Boundary Spanning in Academia:

Antecedents and Near-Term Consequences of Academic Entrepreneurialism

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ABSTRACT

Analyzing the pathways of people who earned interdisciplinary research doctorates in the United States in 2010, we generate three main findings while controlling for gender, ethnicity, discipline, and age. First, individuals who complete an interdisciplinary dissertation display near-term income risk since they tend to earn nearly $1,700 less in the year after graduation. Second, students whose fathers earned a college degree demonstrated a .8% higher probability of pursuing interdisciplinary research. Third, the probability that non-citizens pursue interdisciplinary dissertation work is 4.7% higher when compared with US citizens. Our findings quantify the risks of interdisciplinary work and contribute to policy debates.

Keywords

Boundary spanning, risk, entrepreneurs, over-optimism, interdisciplinary research, wages, immigrants

JEL Codes: D01; D81; I23; I28; J15; J31

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I. INTRODUCTION

Celebrity in academia tends to be gained by integrating knowledge and bridging ideas across multiple disciplines. Highly-cited, best-selling authors seem to emerge most commonly from the ranks of faculty who display command of multiple fields. Dan Ariely, for example, extraordinarily earned two PhDs – in cognitive psychology and business administration – before authoring the best-selling hits *Predictably Irrational* (2008) and *The Upside of Irrationality* (2010). Similarly, Jared Diamond built a career studying birds before winning the Pulitzer Prize for a biogeographic history of humanity, *Guns, Germs and Steel: The fates of human societies* (1997).

In effect, academic celebrity tends to be gained by boundary spanners who "build understanding between areas of functional expertise" and "enable new information to be incorporated on an ongoing basis" (Gittell, Seidner, & Wimbush, 2010). Various characteristics of boundary spanners have been commonly studied across industries in relation to innovation (e.g., Dahlander & Frederiksen, 2012), buyer-supplier relationships (e.g., Perrone, Zaheer, & McEvily, 2003; Zaheer, McEvily, & Perrone, 1998), and inter-firm relationships (e.g., Swan & Newell, 1995). For academicians' own activities, though, the concept of boundary spanning has mainly been applied to consider interactions between academic researchers and non-academic practitioners (e.g., Gulati, 2007; McGivern & Dopson, 2010), perhaps due to an assumption – criticized by Sauerman and Stephan (2013) – that academia has enough organizational uniqueness that concepts that are relevant for business organizations lack relevance.

In this article, we apply the concept of boundary spanning to the industry of academic research and examine the individual pathways of interdisciplinary researchers. Previous studies have considered boundary spanning in relation to

diverse organizational pairs such as medical doctors in the United States (US) and attorneys in Israel (Montgomery & Oliver, 2007) as a means of generating generalizable lessons. In contrast, our study of academia across the gamut of disciplinary domains contributes in a novel way to debates concerning the characteristics of boundary spanners. Previous researchers studying non-academic industries have shown positive (e.g., Fleming & Waguespack, 2007; Foss and Rodgers, 2011) and mixed (Dahlander & Frederiksen, 2012) effects for individuals who are boundary spanners with a general conclusion that contextual factors are important for predicting the specific outcomes. Among the individual-level contextual factors that are important for understanding academic boundary spanners, we will analyze (1) whether there tend to be career consequences associated with pursuit of interdisciplinary knowledge and (2) whether – and how – an individual's background characteristics might predict such endeavors. Comparable to studies that have sought to identify relevant personal traits of corporate leaders and entrepreneurs in relation to outcome variables such as firm performance (e.g., Norburn, 1986, 1989; Pettigrew, 1992), our interests address important gaps in relation to understanding academic boundary-spanners, i.e., those pursuing interdisciplinary research.

In addition to our theoretical motivations to study boundary spanning and spanners in academia, questions involving the antecedents and consequences of the decision to pursue interdisciplinary postgraduate research are significant for several practical reasons. First, institution-level interests often encourage interdisciplinary pursuits on the basis of ideals just as academic analyses often highlight the synergies that can be gained by cross-fertilizing ideas across disciplinary boundaries (e.g., Bozeman, 2013). Yet economic consequences, such as income risk, are either not understood, fully considered or both. To partially fill this gap, our study examines whether individuals who pursue this path tend to face better or worse outcomes immediately after earning the PhD. Second,

against the backdrop of claims that globally important problems require more interdisciplinary integration (e.g., Schmidt et al., 2012), greater knowledge of any factors that currently contribute to boundary spanning should be helpful for encouraging more people to work across disciplinary lines. Finally, in light of interests of colleges and universities to employ diverse workforces (e.g., Oldfield, 2008), it is valuable to know whether people are disproportionately likely to pursue interdisciplinary postgraduate research as a function of demographic variables such as gender, citizenship status, and parental backgrounds.

We approach the subject of academic boundary spanning through a risk-based framework that extends Montmarquette et al.'s (2002) findings that – based on their undergraduate degrees – fields such as the sciences with higher salaries tend to entail more career risk; and, conversely, fields such as education that yield lower salaries tend to entail less career risk. Our approach is comparable to studies concerning the calculation of risks made by boundary spanners in non-academic contexts (e.g., Janowicz-Panjaitan & Noorderhaven, 2009); however, our focus on academicians allows us to consider a clear set of measurable outcomes. More specifically, we assume that interdisciplinary postgraduate research entails relatively greater risks – and potential rewards – when compared with traditional discipline-focused research. Comparable to the question of whether entrepreneurs are aware of the risks that they face (e.g., Cassar, 2010), the current research contributes to greater awareness of the potential costs of academic risk-taking for PhD seekers. Throughout our analyses, we presume that academia is not an exceptional industry whose dynamics are exempt from generalizable organizational dynamics.

Background

The industry of academia is most commonly and directly regulated at the level of discipline-based departments through hiring and promotion. For example, Abbott (2001) argues that "as long as disciplinary academics act as the primary hiring agents for universities, they perpetuate the disciplinary system" (p. 126) and that "absent any radical change in the process of academic hiring, the current social structure of disciplines will endlessly recreate itself" (p. 127). Less directly but still importantly, hiring and promotion decisions at the department level are commonly and, in many cases, strongly influenced by decisions made by discipline-based journals and granting agencies to publish manuscripts and fund research proposals. With respect to these goals, Rhoten and Pfirman (2007, p. 68) stress the fact that "interdisciplinary papers are harder to review" since they are typically judged by people from a variety of disciplines who often have conflicting measures of quality. Similarly, notwithstanding the laudable goals of select journals to embrace diverse perspectives and approaches (e.g., Hinings, 2010) and administrative initiatives to provide interdisciplinary programs with hiring and promotion decisions (e.g., Ehrenberg, 2004), Oberg (2009, p. 408) elaborates that interdisciplinary research is often assessed by reviewers according to discipline-specific biases in favor of certain methods (e.g., large-scale quantitative analysis) over others (e.g., case studies). In other words, people who specialize intensively in a discipline gain knowledge that is "largely tacit, situated, and experiential" (Kellogg, Orlikowski, & Yates, 2006, p. 24) that implicitly presents challenges and risks for would-be spanners.

The relative risk for individuals to span disciplinary boundaries is reflected by Rhoten and Parker's (2004) findings that "graduate students and full professors were indeed overrepresented" in their study of interdisciplinary programs when contrasted with the proportions of non-tenure-track faculty,

postdoctoral researchers, and faculty at the assistant and associate ranks. Reasonable interpretations of this pattern recognize that graduate students have not yet committed as much time to any specific discipline and may be unaware of the potential labor market consequences. Full-rank professors, though, "have accumulated greater professional freedom and more social resources" (Rhoten & Parker, 2004, p. 2046) and, consequently, are more able – at that point in their careers – to become boundary-crossers (cf. Inkson, Gunz, Ganesh, & Roper, 2012). Interestingly, this pattern is comparable with Colignon's (1987) finding that boundary spanners in a large non-academic enterprise tended to occupy highly ranked positions. As for individuals who have made a significant investment of energy through completion of a doctoral program, the traditional discipline-based reward system would seem to explain why those most likely seeking promotion (e.g., to Associate or Full professor) tend to avoid interdisciplinary research.

Beyond Rhoten and Parker's (2004) systematic study based upon career stage, there has been little attention focused on the demographic profile of people who pursue academic boundary spanning; instead, it is more common for researchers to conduct bibliometric studies of boundary spanning that are not focused on the spanners (e.g., Pieters and Baumgartner 2002). In one exception, Falkenheim (2011) tabulates which specific universities tend to graduate the highest number of people who report interdisciplinary research activity. In a more substantive and sweeping exception, Rhoten and Pfirman (2007) test the hypothesis that women might participate disproportionately in interdisciplinary research because of a position that some have advanced that women are more inclined to think holistically, across disciplinary boundaries. While they report mixed results for their "women are more holistic" hypothesis, they are also clear about their main interest to draw more attention to the question of "who" pursues interdisciplinary postgraduate research.

Consistent with our motivation to understand the antecedents and consequences of decisions to span academic boundaries, there are concerns regarding the risks associated with interdisciplinary research and degrees. For example, Rhoten and Pfirman's (2007) consideration of gender as a potentially relevant demographic variable is reflected in their conclusion that "using interdisciplinarity to attract women, as well as other underrepresented minority groups into science, is only practical and ethical if it leads to stable and secure pathways through scientific and academic careers" (p. 72). The relevance of this concern is illustrated clearly through the National Science Foundation's (NSF) Integrative Graduate Education and Research Traineeship (IGERT) programs (e.g., Borrego & Newswander, 2010; Moslemi et al. 2009; Schmidt et al., 2012) that are specifically geared to training graduate students to span academic boundaries. On the one hand, it makes sense for solution-driven projects to proceed without the burden of disciplinary hinges on the grounds that new problems require new "disciplines." In fact, in a study of knowledge-intensive firms outside of academia, Leiponen and Helfat (2010) report that firms tend to enjoy comparative advantages as a function of the breadth of their knowledge sources. On the other hand, though, there has been remarkably little investigation to date with respect to the individual-level outcomes that tend to obtain for graduate students who do engage interdisciplinary studies.

The potential conflict of institution- and individual-level interests anticipated by Rhoten and Pfirman (2007) is best viewed as an extension of the more basic conflict of interest that people have debated with respect to recruiting individuals for any graduate program. For example, as Baird (1991) discovered, the number of graduate students in a department accounts significantly for the number of publications produced by a department's faculty (e.g., in collaboration with graduate student researchers) even though "the publications rate of departments has little to do with educational outcomes for students" (p. 316).

Against that backdrop, departmental efforts to recruit students for interdisciplinary research may reflect the department's goal of broader recognition while not necessarily preparing graduate students for the associated risks.

Independent of one's views on the implications of Baird's findings, students agreeing to pursue interdisciplinary research may not fully consider, or even understand, the risks involved in such doctoral programs. Students may be "naïvely optimistic" (Golde & Dore, 2001) about their postgraduate employment outcomes just as overly optimistic personalities may place disproportionate weight on positive outcomes (Weinstein, 1980, 1989). Regardless of the reason, one of the motivations for our analyses is to generate knowledge concerning the typical pathways taken by individuals pursuing interdisciplinary postgraduate research. Individuals evaluating the benefits and risks associated with these programs will profit from a more systematic analysis of the antecedents and consequences for people enrolled in these programs.

In a risk-return framework, it makes sense that individuals postpone employment for graduate studies since there is a premium associated with the additional schooling (Autor, Katz, and Kearney 2008). Yet, given the academic uncertainties related to interdisciplinary work, as well as the difficulty interdisciplinary PhD degree seekers encounter in completing their studies (Newswander and Borrego, 2009), it is an open question to consider whether interdisciplinary work is rewarded. Specifically, previous research has not quantified the rewards or risks associated with interdisciplinary dissertation research.

In the analysis that follows, we will (1) examine the existence and strength of any near-term income risk associated with completing an interdisciplinary dissertation and (2) consider the distributional characteristics of people who complete an interdisciplinary dissertation. Our approach presumes that

understanding how these doctoral recipients are distributed across demographic dimensions will supply university administrators and policy makers with information for developing relevant curricula and programs to produce successful PhD earners.

II. DATA AND METHODS

Data

The annual Survey of Earned Doctorates (SED) conducted by the National Science Foundation's (NSF) National Center for Science and Engineering Statistics (NCSES) presents the ideal dataset for testing our models. To focus on the most recent year of available data, we utilized responses from the 2010 edition of the Survey, which was administered to everyone earning a research doctorate in the US between July 1, 2009 and June 30, 2010. Fiegener (2011) reports that the 2010 Survey gained responses from 92.9% of the 48,609 people who earned the doctorate that year in the US, and 42,957 of the respondents provided information for the variables that we used in this study (88% of the total population).

For people who do not complete the full survey, the SED records limited information based upon "administrative lists of the university, such as commencement programs and graduation lists." For example, gender is recorded for 99.7% of respondents and citizenship is known for 94.0% of the population of doctorate graduates from 2010. With respect to various kinds of doctoral degrees, the 2010 SED primarily concerns people who earned the Doctor of Philosophy (PhD) (95.8%) and Doctor of Education (EdD) (3.1%) and does not involve people with "professional doctorates" in law, medicine, or dentistry.

For the purposes of this study, we mainly focus on PhD earners who declared US citizenship partly because measures of socioeconomic background as well as culture-specific attitudes to higher education are variable across countries (e.g., Daouli, Demoussis, and Giannakopoulos, 2010; Sen and Clemente, 2010). Our approach omits significant heterogeneity, which can greatly affect standard errors for the point estimates, for our primary analyses. We do, however, examine the impact of US citizenship on the decision to pursue an interdisciplinary degree and are able to compare the 26,568 respondents who are US citizens (61.8%) with the 16,389 respondents in our sample who are immigrants (38.2%).

Variables

Interdisciplinary Postgraduate Research

Following previous researchers (Falkenheim, 2011; Millar & Dillman, 2010a, 2010b), we categorized respondents to the SED who indicated a secondary field for their degree as people who pursued interdisciplinary postgraduate research. More specifically, the 2010 Survey prompted respondents with the following text: "If your dissertation was interdisciplinary, list the name and number of your secondary field." We also control for the primary dissertation field since individuals in some fields are disproportionately likely to pursue interdisciplinary work.

Demographic Variables

Among the background variables that are measured by the Survey, our analysis utilizes measures of Age (or Year of Birth), Gender, Ethnicity,

Citizenship, and parental education. For parental education, respondents are asked to provide one of eight options for each parent, indicating whether an individual's mother and father received anywhere from no education to an advanced degree. Based on previous research described above, we collapsed the range to focus on potential differences as a function of whether a person's mom (*MotherEdu*) or dad (*FatherEdu*) earned a college degree. Throughout our analyses, we adopt the same category labels (e.g., for ethnic categories) as the NSF used in its Survey instrument.

We also utilize the Carnegie classification system to control for university research intensity. While this classification system does not include a ranking per se, it identifies PhD granting institutions as having very high, high, or moderate research activity. These three types of PhD granting institutions represent nearly 95% of the universities in the sample. This classification system also identifies smaller PhD granting institutions that might have minimal or non-existent research activity. For our analysis, we create indicator variables for each of the classifications mentioned above. The variables *CarnegieClass2, CarnegieClass3,* and *CarnegieClass4* are included in the regressions, with the lower classes (1-3) representing universities with the most research activity. The variable *CarnegieClass1*, representing universities with the highest research activity, is left out and serves as the reference category.

Near-Term Consequences

Drawing upon responses to questions about post graduation plans, we utilized answers to the prompts: (1) "Do you intend to take a 'postdoc' position?" and (2) "What will be your basic annual salary for this principal job (in the next year)? Do not include bonuses or additional compensation for summertime teaching or research. If you are not salaried, please estimate your earned

income." While the question regarding postdocs provided two options (yes or no), respondents were invited to select one of 12 options to report their salary, ranging from "$30,000 or less" to "$110,000 or above" with an additional option to indicate that they "Don't know" their salary for the year after earning the doctorate. Salary ranges spanned $5,000 for the first 5 brackets and then $10,000 thereafter. To facilitate interpretation of regression coefficients, we used the means of the salary ranges as values for the dependent variable.

Specifications

For the initial analysis of near-term income risk, in terms of a salary differential, associated with pursuing interdisciplinary postgraduate work, we estimate the impact that the choice to pursue an interdisciplinary degree has on salary outcomes for employment immediately proceeding graduation. Though salary ranges are reported, to generate a continuous variable we use the average value of each salary. Then we assume the following linear relationship between salary and its influencing factors:

$$
\begin{aligned}
Salary_i = x'_{INCi}\gamma \\
&= \gamma_0 + \gamma_1 IntDisc_i + \gamma_2 FatherEdu_i + \gamma_3 MotherEdu_i \\
&+ \gamma_4 Field_{1i} + \gamma_5 Field_{2i} + \gamma_6 Field_{3i} + \gamma_7 Field_{4i} + \gamma_8 Field_{5i} \\
&+ \gamma_9 Field_{6i} + \gamma_{10} Field_{7i} + \gamma_{11} Field_{8i} + \gamma_{12} Field_{9i} \\
&+ \gamma_{13} Field_{10i} \quad + \gamma_{14} CarnegieClass2 + \gamma_{15} CarnegieClass3 \\
&+ \gamma_{16} CarnegieClass4 + \gamma_{17} BirthYr_i + \gamma_{18} Gender_i \\
&+ \gamma_{19} White_i + \varepsilon_{INCi},
\end{aligned}
$$

(1)

where $Salary_i$ is the salary individual *i* will receive post graduation, $IntDisc_i^*$ is the propensity of individual *i* to pursue an interdisciplinary degree, *FatherEdu* is the individual's paternal education level, *MotherEdu* is the individual's maternal education level, $Field_{1\text{-}10}$ denote the individual's primary dissertation field within one of the main disciplinary categories, *CarnegieClass2-4* categorizes universities by Carnegie classifications where level 1 (omitted) represents very high research activity, level 2 represents high research activity, and level 3 represents research activity, and level 4 represents smaller universities or colleges, *BirthYr* is the individual's year of birth, *Gender* is the individual's gender, *White* is the individual's ethnicity, and ε_{PDi} is an independent and identically distributed random error term. The *INC* subscript on the vector of explanatory variables, *x*, and the random error term, ε, denotes that these variables correspond to the equation estimating the impact of factors on income or salary.

Since salary ranges are censored both above and below, standard linear regression techniques will generate inconsistent coefficient estimates and incorrect standard errors. To correct for this specification problem, a double-censored Tobit regression technique is used. This technique accounts for the probability mass that builds up at the censoring points as defined in the survey–$30,000 and $110,000 in this case–and generates appropriate estimates and standard errors.

While income is a good indicator of risks associated with pursuing interdisciplinary postgraduate research, the type of position accepted after graduation can also influence income. In the following specification, we do not control for positions across industries, or other similar dimensions, but instead include a dummy variable indicating whether an individual accepted a postdoctoral position after graduation. Such a position is equivalent to additional years of training and yet again postpones full employment. Thus, in the following specification, we estimate the effect that interdisciplinary research and other

demographic factors have on the decision to accept a postdoctoral position after receipt of the PhD. The estimation equation is given by

$$
\begin{aligned}
PostDoc_i^* = x'_{PDi}\beta \\
&= \beta_0 + \beta_1 IntDisc + \beta_2 FatherEdu_i + \beta_3 MotherEdu_i \\
&+ \beta_4 Field_{1i} + \beta_5 Field_{2i} + \beta_6 Field_{3i} + \beta_7 Field_{4i} + \beta_8 Field_{5i} \\
&+ \beta_9 Field_{6i} + \beta_{10} Field_{7i} + \beta_{11} Field_{8i} + \beta_{12} Field_{9i} \\
&+ \beta_{13} Field_{10i} \\
&+ \beta_{14} CarnegieClass1 + \beta_{15} CarnegieClass2 \\
&+ \beta_{16} CarnegieClass3 + \beta_{17} BirthYr_i + \beta_{18} Gender_i \\
&+ \beta_{19} White_i + \varepsilon_{PDi},
\end{aligned}
$$

(2)

where $PostDoc_i^*$ is the propensity of PhD candidate *i* to accept a postdoctoral position following graduation and the remaining variables are the same as those used in equation (1). Again, note that the subscript *PD* on the vector of explanatory variables, *x*, and the random error term, ε, specifies that these terms correspond specifically to equation (2) and its focus on predicting postdoctoral employment.

We note that the specific propensity of an individual to pursue a postdoctoral degree, $PostDoc_i^*$ is not observed in the data. What is observed, however, is $PostDoc_i = 0$ when $PostDoc_i^* = 0$ and $PostDoc_i = 1$ when $PostDoc_i^* > 0$, making $PostDoc_i$ a binary random variable. As a result, the estimating equation transforms to a generalized linear model of the form

$$P(PostDoc_i = 1 | x_{PDi}) = \Phi(x'_{PDi}\beta),$$

(3)

where Φ is the standard normal cumulative distribution function so we use the probit estimation procedure to estimate the vector β of unknown parameters.

To understand how interdisciplinary degree seekers are distributed across demographic characteristics we assume a linear relationship between the propensity to pursue an interdisciplinary degree, and the independent variables, or factors. The linear relationship we use to test this relationship is given by

$$\begin{aligned} IntDisc_i^* &= x'_{INTi}\alpha \\ &= \alpha_0 + \alpha_1 FatherEdu + \alpha_2 MotherEdu + \alpha_3 Field_{1i} \\ &+ \alpha_4 Field_{2i} + \alpha_5 Field_{3i} + \alpha_6 Field_{4i} + \alpha_7 Field_{5i} + \alpha_8 Field_{6i} \\ &+ \alpha_9 Field_{7i} + \alpha_{10} Field_{8i} + \alpha_{11} Field_{9i} \\ &+ \alpha_{12} Field_{10i} + \alpha_{13} CarnegieClass1 + \alpha_{14} CarnegieClass2 \\ &+ \alpha_{15} CarnegieClass3 + \alpha_{16} BirthYear + \alpha_{17} USCit_i \\ &+ \alpha_{18} Gender_i + \varepsilon_{INTi}, \end{aligned}$$

(4)

where $IntDisc_i^*$ is the propensity of individual i to pursue an interdisciplinary degree, and the remaining variables are as described in equation (1) and ε_{INTi} represents the unobserved effects not captured by the independent variables, and is assumed to be independent and identically distributed. The subscript *INT* on the x vector and random error term ε in equation (4) identifies the vector of explanatory variables and random error term in relation to the decision to pursue interdisciplinary research. As with equation (2), $IntDisc_i^*$ is unobserved so a binary variable is used instead and a probit estimation procedure is used to estimate the vector α of unknown parameters.

Finally, because a significant proportion of PhD earners are not US citizens, we estimate an equation similar to (4) though we do not include the

parental education variables (there are likely significant discrepancies in parental education levels across countries) and include a *USCit* variable indicating whether an individual is a US citizen. Again, we use the probit estimation procedure to estimate individual *i*'s propensity to pursue a boundary-spanning degree.

III. RESULTS

As indicated in Table 1, a significant percentage of individuals who earn doctoral degrees engage in boundary-spanning research. In fact, among those whose primary field is in the Agricultural and Life Sciences, 44% of respondents reported their work as interdisciplinary. Surprisingly, since the disciplines would seem to be closely related, the second lowest percentage of interdisciplinary dissertations (27%) was found among people in the Social Sciences. Across the sample used in this study, it is notable that 13,979 people (32.5 %) reported their work to span academic boundaries.

Insert Table 1 about here

Descriptive measures of the sample of US citizens are given in Table 2. In the sample, 30% of US citizens who earned research doctorates in 2010 chose to pursue interdisciplinary dissertation work, 51% were women, 83% were White or European American, more than half of their mothers and/or fathers had earned a college degree, and their average age was 36. Correlation coefficients for the variables of interest also indicate potential contributors to the decision to pursue interdisciplinary work and factors that may influence salary.

Insert Table 2 about here

Near-term income risk associated with interdisciplinary postgraduate research is indicated by the results in Table 3. Individuals who completed risky boundary-spanning dissertation research tend to earn significantly less income in their first year of employment with a doctoral degree (Table 3 and Figure 1). At the margin, individuals who sought an interdisciplinary degree earn nearly $1700 (3%) (from $58,014 to $56,342; $p<0.001$) less than those who pursued a traditional degree. Holding research fields and other demographic characteristics constant, Table 3 shows that women tend to earn less compared to men upon completion of the doctorate. Interestingly, European American individuals also earn less in their first year after graduation than those in other racial groups. While there is abundant previous research focused upon the role of gender and ethnicity for salaries among professional employees (e.g., Kulich et al., 2011), our findings for the marginal effects of pursuing interdisciplinary postgraduate research – when controlling for gender and ethnicity – provides novel insight.

Insert Table 3 about here

Insert Figure 1 about here

As a corollary to the examination of the salary differential between those who pursue interdisciplinary research and those who select the more traditional route, we examine the propensity of individuals in the sample to choose a

postdoctoral degree, which postpones full employment for additional training. To begin, when we regress salary on primary fields of research and whether an individual chose to accept a postdoctoral research position, we found that – controlling for variation across primary fields of research – postdoctoral researchers are paid nearly $24,000 ($p<0.001$) less than others (results not reported in a table). Then, when we estimate the parameters of equation 2 to examine how the various factors affect the decision to pursue postdoctoral work, we find that the probability of an individual accepting a postdoctoral research position after graduation is 6.1 percentage points higher (from 42.6 to 36.5; $p<0.001$) for those who complete an interdisciplinary dissertation. Similar to our previous analyses, we also find significant effects for the role of gender in this model. Indeed, we find – consistent with previous research (e.g., Moss-Racusin et al., 2012) – that a disproportionate percentage of women and non-white students accept postdoctoral positions.

Insert Table 4 about here

Insert Figure 2 about here

The patterns that we report in Tables 3 and 4 paint a consistent picture whereby people who conduct boundary-spanning doctoral research appear to face relatively worse outcomes in employment in the first year upon graduation. While we found evidence of other factors – gender and ethnicity – contributing to variation in the two outcome variables that we studied, the significant marginal

effect for interdisciplinary background upon employment as a postdoctoral researcher is noteworthy.

Given the evidence for income risk apparent in the data, we also compared the variances for each outcome variable in case those who conducted interdisciplinary dissertations might demonstrate relatively divergent outcomes. In other words, is the distribution of earnings a simple shift in means, or is there greater variance for those pursuing interdisciplinary work? In both cases of salary and postdoctoral status, there was no significant difference in the variances, indicating that pursuing a traditional research PhD or not accepting postdoctoral employment first order stochastically dominates the alternative choices. Consequently, while the potential riches of interdisciplinary research and writing appear obvious when one looks at academic celebrities, our focus on near-term consequences does not permit consideration of outcomes beyond the first year of earning the PhD.

In Tables 3 and 4, we also point out an interesting relationship evident in variables representing the four Carnegie classifications. Individuals who attended a university with moderate research activity reported higher earnings immediately after graduation relative to those who attended universities with extremely high research activity. Results in Table 5 report predicted values for interactions between pursuit of interdisciplinary postgraduate research and the Carnegie classifications. These predicted values were generated from results reported in Tables 3 and 4. Interestingly, a greater proportion of those who attend universities with very high research activity and pursued an interdisciplinary PhD accepted a postdoctoral position, which likely contributes to the lower salary they received.

Insert Table 5 about here

To understand how interdisciplinary degree seekers are distributed across socioeconomic and other dimensions, we estimated the parameters of equation (4). As indicated in Table 6, we find that parental education level – specifically whether a student's father earned a college degree – was weakly important. More specifically, when their father earned a college degree, the percentage of individuals who pursued a boundary-spanning dissertation project increased by .8 points as illustrated in Figure 3. While it is interesting that paternal – and not maternal – education is important, the findings suggest that people from families with more formal education may engage, with greater probability, the risk of interdisciplinary postgraduate research. Table 6 also indicates no significant influence for gender and, curiously, white doctoral students tend to significantly avoid interdisciplinary dissertation research. On the other hand, a greater percentage of individuals from the universities with the highest research activity tend to pursue interdisciplinary research.

Insert Table 6 about here

Insert Figure 3 about here

Finally, results in Table 7 show that the probability that immigrants to the United States – non-citizens, more precisely – choose to span academic boundaries for their doctoral work increases by 3.7 percentage points. Notably, the results for the model used in this analysis indicate that gender does not contribute significantly to predicting the pursuit of interdisciplinary dissertation when citizens and non-citizens are compared. In addition, the university's

research activity, as characterized by the Carnegie classifications, had no impact when examining the full sample of individuals receiving a PhD.

Insert Table 7 about here

Insert Figure 4 about here

IV. DISCUSSION AND IMPLICATIONS

Given the income risk associated with pursuing an interdisciplinary PhD, there is need to understand why individuals accept this risk. While the data does not include measures that can help identify risk preferences or other psychological characteristics, previous research provides some insight on the topic.

Rewards of Risk Taking

The risk-based framework for our analyses of the pathways traveled by people who conduct interdisciplinary research appropriately considers antecedents and consequences given an expectation from standard economic modeling that greater risk should correlate with greater rewards – or, at least, greater variance in rewards. In our case, for example, if market factors were driving individual-level decisions to pursue risky interdisciplinary postgraduate research, then we would expect – following Montmarquette et al. (2002) – that salaries would be generally higher for people who complete risky doctoral research or, at least, that the variance in salaries would be higher among the risk takers when compared with others.

A common assumption in economic models is that individuals have perfect information, which results in optimal market outcomes; however, ample empirical evidence demonstrates that people often make decisions with imperfect information (e.g., Stiglitz & Weiss, 1981). Among entrepreneurs outside academia, Cassar (2010) finds "substantial overoptimism" with respect to the likely chances that a given entrepreneur will successfully translate their efforts into a sustainable venture. Among aspiring academics in general, Golde and Dore (2001) find significant mismatches among doctoral students across a wide range of fields when they compared (a) discipline-specific averages for gaining stable, tenure-track employment and (b) individual expectations that a person would gain tenure-track employment. Our results provide a natural extension of Golde and Dore's (2001) findings whereby we report an apparent gap or mismatch in the near-term rewards that tend to be gained by interdisciplinary postgraduate researchers. In addition, based on our results, it is interesting to consider the combined near-term income risk of individuals who pursue interdisciplinary research *and* accept a relatively low-paid, contingent postdoctoral position.

Privileged Risk Taking

With respect to understanding the motivation of interdisciplinary degree seekers, the conventional view is that risk-taking behavior is a relative luxury. Investors, for example, commonly specify that any money invested in risky speculative stocks should be money that can be lost without great trouble (i.e., a category of money that most would consider to be a luxury). When applied to the questions that we are examining, the prediction is that people who belong to relatively privileged social groups will be more likely to pursue relatively risky interdisciplinary postgraduate research.

Focusing on ways in which a student's socioeconomic background might influence their selection of undergraduate majors, it is notable that students whose

parents did not earn a college degree tend to disproportionately pursue "vocational" degrees (e.g., in business, education, and engineering) while students with at least one parent who earned a college degree tend to pursue the relatively riskier "arts and sciences" (Goyette & Mullen 2006; Mullen et al. 2003; Wolniak et al., 2008). The same variable – whether or not someone is a first-generation college student – also appears to account for differences with respect to other aspects of academic career paths (e.g., Kniffin, 2007), including the pursuit of risky graduate degrees. Drawing on data from the 2002 *Survey of Earned Doctorates* conducted by the National Science Foundation (NSF), Hoffer et al. report: "Compared to doctorate recipients with higher levels of parental education, the first-generation graduates were over-represented in education … and underrepresented in humanities and, to a lesser extent, social sciences and physical sciences" (2003, p. 36). In a separate survey of more than 9,000 doctoral students from 21 research universities in the US, Nettles and Millett (2006) find a similar pattern whereby the percentage of graduate students with at least one parent with a doctoral or professional degree ranges from 16% in the least-risky field of education to 24%, 26%, 27%, and 34% for students, respectively, enrolled in engineering, social science, science, and humanities doctoral programs.

While our results only weakly support privileged risk taking in terms of parental education, it is important to recognize that this variable is only a proxy for parental income and lifetime wealth. In this respect, the significant but weak findings from our study do not negate the evidence from other studies that white males raised by highly educated parents tend to pursue the riskiest degrees (cf. Ball, Eckel, & Heracleous, 2010).

Entrepreneurial Immigrants

Comparing US citizens with non-citizens across industries, immigrants to the US tend to disproportionately pursue entrepreneurial goals (FPI, 2012). Fixed

into the narrative of the US as a "bastion of opportunity," the tradition of immigrants founding companies has a long history and cuts across industries (e.g., Ndofor & Priem, 2011). While much of the popular focus on immigrants opening their own businesses has focused on retail establishments, there is ample evidence that immigrants also contribute significantly – and disproportionately – to innovations in a wide range of skilled professions. Hunt and Gauthier-Loiselle (2010), for example, report that one percent increases in the number of skilled immigrants in the US tend to yield approximately 15% increases in patents per capita. Immigrants are not directly responsible for the full effect; instead, interestingly, their direct contribution to increased patent production appears to have positive spillover effects that help spur more patent claims by non-immigrants.

Within the industry of academics, the integration and application of research concerning immigrants in other industries lends itself to the prediction that non-citizens in the US will be more likely to pursue interdisciplinary postgraduate research. The importance of this relationship is clear in light of the significant increase in non-citizens earning research doctorates in the US. Among doctoral recipients in the US in the natural sciences and engineering, for example, Stephan (2012) reports an increase in non-citizens from 20% in 1966 to approximately 46% in 2010. Consistent with this trend, Mervis (2008) provocatively recognized in *Science* that the "Top Ph.D. Feeder Schools [to the US] Are Now Chinese." In the current research, our focus is not on students' specific country of origin or choice of discipline (cf. Stephan, 2012). Instead, we consider the full array of doctoral recipients rather than limiting our interests on those in the sciences and engineering (Grogger and Hanson, 2013) and we examine the degree to which immigrants pursuing the PhD exhibit the risk-taking entrepreneurial traits of immigrants in other industries. Evidence from our

analysis supports the notion that in academia, immigrants to the US still exhibit an entrepreneurial spirit.

Limitations of our results that point to directions for future research include our reliance on near-term outcome measures since it is possible that longitudinal studies would demonstrate less unfavorable outcomes for those who completed interdisciplinary dissertations. With respect to antecedents, our study does not take into account the possibility of pre-existing differences in the intelligence or aptitude of those who conduct interdisciplinary research. For example, while interdisciplinary postgraduate tracks such as the NSF IGERT programs are prestigious and competitive, it is plausible, at least, that students who choose interdisciplinary paths tend to face relatively worse near-term outcomes for reasons that are not due to their interdisciplinary pursuits. A comparison of standardized test scores (e.g., from the Graduate Record Examination [GRE]) that contrasts the populations of those who do and do not complete interdisciplinary postgraduate research would be one way to address this question of omitted variables with respect to potential differences in aptitude.

Finally, our focus on one year of data invites the question of whether cyclical patterns might exist with respect to the main findings that we report. For example, just as others have found that members of different ethnic groups variably decide to enter graduate school as a function of business cycles (e.g., Bogan and Wu, 2012; Johnson, 2013), it is possible that overall economic climates influence the degree to which doctoral students pursue interdisciplinary research. Empirical investigations modeled on our study could investigate whether expansionary economic periods tend to be accompanied by higher-risk interdisciplinary dissertations.

V. CONCLUSIONS

Our analyses provide significant new insights by estimating the near-term consequences for risky boundary-spanning within the industry of academia and understanding the variables that contribute to pursuit of interdisciplinary postgraduate research. First, we find evidence that boundary spanners face income risk, at least in the first year after graduation. With respect to antecedents, we find among US citizens that people with relatively privileged situations, as measured by paternal education levels or university prestige, appear more likely to be academic boundary-spanners. Additionally, as with other industries, immigrants appear significantly more likely to be academic risk takers. In both of these cases, it is also notable that gender is not predictive of decisions to pursue interdisciplinary postgraduate research. In this sense, our findings reject the "women are more holistic" hypothesis that Rhoten and Pfirman (2007) proposed – though we appreciate that it was their primary interest to draw closer systematic attention to the questions that the current research directly addresses.

To highlight one of our results that in turn highlights our juxtaposition of academia alongside other industries, our finding that academic boundary spanners are more likely to accept relatively short-term employment as postdoctoral researchers is arguably consistent with Dokko and Roskopf's (2010) recognition that boundary spanners outside of academia – perhaps due to their exposure to multiple firms, at least – have more opportunities to gain diverse employment experiences. While we generally accept that the differences between academia and other industries have been "overdrawn" (Sauermann & Stephan, 2013), the current value system in academia clearly imposes a cost on boundary spanning even if – as Kellogg et al. write about general "communities of practice" – the academic discipline system "reflects occupational conventions and understandings rather than rational calculations of efficiency" (2006, p. 24). It is

outside of the scope of our analysis to speculate on the future of academic labor markets; however, it is logical to expect that if academia were to become more institutionally organized to tackle contemporary problems in the way that competitive firms are expected to behave rather than remain tied to historical disciplinary boundaries, then one would expect that boundary spanners would obtain better near-term outcomes. Likewise, one would expect that the demographic profile of boundary spanners to become less extraordinary if the relative risks were minimized.

Uncoincidentally, perhaps, the analyses that we present are interdisciplinary to the extent that we integrate research conducted by education policy researchers and treat the industry of academic research and the market of academic researchers as comparable to other industries and labor markets. Just as studies of the automobile industry might lend themselves to policy recommendations in relation to industry-wide regulations, our study of academia – particularly because of our analyses related to near-term consequences – should inform regulatory-type debates with respect to institution-level encouragement of academic risk-taking. Most remarkably, our findings indicate a mismatch between institution-level interests to foster academic risk taking and individual-level experiences – in the near term, at least. This finding is particularly important since without recognizing the systematically probable outcomes for a given pathway, any policy recommendations (e.g., to encourage more interdisciplinary research) are problematic.

In the case of our analyses, evidence that a greater proportion of immigrants tend to pursue boundary spanning research also lends itself to endorsements of policies that open more doors for immigrants to doctoral programs in the US. On the other hand, though, evidence for near-term income risk should provide caution – or at least more information – for anyone considering institutional encouragement or individual pursuit of academic

boundary spanning at the doctoral-student career stage. When viewed together as part of the risk-based conceptual framework that motivated our work, the implications from our study clearly benefit from the concurrent consideration of factors that contribute to the pursuit of boundary spanning as well as the outcomes that tend to occur.

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TABLE 1

Percentage of doctorates awarded by discipline and interdisciplinary focus

Discipline	% All Research Doctorates	% Interdisciplinary
Agricultural and Life Sciences	2.3	44.5
Biological Sciences	17.6	41.1
Health Sciences	4.4	29.9
Engineering	16.0	32.8
Computer Sciences and Mathematics	7.0	22.7
Physical Sciences	10.9	29.3
Social Sciences	16.2	26.9
Humanities	10.6	37.7
Education	11.0	29.4
Business Management	2.8	31.2
Communications	1.4	39.8

TABLE 2

Descriptive statistics and correlations among US citizens

Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1. Interdisciplinary Dissertation	30.1%	0.459											
2. Father w/ College Degree	59.7%	0.491	0.07*										
3. Mother w/ College Degree	52.8%	0.499	0.05*	0.59*									
4. Salary	$58,210	23.237	-0.07*	-0.01	-0.01								
5. Post Doc	38.4%	0.486	0.08*	0.04*	0.03*	-0.52*							
6. Birth Year	1974.22	8.600	-0.02*	0.19*	0.20*	-0.17*	0.25*						
7. Female	51.3%	0.500	0.00	-0.01	0.02*	-0.10*	-0.04*	-0.09*					
8. Carnegie Classification 1	71.8%	0.378	0.02*	0.12*	0.11*	-0.02*	0.09*	0.22*	-0.06*				
9. Carnegie Classification 2	17.2%	0.223	-0.01	-0.07*	-0.07*	0.01	-0.07*	-0.14*	0.02*	-0.74*			
10. Carnegie Classification 3	5.7%	0.233	-0.03*	-0.08*	-0.07*	0.09*	-0.09*	-0.20*	0.06*	-0.37*	-0.10*		
11. Carnegie Classification 4	5.3%	0.223	0.00	-0.04*	-0.04*	-0.05*	0.03*	-0.03*	0.03*	-0.38*	-0.10*	-0.52*	
12. White	83.3%	0.373	0.01*	0.18*	0.20*	0.02*	-0.10*	-0.06*	0.04*	0.00	0.01	0.01	-0.02*

* $p < .05$

TABLE 3

Influence of interdisciplinary research upon salary

Panel A: Dependent variable: Salary				
Variable	Coefficient	Standard Error	Z-statistic	P-value
Interdisciplinary Dissertation	-1.09	0.38	-2.88	0.00
Father Education	-0.18	0.42	-0.44	0.66
Mother Education	0.13	0.41	0.33	0.74
Biological Sciences	-8.65	1.29	-6.68	0.00
Health Sciences	9.31	1.44	6.46	0.00
Engineering	17.46	1.35	12.96	0.00
Computer Sciences and Mathematics	14.45	1.44	10.04	0.00
Physical Sciences	1.37	1.34	1.02	0.31
Social Sciences	-0.10	1.29	-0.08	0.94
Humanities	-9.91	1.33	-7.46	0.00
Education	7.93	1.32	6.02	0.00
Business Management	41.23	1.67	24.69	0.00
Communications	-0.29	1.83	-0.16	0.88
University w/ High Research Activity	-0.94	0.49	-1.94	0.05
University w/ Moderate Research Activity	3.83	0.78	4.91	0.00
PhD Granting College or University	1.09	0.83	1.32	0.19
Birth Year	-0.59	0.02	-23.89	0.00
Female	-5.93	0.36	-16.33	0.00
White	-1.16	0.49	-2.35	0.02
Constant	1222.23	48.67	25.11	0.00
Panel B: Predicted Salary Based on Marginal Effect of Interdisciplinary Degree				
	Predicted Salary	Std Err	Z-statistic	P-value
Traditional Degree	$58,014	0.21	284.61	0.00
Interdisciplinary Degree	$56,342	0.31	180.97	0.00

TABLE 4

Influence of interdisciplinary research upon employment as postdoctoral researcher

Panel A: Dependent variable: Choose postdoctoral position				
Variable	Coefficient	Standard Error	Z-statistic	P-value
Interdisciplinary Dissertation	0.15	0.02	8.38	0.00
Father Education	0.01	0.02	0.35	0.72
Mother Education	0.01	0.02	0.68	0.49
Biological Sciences	0.60	0.06	10.29	0.00
Health Sciences	-0.26	0.07	-3.95	0.00
Engineering	-0.27	0.06	-4.50	0.00
Computer Sciences and Mathematics	-0.19	0.06	-2.90	0.00
Physical Sciences	0.38	0.06	6.30	0.00
Social Sciences	-0.19	0.06	-3.36	0.00
Humanities	-0.72	0.06	-12.00	0.00
Education	-0.97	0.06	-15.57	0.00
Business Management	-1.40	0.10	-13.66	0.00
Communications	-1.05	0.10	-10.65	0.00
University w/ High Research Activity	-0.19	0.02	-7.77	0.00
University w/ Moderate Research Activity	-0.14	0.04	-3.36	0.00
PhD Granting College or University	-0.09	0.04	-2.34	0.02
Birth Year	0.03	0.00	21.14	0.00
Female	0.06	0.02	3.52	0.00
White	-0.18	0.02	-7.98	0.00
Constant	-53.94	2.54	-21.20	0.00
Panel B: Marginal Effects of Interdisciplinary Degree				
	Coefficient	Standard Error	Z-statistic	P-value
Traditional Degree	36.5%	0.003	116.02	0.00
Interdisciplinary Degree	42.6%	0.005	91.44	0.00

TABLE 5

PhD Recipients From Universities With Very High Research Activity Were Most Likely to Complete an Interdisciplinary PhD

	Received Postdoctoral Position		Salary	
	Pursuit of Interdisciplinary Degree		Pursuit of Interdisciplinary Degree	
Carnegie Classification	**No**	**Yes**	**No**	**Yes**
Very High Research Activity	37.8%	43.8%	$58,700	$56,230
High Research Activity	32.0%	37.9%	$57,750	$55,280
Moderate Research Activity	33.4%	39.3%	$62,520	$60,050
PhD Granting College or University	35.0%	40.9%	$59,790	$57,320

TABLE 6

Socioeconomic background as predictor of interdisciplinary research

Panel A: Dependent variable: Choose interdisciplinary degree				
Variable	Coefficient	Standard Error	Z-statistic	P-value
Father Education	0.04	0.02	1.87	0.06
Mother Education	0.00	0.02	-0.22	0.83
Biological Sciences	-0.04	0.06	-0.74	0.46
Health Sciences	-0.45	0.07	-6.93	0.00
Engineering	-0.29	0.06	-4.81	0.00
Computer Sciences and Mathematics	-0.53	0.07	-8.07	0.00
Physical Sciences	-0.40	0.06	-6.69	0.00
Social Sciences	-0.46	0.06	-8.05	0.00
Humanities	-0.16	0.06	-2.80	0.01
Education	-0.45	0.06	-7.72	0.00
Business Management	-0.31	0.08	-4.09	0.00
Communications	-0.12	0.08	-1.47	0.14
University w/ High Research Activity	-0.06	0.02	-2.71	0.01
University w/ Moderate Research Activity	-0.03	0.04	-0.84	0.40
PhD Granting College or University	-0.02	0.054	-0.53	0.60
Birth Year	-0.01	0.00	-8.37	0.00
Female	0.03	0.02	1.80	0.07
White	-0.08	0.02	-3.78	0.00
Constant	0.18	2.14	8.30	0.00
Panel B: Marginal Effects of Interdisciplinary Degree				
	Coefficient	Standard Error	Z-statistic	P-value
Father: No College Education	30.9%	0.004	69.1	0.00
Father: College Education	31.7%	0.004	89.8	0.00

Method: Cross-section probit specification
Dependent Variable: (0/1) Completion of Interdisciplinary Dissertation

TABLE 7

Citizenship status as predictor of interdisciplinary research

Panel A: Dependent variable: Choose interdisciplinary degree				
Variable	Coefficient	Standard Error	Z-statistic	P-value
Biological Sciences	-0.05	0.04	-1.05	0.29
Health Sciences	-0.40	0.05	-7.86	0.00
Engineering	-0.30	0.04	-6.88	0.00
Computer Sciences and Mathematics	-0.59	0.05	-12.28	0.00
Physical Sciences	-0.38	0.04	-8.42	0.00
Social Sciences	-0.45	0.04	-10.35	0.00
Humanities	-0.16	0.04	-3.48	0.00
Education	-0.42	0.05	-9.13	0.00
Business Management	-0.37	0.06	-6.63	0.00
Communications	-0.12	0.07	-1.74	0.08
University w/ High Research Activity	-0.03	0.02	-1.48	0.14
University w/ Moderate Research Activity	-0.05	0.03	-1.64	0.10
PhD Granting College or University	-0.00	0.03	-0.06	0.95
Birth Year	-0.01	0.00	-9.26	0.00
US Citizen	-0.13	0.01	-9.23	0.00
Female	0.00	0.01	0.16	0.88
Constant	0.17	1.88	9.22	0.00
Panel B: Marginal Effect of US Citizenship				
	Predicted Probabilities	Standard Error	Z-statistic	P-value
Non-US Citizen	35.1%	0.004	89.02	0.00
US Citizen	31.4%	0.003	113.25	0.00

Method: Cross-section probit specification
Dependent Variable: (0/1) Completion of Interdisciplinary Dissertation

FIGURE 1

Interdisciplinary Postgraduate Researchers Tend to Earn Significantly Lower Salaries Upon Earning the PhD

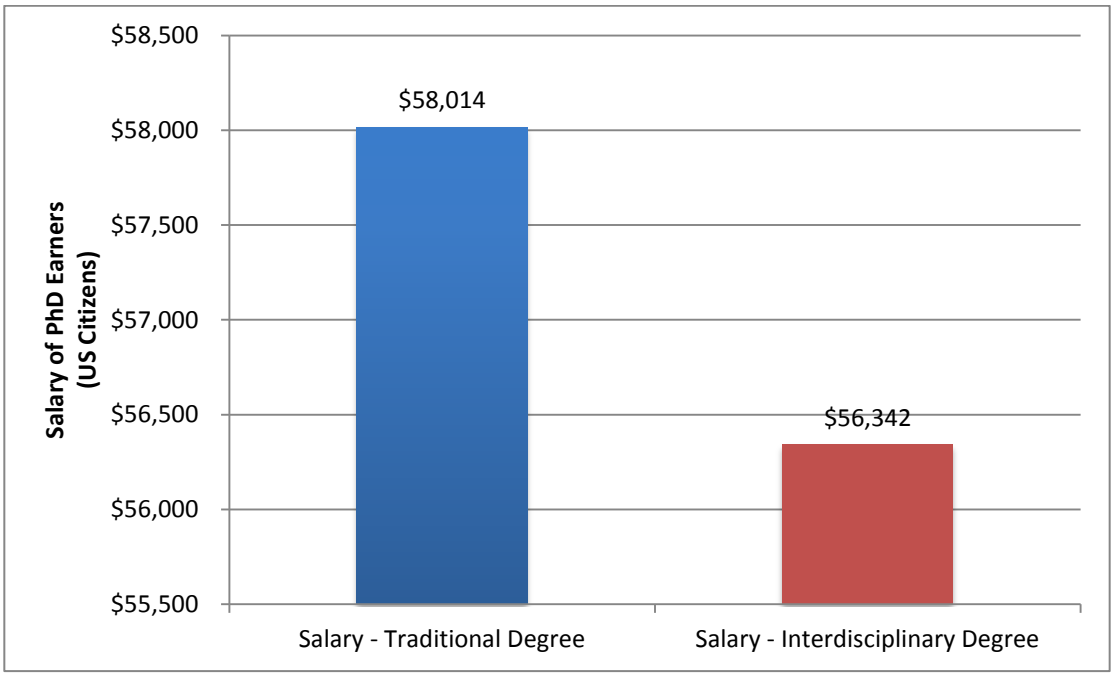

FIGURE 2

Interdisciplinary Dissertations Significantly More Likely to Precede Contingent Postdoctoral Employment

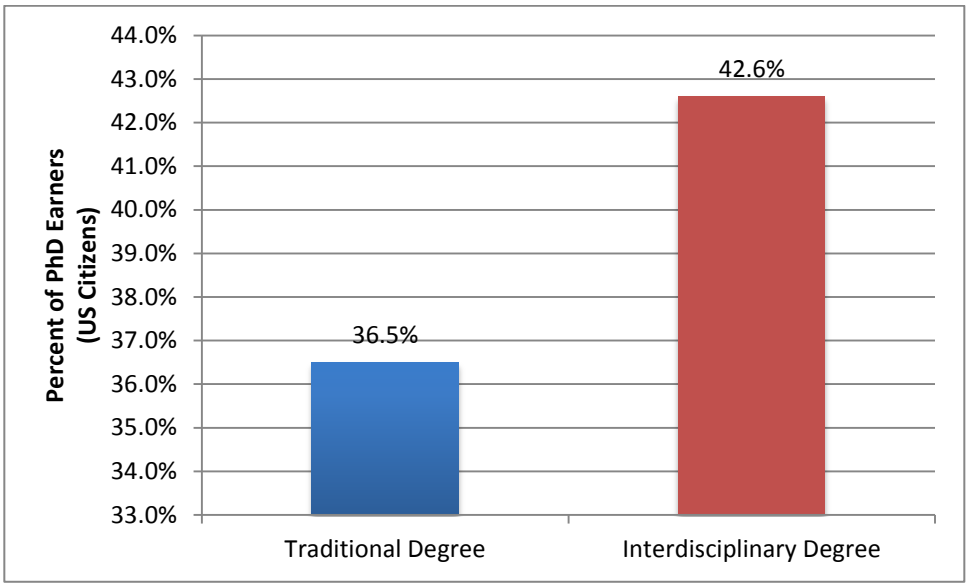

FIGURE 3

Paternal Education Levels Influence
Pursuit of Interdisciplinary Postgraduate Research

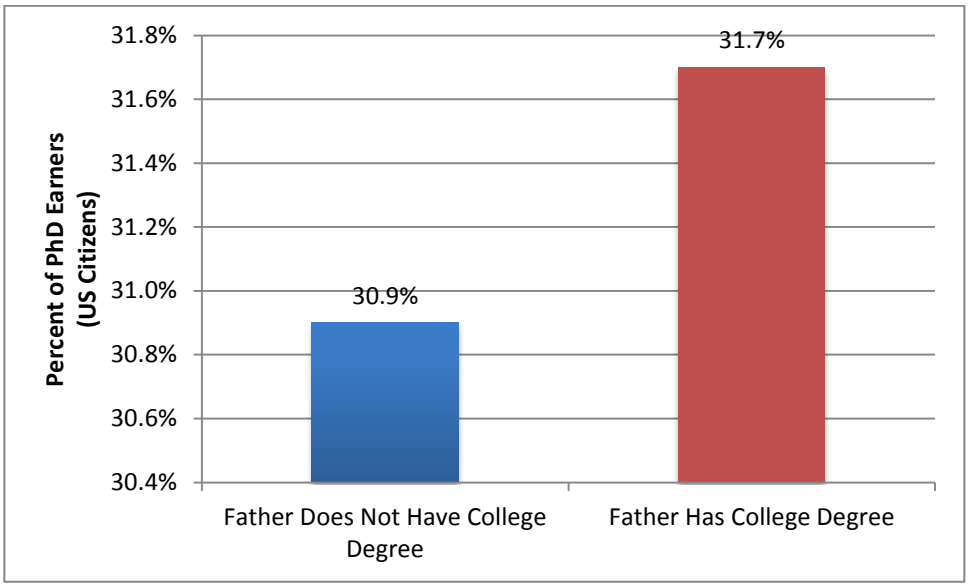

FIGURE 4

Probability of Pursuing Interdisciplinary Postgraduate Research Varies by Citizenship Status