

## **External funding: Impact on promotion and retention of STEM assistant professors**

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### **ABSTRACT**

The purpose of this exploratory study was to examine the relationship of external funding on the recruitment and retention of assistant professors in STEM disciplines and gender differences in the link between funding and promotion and retention. The external funding patterns of two cohorts of recently hired science, technology, engineering, and mathematics (STEM) assistant professors at a major research university were collected and differential outcomes of grant success by gender were measured, as well as gender differences in the correlation between grant activity and reappointment, promotion and tenure (RPT) and retention.

The study found significant gender differences in grant submissions, average number and size of awards, and percentage of grants submitted to federal agencies in the first cohort, but not the second. Grant activity during the first cohort's second probationary period was significantly correlated with RPT for both men and women, but there were no correlations between grant activity and RPT during the first probationary period. Also, women submitted proposals as the lead principal investigator less often than men, and the average number of co-investigators was higher on proposals submitted by women, compared to men. This framework will allow the institution in this analysis to regularly monitor early career faculty and measure links between grant activity and RPT. Results can be used to mentor early career faculty and address specific issues that improve faculty success. This framework might be applied to other research-intensive institutions which hold similar expectations regarding external funding of STEM faculty.

Keywords: STEM, gender, grant funding, promotion, tenure, retention

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## INTRODUCTION

There has been widespread interest recently in understanding and increasing women's participation and success in science, technology, engineering, and mathematics (STEM) careers, especially in the academic sciences (National Academy of Sciences, 2007). One thread of research about women's participation in the professoriate is the promotion and tenure process and potential barriers in the process for women faculty. An important evaluation criterion associated with faculty reappointment, promotion and tenure (RPT) at research-intensive universities is the level of effort in applying for and success in securing external grant funding to support research and scholarship. A recent study by the National Institutes of Health (NIH) suggested there are differences in the number of research grants submitted and awarded, as well as the size of the awards, based on gender of the principal investigator(s) (Pohlhaus, Jiang, Wagner, Schaffer, & Pinn, 2011). Since success in external funding is known to have a significant impact on RPT, the present study was initiated to examine the grant activity of assistant professors and differences by gender, as well as the correlation between grant activity and RPT.

In this introduction, the relevant literature is discussed to present the case for studying women faculty's external funding patterns. Three areas of existing research influenced the hypotheses and design of this study: the relationship between research and RPT, gender differences in grant activity, and gender differences in retention and promotion. After reviewing literature across these three areas, three propositions were defined for exploration in this study.

### **The Relationship between Research and Reappointment, Promotion, and Tenure**

Research-intensive universities have historically fulfilled a basic science service for the United States (Geiger, 2005). U.S. universities perform approximately 56 percent of the nation's basic research (Association of American Universities, 2011). As such, the federal government financially supports approximately 60 percent of research conducted at universities (Association of American Universities, 2011). Most research-intensive universities have a tripartite mission of teaching, research, and service. All three of these responsibilities play a role in faculty evaluation and whether or not a faculty member secures tenure; however, the importance of research in the RPT process should not be understated.

Grantsmanship can easily be argued to be an important prerequisite to engaging in the research productivity necessary to obtain promotion and tenure in research-intensive institutions. However, a focus on the process of submitting or being awarded grant funding and its relationship to acquisition of tenure has not been adequately explored in the literature (Collins, 1993). The literature on this topic mainly discusses RPT as a reward structure developed and maintained by institutions in order to promote research productivity among faculty (Collins, 1993; Fox, 1983; Holley, 1977), and some literature has determined that the relationship is unclear, whether correlational, causal, or lacking specified direction at all (Collins, 1993). Despite this uncertainty, Schuster and Finkelstein (2006) established that research is a core component of faculty evaluation within research-intensive institutions. These scholars found ample evidence that "at those institutions that expect more of their faculty than being instructors, the rewards of research are significant" and come in the form of tenure and salary, and research productivity (Schuster & Finkelstein, 2006, p. 270). Although the criteria used for evaluating research productivity are usually not explicitly stated, the value of research is typically based on a combination of the quantity and quality of outputs such as publications and intellectual

property (Collins, 1993; Comm & Mathaisel, 1998; Englebrecht, Iyer, & Patterson, 1994; Fox, 1983; Holley, 1977; Reis, 1997). The studies to date, however, do not show if there are specific patterns in research grant activity for early career faculty during their probationary periods and specifically if there are correlations regarding grant activity during the probationary years with RPT that could be used to guide early career faculty.

### **Gender Differences in Grant Activity**

Several studies have noted gender differences in the numbers of applications for and award of research grants. Waisbren et al. (2008) found gender differences among Harvard Medical School faculty in terms of the number of applications, success rate, and amounts requested, particularly in the lower academic ranks, with men submitting and receiving more and larger grants than women. Gordon, Osganian, Emans, and Lovejoy (2009) found similar gender differences in grant activity as early as residency among the pediatric physicians they studied. Another study (Pohlhaus, Jiang, Wagner, Schaffer, & Pinn, 2011) noted that men were awarded more NIH Research Project Grants (R01s) than women at all points in their careers. Similar results were reported by Boyer (2007), who found that, among faculty at U.S. two-year institutions, women faculty were significantly less likely than their male counterparts to secure grants. There were no studies found, however, that monitored the gender differences in grant activity, including grant submission and success, for faculty during their probationary period.

### **Gender Differences in Retention and Promotion**

Several studies have explored gender differences in STEM faculty success, as measured by retention and promotion with tenure (Bonawitz & Anandel, 2009; Brockopp, Isaacs, Bischoff, & Millerd, 2006; Kaminski & Geisler, 2012; National Academy of Sciences, 2007).

As noted in *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering*, women employed in 1995 as untenured, tenure-track science, engineering, and social science faculty at research-intensive institutions were more likely than men not to be retained in the academy in 2001 (2.5% of women and 0.6% of men) (National Academy of Sciences, 2007). Additionally, data showed that women in their analyses “were less likely to have received tenure in 2001 than corresponding men (56.3% of women and 61.6% of men)” (National Academy of Sciences, 2007, p. 91).

Bonawitz and Anandel (2009) noted that the “number of women who are tenured to full professorships have not kept pace with women’s growing inclusion in the academy” (p. 2) and this is true beyond STEM disciplines. They found that women faculty earn lower salaries than equivalent men, and publish fewer journal articles and books, which has implications for tenure since research productivity is highly valued in the RPT process (Bonawitz & Anandel, 2009). Brockopp et al. (2006) reported related findings of “evaluation inequities” linked to women’s scholarship as compared to men’s (p. 255).

In contrast, Kaminski and Geisler (2012) found that overall, men and women faculty in science and engineering disciplines at fourteen public universities were retained and promoted in the academy at the same rate, with one major exception. In mathematics, they found a stark contrast between the retention of men and women. In that discipline, women left significantly sooner than men, after an average 4.45 years compared with 7.33 years (Kaminski & Geisler, 2012). These authors posited that gender disparity among science and engineering faculty can be traced to differential application rates. “Once women apply for or are in consideration for a

career move, they are equally likely to succeed, but they are often not in the pool” (Kaminski & Geisler, 2012, p. 864).

Women’s absence from the pool is not a matter of education or preparation. In 2010, women earned 55% of the life sciences doctorates, 29.5% of the doctorates in physical sciences, and 23.1% of the engineering doctorates (National Center for Science and Engineering Statistics, 2012). However, as of 2003, women were less likely to be employed as tenured or tenure-track faculty at research institutions than masters-granting institutions and medical schools (National Science Foundation, 2008).

In summary, while the gender differences in the success of STEM faculty as measured by retention and promotion, have been studied, the specific changes that occur in grant activity that correlate with success during the probationary period have not been studied in detail.

## **Research Questions**

Given the wide range of studies related to gender, research and grant activity, and RPT, this study sought to explore these relationships at a major Midwest university.

The overarching question of this study was: how successful are early career women faculty in STEM disciplines at this institution compared to men faculty in these disciplines, as measured by retention and promotion? The study explores the extent to which faculty success is related to research grant awards, and whether differences exist between men and women in their probationary periods and at the time of tenure review.

Existing literature and interest in the experiences of pre-tenured faculty at this institution led to the development of three broad propositions for the study. As the first research question, this study asked if there are differences between pre-tenure women and men in their grant activity (number of submissions, number of awards, size of awards, award agency) during the pre-tenure period. Research Question 2 asks if there is a correlation between grant activity and RPT, and if the correlation differs for women and men. Research question 3 asks if there are gender differences in the composition of principal investigators (single, co-investigators) on grants submitted by and awarded to pre-tenured faculty.

## **METHODOLOGY**

### **Research Setting**

This research study was commissioned by Advancing Diversity through the Alignment of Policies and Practices (ADAPP), an ADVANCE Institutional Transformation initiative funded by the National Science Foundation to Michigan State University. The ADAPP project was designed to promote a more inclusive work environment for STEM women at Michigan State University (MSU). ADAPP seeks to increase the numbers of women faculty recruited; improve their retention and advancement; and improve the climate for STEM women. These goals address issues that have been identified as barriers for women in STEM disciplines both nationally and at MSU. The intent of the present study was to determine whether or not there are gender differences in early career faculty retention and promotion and the role of grant success in promotion and tenure decisions. The study asks if there were defined associations or correlations that were gender related. Although the results do not build a predicative model, the analyses may inform the institution on approaches for improving success of early career faculty, and potentially establish a method of monitoring early career data with institutional data analysis.

This study may also inform a larger audience of research-intensive universities and provide a model for institutional data analysis that can be carried out on other campuses.

At the institution of study, an assistant professor newly hired into the tenure system is appointed for an initial probationary period of four years. During the first probationary period, much of the research support for new faculty is provided through start-up funds. Reappointment for an additional three year probationary period is based primarily on the activities of the previous three years. Faculty reappointed for a second probationary period are normally evaluated for promotion with tenure during the third year of the second probationary period, or the seventh year following their initial appointment. Some assistant professors are evaluated for promotion earlier than their seventh year. Also, extensions of the probationary periods can be requested but may require approval at the unit, college and central administration levels. Since newly appointed assistant professors are evaluated at the end of the two probationary periods, for this study, grant activity of faculty was evaluated during their first probationary period, e.g., the activities in their first three years of appointment, separate from their second probationary period, years four through seven following their initial appointment. Those two sets of faculty activities were then correlated with their ultimate promotion (attained associate professor status by year seven) and retention (were still employed at the institution in year seven). A correction was not made for faculty who were granted leaves that extended their probationary periods, nor were faculty who were promoted early considered separate from their cohort. The study did not consider formal evaluations resulting in non-reappointment or denial of promotion/tenure since early career faculty who are not making sufficient progress are often counseled about their lack of progress and leave the university without a formal evaluation. However the number of faculty not retained for either reason were measured as an aggregate and analyzed.

Between 2001 and 2011, total external grant funding at the study institution increased significantly. During that period, the institution saw changes in research infrastructure and support. Several colleges started pre-award research offices to assist faculty in identifying and submitting grant applications. Some colleges modified their new faculty appointment letters to explicitly describe research expectations. In 2007, the faculty start-up process for all colleges was rationalized to allow for more consistency in the criteria for allocating faculty research start-up funds to colleges. This change provided faculty with more clearly defined research expectations for promotion and tenure, placing a strong emphasis on external funding. During this ten year period, the university facilitated the practice of faculty cluster hires and hiring more mid-career and senior faculty with existing research programs, in an effort to increase mentoring of assistant professors as well as to enhance existing research strengths and catalyze new areas of research. Together, the changes that took place between 2001 and 2011 likely influenced the transparency of understanding of research expectations and activity among pre-~~tenure~~tenured faculty.

### **Study Design and Analyses**

The faculty members included in this study were assistant professors hired by nine STEM colleges between 2001 and 2009 (451 total faculty). Information about these faculty members obtained from the Human Resources office of the institution included gender, race/ethnicity, and retention and promotion status as of October, 2011. The gender distribution in this pool was 40% women, 60% men. The pool was separated into two cohorts: cohort one included assistant professors hired between 2001 and 2005 (45%; used to analyze promotion/retention in 2011) and cohort two included assistant professors hired between 2006 and 2009 (55%). To better



understand the demographic representation within each cohort, the racial/ethnic distribution of faculty was defined. In cohort one, twenty-seven (13%) were from racial groups underrepresented in the STEM disciplines (African American, Hispanic/Latino, American Indian). Forty-one (20%) of the faculty in this cohort were Asian or Other Pacific Islander, and one hundred thirty-three (66%) were White. In cohort two, twenty-seven (9%) were from racial groups underrepresented in the STEM disciplines (African American, Hispanic/Latino, American Indian). Sixty-four (22%) faculty members in this cohort were Asian or Other Pacific Islander, and one hundred ninety-four (68%) were White.

For this pool of faculty, data on grants submitted and awarded were obtained from the institution's Office of Sponsored Programs' database. The data included information on grants submitted and awarded each year for each faculty member in the pool. For cohort one, the grant activity was separated into two time periods: 1) grants submitted and awarded in the first three years of appointment, called probationary period one, which is the period included in the reappointment review, and 2) grants submitted and awarded in years four through seven following the start of their appointment, up to the point of the promotion/tenure decision for most faculty, called probationary period two. In the initial data requisition, data were collected by faculty member. Data included number of grants submitted, award status, awarded amount, and granting agency (federal or not federal). From these data, for each faculty cohort and for each of the probationary periods, the average of the total number of grants submitted and awarded was determined, the average percentage of grants submitted that were awarded was calculated, and the average percentage of grants submitted that were to federal agencies was analyzed. In addition, the total amount of grant funds awarded over the two time periods was determined as was the average number of years that the faculty in different groups did not submit a grant.

To analyze the gender differences in number of co-investigators on the grants, a second data set was collected for each grant submitted between 2001-2011 on which a faculty member from our study was the lead PI or a Co-PI. The following data were collected per grant: gender of the lead PI (if s/he was a faculty member in the study), the award status, the total size of each awarded grant, and the number of co-PIs on the grant.

All faculty in the pool were assigned random identification codes by personnel in the Ohio Evaluation and Assessment Center, who are partners on this study. The connection of the human resources data to grant data was made using this coding system. No identifiers were maintained by the research team.

## RESULTS

### **Gender Differences in Grant Activity during the Probationary Period – Addressing Proposition 1**

For assistant professors in cohort one (hired 2001-2005), there were significant gender differences in both probationary periods (years one through three or “probationary period one,” and years four through seven or “probationary period two”) in terms of grant submissions. Independent samples *t*-tests revealed that women and men differed in the number of grants submitted across both probationary periods. In particular, women submitted significantly fewer grants than men during probationary period one. Similarly, the total number of grants submitted in probationary period two by women in this cohort was significantly less than the total number of grants submitted by men (see Table 1, Appendix).

The numbers of years that faculty did not submit any grants within both probationary periods were also compared by gender. In each probationary period, and cumulatively over all seven years of their probationary periods, women averaged more years of not submitting any grants than did men (see Table 1, Appendix).

For assistant professors in cohort two (hired 2006-2009), no statistically significant differences were found between women and men on either the total number of grants submitted or the number of years that faculty did not submit grants during probationary period one.

When combining the two cohorts (all assistant professors hired 2001-2009), the gender differences were significant for both the total number of grants submitted and the number of years that faculty did not submit any grants during probationary period one, favoring men (see Table 1, Appendix). Women and men were also compared separately across the two cohorts, and no statistically significant differences between women in cohorts one and two or men in cohorts one and two were found.

In addition to the number of grants submitted, the number of grants awarded was also analyzed across gender, probationary periods, and cohorts. In cohort one, there were no gender differences in the total number of grants awarded or in the grant award success rate (percent of awarded grants among all submissions) within either probationary period. However, there were gender differences in the dollar amounts awarded for this cohort. More specifically, when only considering those faculty who were actually awarded grants, there were statistically significant gender differences in the total amount awarded per faculty during probationary period two [ $M_{\text{women}} = \$706,186$ ,  $SD_{\text{women}} = \$770,113$ ,  $M_{\text{men}} = \$1,202,922$ ,  $SD_{\text{men}} = \$1,235,752$ ,  $t(136) = -2.94$ ,  $p = .004$ ], and in the average amount awarded per faculty per year in probationary period one [ $M_{\text{women}} = \$159,656$ ,  $SD_{\text{women}} = \$158,114$ ,  $M_{\text{men}} = \$389,084$ ,  $SD_{\text{men}} = \$771,353$ ,  $t(101) = -2.65$ ,  $p = .009$ ]. On average, women were awarded significantly less than men during probationary period two, as well as per year within probationary period one.

For assistant professors in cohort two, similar to their cohort one peers, there were no gender differences in the total number of grants awarded or in the success rate (percent of awarded grants among all submissions) within probationary period one. While no statistically significant gender differences were observed within this cohort, when only considering those faculty who were actually awarded grants, women were awarded less funding than men during probationary period one in total, as well as on average per year.

### **Correlation between Grant Activity and RPT – Addressing Proposition 2**

To evaluate the relationship between grant activity and faculty success, as defined by retention and/or promotion, grant and human resources data were analyzed for the first cohort of faculty in the study. Faculty members in cohort one were in the tenure system for sufficient time to allow for evaluation of retention and promotion. First, the number of grants submitted by faculty in probationary period one was analyzed separate from those submitted in probationary period two. Pearson's correlation coefficients were calculated to show the correlations between number of grants submitted/years without submissions and promotion and retention. Fisher's Z-tests were employed to identify gender differences between the correlations (see Table 2, Appendix).

Findings revealed that the number of grants submitted during probationary period one did not show a significant correlation with the ultimate decisions regarding promotion and retention for either men or women. However, as expected, the correlation between the number of grants submitted in probationary period two and promotion and retention was significant for women,

but was significant only with retention for men. Although the number of grants submitted in probationary period two was positively correlated with promotion for men, the correlation was not significant. As noted previously, men in this cohort submitted significantly more grants than women during probationary period two.

Table 2 (Appendix) also summarizes data on the correlation between not submitting grants and promotion and retention. Similar to the analysis of total grants submitted, the average number of years that faculty did not submit a grant showed significant negative correlations with retention and promotion only for activity in probationary period two; this was true for both men and women. The lack of grant submissions during probationary period one did not correlate significantly with faculty promotion or retention for either men or women.

A second analysis was undertaken for the same cohort to identify the correlation between the number of grants *awarded* and promotion and retention. Similar to the grant submission data, Pearson's correlation coefficients and Fisher's Z-tests showed there was not a significant correlation between the number of grants awarded in probationary period one with either promotion or retention, and this was true for both men and women (see Table 2, Appendix). However, the number of grants awarded during probationary period two showed a significant correlation with promotion for women (the correlation with retention was not significant) and a significant correlation with retention for men (the correlation with promotion was not significant). Note that the grant success rate (percentage of grants submitted that were awarded) in either probationary period showed no significant correlation with promotion or retention for either men or women (data not shown). And finally, the total amount of grant funding awarded to faculty in probationary period one did not correlate with promotion or tenure for either men or women, but the size of the awards in probationary period two was significantly correlated with retention. Note that the correlation of the total amount of grant awards with promotion in probationary period two, while positive, was not significant for either men or women (see Table 2). Also of note, the average amount of grants awarded had no significant correlation with promotion or retention for either men or women in probationary period one, and in probationary period two was not significantly correlated with promotion or retention for women, and only significantly correlated with retention (but not promotion) for men.

The results of these analyses suggest that the grant activity, as analyzed by number of submissions and awards during probationary period one, is not correlated with promotion and retention. However, the grant activity during probationary period two had significant bearings for both men and women. These results imply that grant submissions and awards during probationary period two are related to faculty success. Since roughly 60% of university research is funded by the federal government (Association of American Universities, 2011), one metric that bears importance in faculty evaluations in STEM disciplines is the faculty member's activity in seeking and securing research funding from federal agencies. To address the question of funding agency and its correlation with RPT, an independent-sample *t*-test was used to look at submission and award rates to and from federal agencies for women and men, to identify any differences by gender. When analyzing both cohorts together, during probationary period one, women submitted a statistically significant lower percentage of their applications to federal agencies, compared to men. As such, significantly fewer of the awards to women were from federal agencies compared to men. However, when analyzing the cohorts separately, the statistically significant gender difference was only found in cohort one. For cohort two, women submitted a lower percentage of their applications to federal agencies than men, and their average percentage of awards from federal agencies was lower than men's, but neither difference was statistically significant (see Table 3, Appendix).



For faculty in cohort one, the application rate to federal agencies changed significantly during probationary period two. The percentage of federal grant applications by women matched that of men during probationary period two. Similarly, the difference in percentage of awards that were from federal agencies in probationary period two went up for women in cohort one, and was not significantly different than the percentage awarded for men in the same cohort.

To identify the association between funding source and RPT, the correlation of the funding agency type (federal agency or other funding sources) with promotion and retention was analyzed for cohort one using Pearson's correlation coefficients, followed by Fisher's Z-tests to identify any gender differences between the correlations. These analyses showed no correlation between the average percentage submitted or awarded to federal agencies during probationary period one and promotion or retention for women or men (see Table 4, Appendix). In contrast, the type of grant submitted and awarded during probationary period two had a significant correlation with both retention and promotion. For women in probationary period two, there was a significant correlation between the percent of federal grant submissions and awards with both retention and promotion, and for men this correlation was significant for retention and not for promotion (see Table 4, Appendix).

### **The Composition of Principal Investigators – Addressing Proposition 3**

Pre-tenure faculty use various strategies to secure funding. A common strategy is to submit a proposal as a co-investigator (sometimes referred to as a co-principal investigator) along with senior faculty as the lead principal investigator. This strategy was used by women more often than men in this study. Out of all the grants submitted by women as lead PI, 68.3% were submitted by a single PI, 24.4% were by a PI plus one to two CoPIs, and 7.2% were by a PI and more than three CoPIs. Out of all the grants submitted by men as lead PI, 71% were submitted by a single PI, 23.5% were by a PI plus one to two CoPIs, and 5.5% were by a PI and more than three CoPIs. There was a significant relationship between PI's gender and the number of CoPIs for grants submitted ( $\chi^2(2, n = 4806) = 6.77, p < .034$ ), with women submitting grants with more CoPIs than men. However, men and women PIs are awarded grants with comparable numbers of co-PIs. Yet, since the tenure evaluation rubric varies across departments and disciplines, receiving a grant as a co-investigator may or may not fulfill the external funding requirement for promotion and retention. Some departments and disciplines require that junior faculty demonstrate independence by serving as the lead principal investigator; therefore, it is important for women faculty to understand early in their career how serving as a co-investigator is perceived. Conversely, developing research collaboration skills could provide an advantage to women since problem solving in science is becoming more multidisciplinary.

## **DISCUSSION**

In this study, research question 1 asked if differences existed between women and men in their grant activity (number of submissions, number of awards, size of awards, award agency) during the pre-tenure period. The findings revealed that, in probationary periods one and two, women in cohort one submitted grant applications at lower rates than men. However, during probationary period one, women in cohort two submitted grants at the same rate as men. This finding could be a reflection of the shift in the university's expectations regarding the importance of grant funding. During that period, at this institution, administrative expectations regarding the importance of applying for grant funding became much more explicit. Additionally, there were

no gender differences in the success rates of grants awarded, which may imply that women are not disproportionately awarded fewer grants than men.

The second research question was whether there was a correlation between grant activity and RPT, and if the correlation differed for women and men. The results of this analysis indicated that grant activity, including the number of grants submitted, awarded, size and type (federal/non-federal) showed a significant correlation with RPT and retention, but only the grant activity in probationary period two. There were gender differences regarding the correlation of the number of grants submitted and promotion, with the number being greater for women. This may reflect that, in cohort one during probationary period two, women submitted significantly fewer grants than men. Similar gender differences were seen in the importance of the number of grants awarded and the type of grants with promotion, also reflecting the gender difference in the numbers and types of grants awarded during probationary period two. The size of grants did not correlate with promotion. Taken together, these findings suggest that women faculty in cohort one were not as active as men in submitting grant applications, including those to federal agencies, during probationary period one. Women in cohort one also submitted fewer grants in probationary period one than the women in cohort two in probationary period one. Interestingly, there were no differences between the men faculty in cohort one and the men faculty in cohort two; their productivity measures were approximately the same during both probationary periods.

The third research question asked if there were gender differences in the composition of principal investigators (single, co-investigators) on grants submitted by and awarded to pre-tenure faculty at MSU. The role of being a sole principal investigator; a lead principal investigator with co-principal investigators; and a co-principal investigator each have implications on how quickly junior faculty are able establish their research independence. In this study, 68% of women (compared to 71% of men) submitted external proposals as the sole principal investigator. This group of women could have had research collaborators within the institution of study but those collaborators may not have been elevated to the role of co-principal investigator. Data on co-principal investigators outside the institution were not available for this study. Additionally it was out of the scope of this project to identify the faculty ranking and tenure status of the co-investigators.

Similar percentages of women and men (24.4% and 23.5% respectively) were principal investigators who invited one to two faculty to be co-principal investigators. This demonstrates a willingness to collaborate among faculty at the institution, which counts as tacit check mark within departments and colleges. The percentages decreased to fewer than 10% among both genders, with regard to three or more co-principal investigators. Overall, women PIs, on average, had more co-PIs than men, suggesting that women seek larger groups of collaborators. However, the grants awarded to women had the same number of co-PIs as grants awarded to men, suggesting that the larger number of collaborators on applications from women may not positively impact decisions on awards.

## **Limitations**

This study had three noteworthy limitations. First, the data available were limited by the database capabilities of the institution used in this study, and were only able to collect data from 2001 to 2011. Consequently, the results about RPT were limited to the analysis of faculty in cohort one. A follow-up analysis will be carried out once cohort two has reached the tenure and promotion stage. The study has also created an institutional framework for analyzing grant

activity, its correlation to RPT, and gender differences. Moving forward, the institution of this study now has the methodology to collect these data at regular intervals.

The second limitation of the present study is its single institution site, which renders the results of the study as not generalizable to the wider STEM faculty population. The methodologies, however, are transferable, and presumably the study design can inform other institutional studies of a similar nature. In the future, the investigators plan to engage other universities in a larger study of grant activity and its correlation to RPT.

Third, the questions in this study were to define gender specific associations and correlations and not to develop a predicative model. To build a predicative model would require access to additional data that would control for other possible factors. Such an analysis would be built on the current study.

### **Implications for Policy and Practice**

There are several theoretical and practical approaches that can be used to assist universities in creating a better context that supports the success of their investments - new faculty. The implications of this study use common best practices and organizational theory to influence the adoption and implementation of both policy and practice that can impact faculty success. Below, we discuss the need for greater transparency in communicating institutional expectations of faculty, the potential role of mentoring, and the importance of continuously monitoring policy implementation.

Research, including this study, has shown that securing external funding to support one's research is correlated with the success of pre-tenure STEM faculty, both men and women. Success of early career faculty in research-intensive institutions is of critical importance because to recruit such faculty requires significant investment, and their success, as measured by grant funding and premier publications, impacts the standing of the institution. Among the women faculty in this study, the results indicated dramatic differences in the grant activity of women in cohort one and those in cohort two. As previously noted, there was increased clarity at the institution used in the study in communicating the importance of external funding for retention and promotion in the last six years, especially in the STEM disciplines. This greater clarity may have had a differential influence on women faculty, and additional studies should be carried out to determine if clarifying expectations and communicating them transparently to all early career faculty might alter and improve their success. This study identified a difference in women faculty's efforts to secure external funding in the time period when those expectations were made more transparent.

Through use of a continuous change framework to monitor the implementation of policies and practices, including RPT, the university can more intentionally be transparent and consistent in evaluating faculty (Weick & Quinn, 1999). This study has established an inquiry framework for one institution that will allow for regular monitoring of faculty by cohort, and any correlations between their grant activity and promotion and retention. Any future concerns raised by regular monitoring can be addressed in a timely fashion. Additionally, we suggest that monitoring and evaluation by assessing faculty perceptions about institutional policies and practices could be added to future studies. Questions about transparency and clarity in expectations could be used to measure any changes over time.

Overall, universities struggle with the same leadership support and development issues as other organizations – how to best support the future innovators and leaders. Implications of this study include transparency, clarity, mentoring, and continuous organizational learning and

evaluation. The results of this study may not directly apply more broadly to other research-intensive institutions. However, most research-intensive institutions hold similar expectations of their STEM faculty and may wish to consider how the creation and continuing analysis of policies and practices related to early career faculty could enhance success.

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## APPENDIX

**Table 1** Number of Grants Submitted and Number of Years Without Submission by Gender, Assistant Professors Across Cohorts

Variable	Gender	N	Mean	SD	<i>t</i>	<i>df</i>	<i>p</i>	Mean Diff																																																																																						
Cohort 1: Total number of grants submitted, probationary period 1	Women	79	4.42	6.74	-2.84	192	.005**	-3.09																																																																																						
	Men	122	7.51	8.62					Cohort 1: Total number of grants submitted, probationary period 2	Women	79	7.35	13.30	-2.15	199	.033*	-4.31	Men	122	11.66	14.23	Cohort 1: Total number of years not submitting any grant, probationary period 1	Women	79	1.39	1.10	2.88	155	.005**	0.44	Men	122	0.95	0.99	Cohort 1: Total number of years not submitting any grant, probationary period 2	Women	79	1.67	1.47	2.03	199	.044*	0.42	Men	122	1.25	1.44	Cohort 1: Total number of years not submitting any grant across probationary periods	Women	79	3.06	2.09	2.79	199	.006**	0.87	Men	122	2.20	2.18	Cohort 2: Total number of grants submitted, probationary period 1	Women	101	5.83	6.77	-1.50	239	.135	-1.43	Men	149	7.26	8.22	Cohort 2: Total number of years not submitting any grant, probationary period 1	Women	101	1.15	1.12	0.47	248	.635	0.07	Men	149	1.08	1.11	Cohorts Combined: Total	Women	180	5.21	6.78	-3.01	432	.003**
Cohort 1: Total number of grants submitted, probationary period 2	Women	79	7.35	13.30	-2.15	199	.033*	-4.31																																																																																						
	Men	122	11.66	14.23					Cohort 1: Total number of years not submitting any grant, probationary period 1	Women	79	1.39	1.10	2.88	155	.005**	0.44	Men	122	0.95	0.99	Cohort 1: Total number of years not submitting any grant, probationary period 2	Women	79	1.67	1.47	2.03	199	.044*	0.42	Men	122	1.25	1.44	Cohort 1: Total number of years not submitting any grant across probationary periods	Women	79	3.06	2.09	2.79	199	.006**	0.87	Men	122	2.20	2.18	Cohort 2: Total number of grants submitted, probationary period 1	Women	101	5.83	6.77	-1.50	239	.135	-1.43	Men	149	7.26	8.22	Cohort 2: Total number of years not submitting any grant, probationary period 1	Women	101	1.15	1.12	0.47	248	.635	0.07	Men	149	1.08	1.11	Cohorts Combined: Total	Women	180	5.21	6.78	-3.01	432	.003**	-2.16	Men	271	7.37	8.39								
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	Men	122	0.95	0.99					Cohort 1: Total number of years not submitting any grant, probationary period 2	Women	79	1.67	1.47	2.03	199	.044*	0.42	Men	122	1.25	1.44	Cohort 1: Total number of years not submitting any grant across probationary periods	Women	79	3.06	2.09	2.79	199	.006**	0.87	Men	122	2.20	2.18	Cohort 2: Total number of grants submitted, probationary period 1	Women	101	5.83	6.77	-1.50	239	.135	-1.43	Men	149	7.26	8.22	Cohort 2: Total number of years not submitting any grant, probationary period 1	Women	101	1.15	1.12	0.47	248	.635	0.07	Men	149	1.08	1.11	Cohorts Combined: Total	Women	180	5.21	6.78	-3.01	432	.003**	-2.16	Men	271	7.37	8.39																					
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	Men	122	2.20	2.18					Cohort 2: Total number of grants submitted, probationary period 1	Women	101	5.83	6.77	-1.50	239	.135	-1.43	Men	149	7.26	8.22	Cohort 2: Total number of years not submitting any grant, probationary period 1	Women	101	1.15	1.12	0.47	248	.635	0.07	Men	149	1.08	1.11	Cohorts Combined: Total	Women	180	5.21	6.78	-3.01	432	.003**	-2.16	Men	271	7.37	8.39																																															
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	Men	149	7.26	8.22					Cohort 2: Total number of years not submitting any grant, probationary period 1	Women	101	1.15	1.12	0.47	248	.635	0.07	Men	149	1.08	1.11	Cohorts Combined: Total	Women	180	5.21	6.78	-3.01	432	.003**	-2.16	Men	271	7.37	8.39																																																												
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	Men	271	7.37	8.39																																																																																										

number of grants  
submitted,  
probationary  
period 1

Cohorts	Women	180	1.26	1.11	2.22	370	.027*	0.23
Combined: Total number of years not submitting any grant, probationary period 1	Men	271	1.02	1.06				

\*  $p < .05$ , \*\*  $p < .01$

**Table 2** Cohort 1: Correlation between number of grants submitted / years without submissions / number of grants awarded / amounts of awards and promotion and retention by gender

Variable	Women (N = 79)		Men (N = 122)	
	Promotion	Retention	Promotion	Retention
Number of grants submitted probationary period 1	.199	.049	.073	.107
Number of grants submitted probationary period 2	.313 **	.262 *	.176	.263 **
Number of years not submitting any grant probationary period 1	-.174	.039	-.023	-.048
Number of years not submitting any grant probationary period 2	-.380 ***	-.530 ***	-.305 ***	-.520 ***
Number of years not submitting any grant years 1-7	-.358 ***	-.351 **	-.213 *	-.366 ***
Number of grants awarded probationary period 1	.107	.011	.043	.111
Number of grants awarded probationary period 2	.250 *	.183	.132	.181 *
Total amount awarded per faculty probationary period 1 (including 0 submissions)	-.053	-.120	.075	.080
Total amount awarded per faculty probationary period 2 (including 0 submissions)	.185	.269 *	.235	.351 ***
Average amount awarded per faculty per year, probationary period 1 (including 0 submissions)	.137	-.050	.071	-.047
Average amount awarded per faculty per year, probationary period 2 (including 0 submissions)	.030	.145	.140	.296 ***

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

**Table 3** Average percentage of grants submitted to and awarded from federal agencies by gender

Variable	Gender	N	Mean	SD	<i>t</i>	<i>df</i>	<i>p</i>	Mean Diff
Cohorts 1 & 2: Avg % of total grants submitted that were to federal agencies, probationary period 1	Women	144	54%	0.36	-2.49	374	.013*	-0.09
	Men	232	63%	0.34				
Cohorts 1 & 2: Avg % of total grants awarded that were from federal agencies, probationary period 1	Women	89	40%	0.44	-2.76	262	.006**	-0.15
	Men	175	55%	0.43				
Cohort 1: Avg % of total grants submitted that were to federal agencies, probationary period 1	Women	61	49%	0.39	-2.35	167	.020*	-0.14
	Men	108	63%	0.35				
Cohort 1: Avg % of total grants submitted that were to federal agencies, probationary period 2	Women	68	62%	0.37	0.21	174	.831	0.01
	Men	108	61%	0.34				
Cohort 1: Avg % of total grants awarded that were from federal agencies, probationary period 1	Women	38	31%	0.43	-3.07	123	.003**	-0.26
	Men	87	57%	0.44				
Cohort 1: Avg % of total grants awarded that were from federal agencies, probationary period 2	Women	49	49%	0.43	-0.62	140	.538	-0.05
	Men	93	53%	0.41				

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

**Table 4** Cohort 1: Correlation between percentage of federal grants submitted and awarded and promotion and retention, by gender

Variable	Women (N = 79)		Men (N = 122)	
	Promotion	Retention	Promotion	Retention
Avg % of federal grants submitted probationary period 1	.198	.022	.054	.053
Avg % of federal grants submitted probationary period 2	.285 *	.267 *	.084	.242 **
Avg % of federal grants awarded probationary period 1	.193	.022	.098	.066
Avg % of federal grants awarded probationary period 2	.341 **	.259 *	.115	.304 ***

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$