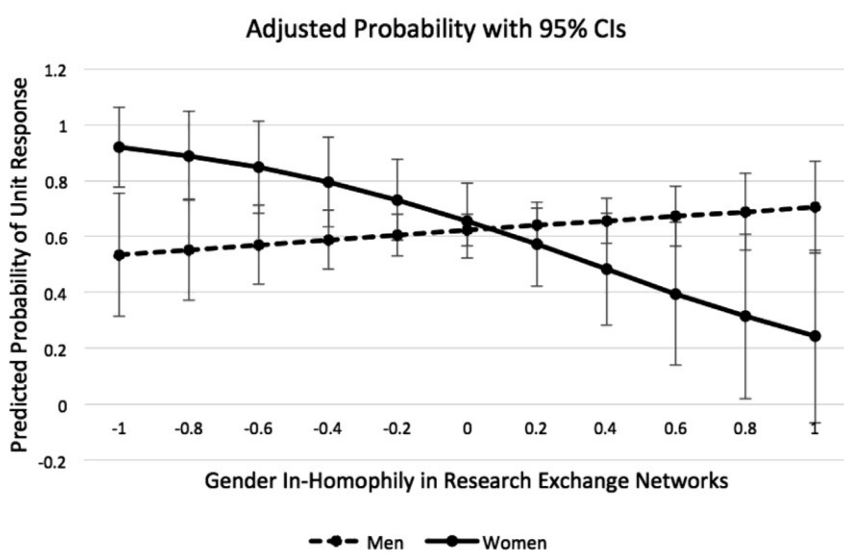

Fig. 3. Predicted probability of unit response by gender in-homophily in research exchange networks for men and women.

Notes

1. Full rank network data is different from personal (ego) network data, which relies solely on a single respondent to identify their own network (i.e., reports on the number of collaborators, friends, and so on). It is also different from 'social networks' in the current vernacular of websites such as Facebook, LinkedIn, or Twitter because full rank networks have a clearly bounded set of actors, such as within an organization.

2. Out-degree (the number of sent nominations) or perceived social isolation may be a better predictor of survey nonresponse than received social isolation. Some individuals with few nominations from others may not perceive that these ties exist. Out-degree is not available on nonrespondents. Among respondents, in-degree and out-degree are correlated ($r = 0.41$ for research and $r = 0.37$ for friendship).

3. AAPOR Standard Definitions permit study-specific definitions of a partial complete (AAPOR, 2015). In this study, a partial complete was defined as a respondent who completed at least 70% of the network questions.

4. Including the three low response rate departments would produce a less stringent test of the social isolation hypothesis, because the network size of faculty (a key independent variable) within the low response rate departments will be underestimated. Specifically, a lack of connections within low response rate departments is likely due to nonresponse error on the key independent variable (there are not enough respondents in the department to accurately measure the number of received nominations for any faculty member in the department) rather than being truly isolated in one's department.

5. The nonwhite sample is very small and comprised of a variety of different racial minority groups such as African-Americans, Asians and Latinos. Thus, homophily among non-white respondents would not accurately reflect the theoretical meaning of homophily (e.g., nonwhite homophily could be a tie between an African-American and an Asian faculty member).

6. Under 100 ($n = 96$) respondents to the SPFS did not participate in the COACHE survey, and thus are excluded from the nonresponse bias analyses.

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Appendix A. Supplementary data
Supplementary data related to this article follows the References.

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Tables 1 – 4 follow.

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Table 1. Descriptive statistics.

	Mean	S.D.	Min.	Max.
Individual-level variables (N = 448)				
Dependent variable				
Unit response	0.61	0.49	0.00	1.00
Social network isolation				
Research exchange network				
In-degree	3.60	2.35	0.00	13.00
Friendship network				
In-degree	3.19	2.44	0.00	13.00
Status homophily				
Research exchange network				
Gender in-homophily	0.06	0.29	–1.00	1.00
Friendship network				
Gender in-homophily	0.11	0.31	_1.00	1.00
Marginalized status				
Female (1 = female)	0.15		0.00	1.00
Nonwhite (1 = nonwhite)	0.19		0.00	1.00
Controls				
Years working at the institution	15.51	11.26	11.26	48.00
Academic rank				
Assistant professor	0.19		0.00	1.00
Associate professor	0.30		0.00	1.00
Full professor	0.51		0.00	1.00
Administrator (1 = administrator)	0.14		0.00	1.00
Teaching appointment	35.65	18.64	0.00	98.00
Department-level variables (N = 26)				
Academic area				
Physical/Biological sciences	0.24		0.00	1.00
Agriculture/Natural resources	0.30		0.00	1.00
Engineering/Math	0.46		0.00	1.00
Department size	21.44	9.48	8.00	38.00

Table 2. Multilevel mixed-effects logistic regression models for unit response — research exchange networks.

	Model 1		Model 2		Model 3	
Fixed effects	b/se	OR	b/se	OR	b/se	OR
Social network isolation						
In-degree[a]	0.27***	1.32	0.28***	1.32	0.27***	1.31
	[0.06]		[0.06]		[0.06]	
In-degree squared[a]			0.00	1.00		
			[0.02]			
Status homophily						
Gender in-homophily	–0.07	0.93	–0.07	0.93	0.36	1.44
	[0.37]		[0.37]		[0.41]	
Social group isolation						
Gender X Gender in-homophily					–2.15*	0.12
					[0.95]	
Marginalized status						
Female	–0.01	0.99	–0.01	0.99	0.14	1.15
	[0.30]		[0.30]		[0.32]	
Nonwhite	–0.31	0.73	–0.31	0.73	–0.28	0.76
	[0.28]		[0.28]		[0.28]	
Controls						
Years working at the institution	0.00	1.00	0.01	1.00	0.00	1.00
	[0.01]		[0.01]		[0.01]	
Assistant professor[b]	0.11	1.12	0.11	1.12	0.11	1.12
	[0.37]		[0.37]		[0.37]	
Associate professor[b]	–0.09	0.92	–0.08	0.92	–0.10	0.90
	[0.27]		[0.27]		[0.27]	
Administrator	0.80	2.22	0.80	2.22	0.89	2.44
	[0.35]		[0.35]		[0.35]	
Teaching appointment	–0.01	0.99	–0.01	0.99	–0.01	0.99
	[0.01]		[0.01]		[0.01]	
Model for department means						
Intercept	0.81	2.25	0.83	2.28	0.73	2.07
	[0.43]		[0.44]		[0.43]	
Physical/Biological sciences[c]	–0.03	0.97	–0.03	0.97	0.02	1.02
	[0.31]		[0.31]		[0.31]	
Agriculture/Natural resources[c]	–0.17	0.85	–0.16	0.85	–0.08	0.93
	[0.30]		[0.30]		[0.31]	
Department size[d]	0.01	1.01	0.01	1.01	0.00	1.00
	[0.01]		[0.01]		[0.01]	
Random effects	VC		VC		VC	
Department mean	0.03		0.02		0.02	
ICC	0.01		0.01		0.01	

VC = variance components, ICC = intraclass correlation, and OR = odds ratio.
* p < 0.05 ; ** p < 0.01 ; *** p < 0.001 (two-tailed tests)
a. In-degree is grand-mean-centered.
b. Full professor is the omitted reference group.
c. Engineering/Math is the omitted reference group.
d. Centered with the mean of 26 departments.

Table 3. Multilevel mixed-effects logistic regression models for unit response — friendship networks.

	Model 1		Model 2		Model 3	
Fixed effects	b/se	OR	b/se	OR	b/se	OR
Social network isolation						
In-degree[a]	0.26***	1.29	0.31***	1.36	0.30***	1.35
	[0.05]		[0.06]		[0.06]	
In-degree squared[a]			–0.03*	0.97	–0.03*	0.97
			[0.01]		[0.01]	
Status homophily						
Gender in-homophily	0.02	1.02	–0.04	0.96	0.22	1.25
	[0.34]		[0.34]		[0.39]	
Social group isolation						
Gender X Gender in-homophily					–1.18	0.31
					[0.82]	
Marginalized status						
Female	–0.06	0.94	–0.08	0.93	0.09	1.09
	[0.30]		[0.30]		[0.33]	
Nonwhite	–0.15	0.86	–0.16	0.85	–0.15	0.86
	[0.27]		[0.27]		[0.27]	
Controls						
Years working at the Institution	0.00	1.00	–0.01	0.99	–0.01	0.99
	[0.01]		[0.01]		[0.01]	
Assistant professor[b]	0.11	1.12	0.04	1.04	0.07	1.07
	[0.37]		[0.37]		[0.37]	
Associate professor[b]	–0.07	0.93	–0.10	0.90	–0.12	0.89
	[0.26]		[0.27]		[0.27]	
Administrator	0.76*	2.14	0.70*	2.01	0.70*	2.01
	[0.34]		[0.35]		[0.35]	
Teaching appointment	–0.01*	0.99	–0.01*	0.99	–0.01*	0.99
	[0.01]		[0.01]		[0.01]	
Model for department means						
Intercept	0.95	2.59	1.17**	3.23	1.13*	3.09
	[0.42]		[0.44]		[0.44]	
Physical/Biological sciences[c]	0.22	1.24	0.20	1.22	0.19	1.21
	[0.28]		[0.29]		[0.29]	
Agriculture/Natural resources[c]	0.14	1.15	0.16	1.17	0.20	1.22
	[0.29]		[0.29]		[0.29]	
Department size[d]	0.00	1.00	0.00	1.00	0.00	1.00
	[0.01]		[0.01]		[0.01]	
Random effects	VC		VC		VC	
Department mean	0.00		0.00		0.00	
ICC	0.00		0.00		0.00	

VC = variance components, ICC = intraclass correlation, and OR = odds ratio.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ (two-tailed tests)
a. In-degree is grand-mean-centered.
b. Full professor is the omitted reference group.
c. Engineering/Math is the omitted reference group.
d. Centered with the mean of 26 departments.

Table 4. Ordinary least squares regressions for the COACHE faculty work life measures – friendship networks.

	Overall workplace satisfaction		Work valued by colleagues		Work-life balance		Collegiality		Tenure/Promotion fairness	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
SPFS respondent	0.38*	0.30	0.44*	0.36	–0.18	–0.15	0.46*	0.33	0.50*	0.43*
	[0.21]	[0.21]	[0.22]	[0.22]	[0.20]	[0.20]	[0.23]	[0.22]	[0.25]	[0.24]
In-degree		0.09**		0.10**		–0.05		0.14***		0.09**
		[0.03]		[0.03]		[0.03]		[0.03]		[0.04]
Constant	3.41***	3.16***	3.06***	2.79***	3.24***	3.38***	3.45***	3.04***	3.52***	3.27***
	[0.19]	[0.21]	[0.20]	[0.21]	[0.19]	[0.20]	[0.21]	[0.22]	[0.23]	[0.24]
R^2	0.02	0.05	0.02	0.07	0.00	0.02	0.02	0.11	0.02	0.05