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# The Price of Silence: Scientistsâ€™ Trade-offs between Publishing and Pay

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Abstract

A growing body of research draws on the notion that scientists face trade-offs between publishing research results and larger financial returns associated with limited disclosure. Yet little is known how scientists resolve such trade-offs. Using survey data from 1,400 junior life scientists, we find considerable heterogeneity in the ?price? scientists assign to publishing when they consider research positions in industry that allow versus restrict publishing, including scientists who are willing to give up publishing ?for free?. Analyzing sources of heterogeneity, we find that the required wage premium increases with a scientist?s preference for publishing but decreases with the preference for money. Scientists who value publishing primarily as a currency in the labor market require a smaller wage premium, ceteris paribus, than scientists who value publishing as a mechanism to advance scientific knowledge, presumably reflecting different degrees of substitutability between publishing and pay. Finally, ability and the quality of training have a positive relationship with the required wage premium. We discuss implications for research on the economics of science, for managers seeking to attract and retain academically trained scientists, and for firms considering their participation in ?open science?. Jelcodes:O31,-

# The Price of Silence: Scientists' Trade-offs between Publishing and Pay


## ABSTRACT

A growing body of research draws on the notion that scientists face trade-offs between publishing research results and larger financial returns associated with limited disclosure. Yet little is known how scientists resolve such trade-offs. Using survey data from 1,400 junior life scientists, we find considerable heterogeneity in the "price" scientists assign to publishing when they consider research positions in industry that allow versus restrict publishing, including scientists who are willing to give up publishing "for free". Analyzing sources of heterogeneity, we find that the required wage premium increases with a scientist's preference for publishing but decreases with the preference for money. Scientists who value publishing primarily as a currency in the labor market require a smaller wage premium, ceteris paribus, than scientists who value publishing as a mechanism to advance scientific knowledge, presumably reflecting different degrees of substitutability between publishing and pay. Finally, ability and the quality of training have a positive relationship with the required wage premium. We discuss implications for research on the economics of science, for managers seeking to attract and retain academically trained scientists, and for firms considering their participation in "open science".

## 1 Introduction

A growing body of research draws on the notion that scientists face trade-offs between the open disclosure of research results and larger financial returns associated with limited disclosure or secrecy. For example, many firms permit their scientists to publish research results (Hicks, 1995; Sauermann & Stephan, 2010; Vallas & Kleinman, 2008) but firms that restrict publishing offer higher wages (Stern, 2004). Thus, scientists in industry may have to make trade-offs between publishing and pay when choosing between jobs in firms that pursue an "open science" approach versus firms that restrict disclosure.[1] The choice between disclosure and pay may become increasingly important also in academia, where scientists may decide to limit or delay the disclosure of research results in order to advance commercial objectives (cf. Blumenthal et al., 1986; Hackett, 1990; Slaughter & Rhoades, 2004; Stephan & Levin, 1996). Given these choices, scientists' preferences for publishing and the way in which they resolve trade-offs between publishing and pay have important direct and indirect effects on outcomes such as the disclosure strategies chosen by organizations (Gans, Murray, & Stern, 2010a), the distribution of rents between firms and their scientific employees (Stern, 2004), on firms' innovative performance (Cockburn & Henderson, 1998), and on the overall progress of the scientific enterprise (Huang & Murray, 2009; Nelson, 2004; Sorenson & Fleming, 2004).

While prior work shows that scientists value publishing and that preferences for publishing may have important economic consequences, our empirical understanding of these preferences and of the trade-offs scientists are willing to make between publishing and pay is very limited. For example, building on the seminal work by Merton and other scholars of science (e.g., Dasgupta & David, 1994; Merton, 1973; Stephan, 2010), it is often implicitly assumed that all scientists share a strong taste for publishing. However, there may be significant heterogeneity in scientists' preferences for publishing, with important implications for scientists' sorting into jobs with different publishing policies and for the resulting wage differences across jobs (Killingsworth, 1987; Roach & Sauermann, 2010). Second, little

[1] While disclosure in a formal sense can occur in a variety of ways, including informal interactions between scientists or even in the form of patents, we follow the prior literature in focusing on "open disclosure" in the form of publications.

attention has been paid to the possibility that scientists may value the ability to publish for different reasons, e.g., because publications may increase career opportunities, allow a researcher to contribute to the advancement of science, or increase the chances of obtaining funding for future work. Different reasons, in turn, may be related to the trade-offs scientists are willing to make between money and publishing, but also to other important economic outcomes. Finally, we have limited understanding of how preferences for publishing are related to scientific ability and, therefore, to the likelihood that a scientist produces valuable knowledge in the first place (Agarwal & Ohyama, 2010; Sauermann & Cohen, 2010; Stern, 2004).

To address these questions, we first predict the relationships between the wage premium a scientist requires in order to give up publishing on the one hand, and his underlying preferences for both publishing and money, different reasons to publish, and research ability on the other.[2] We then test our predictions using novel survey data from 1,400 junior life scientists. To elicit information on the wage premium required to forego publishing, we asked respondents to indicate their reservation wages for industrial research positions in firms that varied systematically with respect to publishing opportunities while holding other job attributes constant. While this approach has its own limitations, it has several advantages. Among others, it allows us to characterize the full distribution of preferences and required wage premia in the population, thus providing novel insights into heterogeneity across individual scientists and complementing prior work that has focused on average compensating differentials emerging in the labor market (cf. Heckman, Matzkin, & Nesheim, 2010; Killingsworth, 1987; Stern, 2004).[3]

We find significant heterogeneity in scientists' preferences for publishing and in the wage premia they require to forego publishing opportunities. Our insights into the distribution of preferences are useful in thinking about counterfactual labor market transactions and in predicting market outcomes when

[2] The wage premium a scientist requires to forego publishing can also be interpreted as his "willingness to pay" for the ability to publish by taking a wage cut (cf. Stern, 2004). Given that publishing appears to be the norm rather than the exception (Sauermann & Stephan, 2010; Stern, 2004), we frame our discussion in terms of the wage premium.

[3] The term "compensating differential" is used widely in the labor economics literature to describe the additional amount of money a job pays to offset the absence of a desirable attribute (e.g., publishing) or the presence of an undesirable attribute (e.g., hazardous work conditions) (e.g., Hamilton, 2000; Hwang, Reed, & Hubbard, 1992; Rosen, 1986). We use the term "compensating differential" to refer to the wage premium that is realized in the labor market equilibrium and we use the term "required wage premium" to refer to the wage premium that a particular individual asks for to take the job without publishing.

demand or supply conditions change (Heckman et al., 2010). For example, they may allow us to predict changes in compensating differentials as a greater number of firms adopt "open science" approaches (Ding, 2011; Lacetera, Cockburn, & Henderson, 2004; Vallas & Kleinman, 2008). Second, we find that scientists value publishing for different reasons. These reasons, in turn, predict differences in the required wage premium, even controlling for the importance of publishing per se, possibly because they imply different degrees of substitutability between publishing and money. Thus, future work may benefit from recognizing that scientists see publishing not as an end in itself, but as a means towards qualitatively different (and substantively interesting) ends. Finally, we find that ability is positively related with the required wage premium because it increases scientists' preference for publishing. This relationship between ability and the required wage premium is particularly relevant for employers, who have to consider trade-offs between publishing and pay in the context of scientific productivity.

In the following section, we develop a simple conceptual model of the determinants of scientists' required wage premium and we derive a set of propositions. In section 3, we describe the data and measures. We present our empirical results in section 4. We discuss potential sorting effects in the presence of heterogeneity in section 5 and conclude in section 6.

## 2 Conceptual background

### 2.1 The economics of science and the trade-off between publishing and pay

The disclosure of research results in the form of publications or conference presentations is a key feature of the institution of science (Dasgupta & David, 1994; Merton, 1973; Stephan, 2010). Among others, disclosure enables new knowledge to be evaluated by peers for accuracy and for its contribution to the advancement of science. Open disclosure also facilitates the rapid dissemination of new knowledge, which can then serve as input into subsequent research activities (Murray & O'Mahony, 2007; Nelson, 2004; Sorenson & Fleming, 2004). To encourage the production and open disclosure of research results,

the reward system of science emphasizes priority in discovery and rewards timely publication with peer recognition in the scientific community (Dasgupta & David, 1994; Merton, 1957; Stephan, 2004).

The open disclosure of research results may come at a cost, however, especially in the private sector. To the extent that knowledge has characteristics of a "public good", open disclosure reduces the ability to exclude others from using that knowledge and limits the ability to appropriate financial returns (Arrow, 1962). In many cases, the financial returns from knowledge accrue primarily to employers rather than scientists themselves (Harhoff & Hoisl, 2007; IPO, 2004), such that the "cost" of disclosure are born mainly by employers, while the benefits of disclosure (e.g., peer recognition) accrue primarily to the individual scientists. Notwithstanding the potential strategic benefits of publishing (Cockburn & Henderson, 1998; Hicks, 1995; Penin, 2007), employers may thus have an incentive to limit the disclosures made by their scientists. Scholars have long seen a fundamental tension between scientists' desire to publish research results and between employers' desire to limit disclosure (Gans et al., 2010a; Miller, 1976; Shepard, 1956). A growing body of work has examined how this tension is resolved, focusing on compensating wage differentials associated with jobs that do not permit publishing versus jobs that do as the equilibrating mechanism. For example, in an important study Stern (2004) showed that firms that follow an "open science" approach pay lower salaries, suggesting that scientists may have to "pay" to publish. In related theoretical work, Gans et al. (2010a) model the negotiation between scientists and firms and show that scientists' preferences for publishing are a key determinant of the sharing of rents between the different actors as well as of the overall level and form of disclosure.

In summary, prior work suggests that (1) scientists value publishing and (2) preferences for publishing and the trade-offs scientists make between publishing and pay may have important economic consequences. The key objective of this paper is to examine theoretically and empirically heterogeneity in scientists' preferences for publishing and in the wage premium they require to forego publishing. Thus, rather than examining the effects of scientists' preferences (cf. Ding, 2011; Gans et al., 2010a; Roach & Sauermann, 2010), or estimating average preferences and compensating differentials (Stern, 2004), we examine the extent to which scientists differ in their preferences and required wage premia and we seek to

understand the sources of such heterogeneity. The resulting insights may prove useful for future work drawing implicitly or explicitly on the notion that scientists value publishing, including – but not limited to – future work on compensating differentials in the scientific labor market.

### 2.2 Drivers of the required wage premium

We define a scientist's required wage premium to forego publishing (RWP) as the additional amount of pay at which the particular scientist is indifferent between a job that allows publishing and a job that restricts publishing but pays a wage premium, holding all other job attributes constant. We consider three sets of determinants of the required wage premium: preferences for publishing and pay, reasons to publish, and ability.

#### 2.2.1 Preferences for publishing and pay

How much money a scientist requires to forego publishing should depend on his preference for publishing, which we conceptualize as a parameter in the utility function such that a stronger preference for publishing increases the utility derived from the opportunity to publish (cf. Goddeeris, 1988; Hwang et al., 1992; Stern, 2004). Intuitively, a scientist with a stronger preference for publishing realizes greater utility from a job that offers publishing, holding other preference and job attributes constant. As such, when considering the trade-off between a job that offers publishing and one that prohibits it, this scientist requires a larger wage premium because the lack of publishing opportunities leads to a larger loss of utility that must be offset, in this case with greater pay. This logic immediately suggests that the wage premium should also depend on the scientist's preference for money. A scientist with a stronger preference for money gains greater utility from a given unit of money, and a smaller wage premium will be sufficient to offset a given amount of utility lost due to publishing restrictions. At the extremes, a scientist who has a very strong preference for publishing and does not care about money would not give

up publishing for any price, while a scientist who cares very little for publishing but a great deal about money may be willing to give up publishing for (close to) free.[4]

*Proposition 1: A scientist's preference for publishing increases his required wage premium.*

*Proposition 2: A scientist's preference for money decreases his required wage premium.*[5]

### 2.2.2 Reasons to publish

Prior work typically focuses on scientists' preferences for publishing per se, yet scientists may value the opportunity to publish for different reasons. In the established view, individual scientists value publishing because it allows them to establish priority and gain recognition (or "kudos") in the community of their peers (Gans, Murray, & Stern, 2010b; Merton, 1973). Many scientists may not care about recognition per se, however, but about a variety of indirect payoffs from recognition, including better career opportunities, access to research funding, or the ability to cooperate on interesting research projects (Latour & Woolgar, 1979). One of these indirect outcomes is of particular interest in our context, namely that publications and the resulting recognition may increase a scientist's labor market value and future pay, as documented in a long line of empirical research (Diamond, 1986; Konrad & Pfeffer, 1990; Liu & Stuart, 2010; Tuckman & Leahey, 1975). Thus, publications may be seen by scientists as a "currency" in the scientific labor market, and giving up current pay in order to build a stock of publications and the associated recognition may be seen as an investment into future pay (cf. Becker, 1962; Levin & Stephan, 1991; Rosen, 1986). As described by one of our survey respondents: "Publishing builds a base where you can get better (i.e. higher-paying) jobs later. Less money now for the chance to make more later." While we focus on higher future pay as one potential indirect payoff from recognition,

[4] Individuals with a strong preference for money may well expect higher levels of overall pay. However, we are not concerned with wage levels per se but with the wage premium that creates the same amount of utility as the opportunity to publish, i.e., with the trade-off scientists make between pay and another job attribute (publishing).

[5] Propositions 1 and 2 jointly imply that the required wage premium increases as the preference for publishing increases *relative* to the preference for pay. In economic terms, the strength of the preference for publishing relative to the preference for money indicates the marginal rate of substitution between these two job attributes.

our empirical analysis will also control for the degree to which respondents value the recognition resulting from publications more generally.

Even though recognition and its associated benefits are typically seen as the key individual-level reasons for scientists to publish, we suggest that some scientists may also subscribe to norms of openness without the expectation of any associated direct personal benefits. They may value the various functions of publishing for the advancement of science, e.g., that it enables peer review, widely disseminates novel findings that can be built upon, and reduces redundant research efforts (Dasgupta & David, 1994; Merton, 1973). To quote one of our respondents, "Knowledge belongs to everyone, and the growth of scientific knowledge cannot occur if it is hoarded for money and collaboration and conversation is discouraged."

How important each of these reasons for publishing is to the average scientist is an empirical question. Similarly, we cannot predict whether the preference for publishing is stronger for those individuals who value publishing primarily for its career benefits versus those who value publishing primarily as a mechanism to contribute to the advancement of science. However, we conjecture that for a *given* level of an individual's preference for publishing, *why* a scientist values publishing may affect the degree to which money can serve as a substitute for publishing in the scientist's utility function, and may thus affect the required wage premium. Our argument draws on prior work in behavioral decision making, where subjects have been shown to more easily make trade-offs between similar kinds of attributes, especially if these attributes are "commodities" such as money or physical goods. On the other hand, individuals are less willing to make trade-offs between dissimilar attributes, especially when "protected" values such as honesty or human lives are involved that have normative connotations (Baron & Spranca, 1997; Beattie & Barlas, 2001; Luce, Payne, & Bettman, 1999). In our context, scientists who subscribe to the scientific norm of openness may consider publishing to be more "sacred" and see restrictions on publishing as a violation of their moral code as scientists, leading to a low substitutability between publishing and money. In contrast, substitutability is arguably highest if publishing is valued as a "currency" that is expected to increase future pay; that is, a scientist who publishes primarily to gain higher future earnings should be more willing to give up publishing in return for higher current pay.

*Proposition 3: Controlling for the importance of publishing and money per se, when a scientist values publishing primarily as a means to obtain higher future pay the wage premium will be smaller than when he values publishing primarily as a means to contribute to the advancement of science.*

### 2.2.3 Ability

Scientists with strong research capabilities can expect to generate a larger quantity of new knowledge (or knowledge of a higher quality) than low-ability scientists. Assuming that journal submissions are judged based on objective criteria, high-ability scientists can thus expect more and better publications if they are allowed to publish (cf. Stern, 2004). A larger quantity and quality of publications, in turn, will translate into higher levels of the indirect benefits resulting from publications such as contribution to the advance of science, career opportunities, or higher pay. Thus, there is a positive relationship between ability and the (expected) utility from the opportunity to publish. As a consequence, high-ability scientists should have a stronger preference for publishing and should require a larger wage premium to give up publishing.

In other words, we expect a positive relationship between ability and the required wage premium, and this relationship should be mediated by the preference for publishing (cf. Baron & Kenny, 1986). Interestingly, while future productivity will depend on a scientist's *objective* ability, the wage premium he requires to give up publishing will depend primarily on his own *subjective* assessment of his ability.

*Proposition 4: A scientist's ability increases the wage premium required to give up publishing.*
*Proposition 5: The effect of ability on the required wage premium is mediated by the preference for publishing.*

## 3 Data and Measures

### 3.1 Sample and data collection

We use data from a recent survey of junior scientists in training at tier 1 U.S. research universities (Science and Engineering PhD and Postdoc Survey, SEPPS). Using data from scientists in training rather than employed scientists has two key advantages. First, the trade-offs between financial and non-financial job attributes such as pay and publishing are particularly salient in the context of job and career choices (cf. Agarwal & Ohyama, 2010; Aghion, Dewatripont, & Stein, 2008; Roach & Sauermann, 2010; Stern, 2004), making junior scientists facing such choices the more relevant sample to study these issues. Second, to the extent that individuals self-select into particular jobs or sectors based on their preferences for publishing, samples of scientists in particular career trajectories such as industry or academia are likely to suffer from selection bias and provide only a limited picture of the full distribution of scientists' preferences (Killingsworth, 1987; Rosen, 1986; Shanmugam, 2001). Since virtually all scientists go through extensive academic training, our sampling strategy provides insights into a large part of the distribution of scientists' preferences.[6] In the following, we describe the general survey strategy for the SEPPS, followed by a short description of the particular subsample used in this study.

We consulted the National Science Foundation's (2008) reports on earned doctorates to identify U.S. research universities with large doctoral programs in science and engineering fields. We selected a subset of 39 institutions based primarily on program size but also based on private/public status and geographic region. We pre-tested our survey in the winter of 2009 and conducted the main data collection in the spring of 2010, approaching individual PhD students and postdoctoral researchers in two ways.

First, we collected roughly 30,000 names and email addresses from listings provided on many of our target departments' websites. We invited these individuals to participate in the survey using a four-

[6] A potential concern with our sampling strategy is that scientists' preferences may not be fully formed until later in the career. While preferences may indeed change over time, such changes are likely to be incremental and preferences are to a large degree inherited or shaped throughout adolescence and graduate school (Allen & Katz, 1992; Austin, 2002; Galton, 1874; Lykken et al., 1993). More importantly, even if preferences change over the life cycle, junior scientists are more likely to face the career and job choices of interest, making their preferences more relevant than those of senior scientists.

contact strategy (one invitation, three reminders) following recommendations by Dillman et al. (2009). A concern with any surveys is that the particular way in which respondents are approached may lead to sample selection or biased responses (Groves & Peytcheva, 2008). In our context, offering financial incentives for responding may increase the likelihood that respondents with above-average preferences for money respond, while surveys without financial incentives may especially attract respondents with above-average non-pecuniary preferences (e.g., interest in research, helping others, etc.). To address this concern, we randomly assigned respondents into different conditions and varied key aspects of the survey invitation including incentives. This strategy should mitigate selection biases by its very design but it also allowed us to explicitly examine the presence and magnitude of such biases. We did not find significant differences across conditions with respect to the key variables considered in this study. Adjusting for 6.3% undeliverable emails, the direct survey approach achieved a response rate of 30%.

We used department administrators as a second channel to approach respondents when individual contact information was not available. In those cases, we emailed administrators with the request to forward a survey link to their graduate students, and our research assistants additionally called administrators on the telephone to encourage their cooperation. Overall, 89% of our responses were obtained directly from respondents and 11% were obtained through administrators.

Our initial sample covered a wide range of fields and a heterogeneous set of respondents. For this study, we focus on a subset of respondents as follows. First, we limit our sample to respondents in the life sciences to limit heterogeneity introduced by potential field differences in the function of publications or labor market conditions. This focus also allows us to compare our results to prior work that has focused on the life sciences. Second, we focus on PhD students in the advanced stage of their studies, i.e., those who report that they have successfully completed their qualifying exams or equivalent milestones. Advanced students are likely to have better-formed preferences and to have given more consideration to job and career choices than junior students. Third, we exclude respondents whose departments are not

included in the most recent ranking of PhD program quality conducted by the National Research Council (see below). The final sample used for this study comprises 1,400 life scientists at 37 institutions.[7]

### 3.2 Measures

We developed our key measures based on prior research and on S&E-related micro-surveys carried out by the National Science Foundation (e.g., National Science Foundation, 2003) and we pre-tested the instrument in interviews with junior scientists similar to our target population. While the survey instrument contained a broader range of questions regarding scientists' current research and employment, this paper focuses on a smaller set of questions pertinent to this study.

**Required wage premium.** To measure the wage premium a scientist requires to forego publishing opportunities, we asked the following question:

> *Assume that you are offered the following two jobs in an established firm. The positions differ only with respect to your opportunities to publish. What would be the <u>minimum</u> starting compensation <u>for you to accept each position</u>?*
> *Job 1: Allowed to publish research results*
> *Job 2: NOT allowed to publish research results*

Note that our framing explicitly states that the two jobs differ only with respect to publishing opportunities, i.e., the question holds all other job attributes constant. Respondents indicated their reservation wage for each job using two sliding scales with anchors ranging from $0 to $200k (respondents were familiar with the sliding scales format from earlier questions). Our measure of the required wage premium (RWP) is computed as the difference between the reservation wage for the job that does not allow publishing (RESWAGE_NOPUB) and the reservation wage for the job that does allow publishing (RESWAGE_PUB). Thus, RWP = RESWAGE_NOPUB - RESWAGE_PUB. This measure reflects the additional amount of pay that a scientist would require to be indifferent between the

[7] Institutions with large numbers of cases in our sample include, for example, UC Davis, Johns Hopkins, University of Washington, University of Michigan, University of Wisconsin, University of Florida, Emory University, Washington University in St. Louis, and Harvard University.

two jobs. In addition to the absolute measure of the required wage premium, we also compute a measure that expresses the wage premium as a percentage of the reservation wage for the job with publishing: RWP_PERCENT = (RESWAGE_NOPUB/RESWAGE_PUB - 1)*100.[8]

**Preferences for publishing and pay.** In a second question block, we asked respondents "When thinking about an ideal job, how important is each of the following factors to you?" Respondents rated the items "Ability to publish research results" and "Financial income (e.g., salary, bonus)", respectively, on a 5-point scale ranging from 1 (not at all important) to 5 (extremely important), resulting in the measures PREF _PUB and PREF _SAL. We also created two dummy variables indicating the relative strength of the two preferences. PREFPUB>PREFSAL equals 1 if the rating for publishing is higher than that for salary, and PREFSAL> PREFPUB equals 1 if it is lower. Cases with the same rating for both attributes are in the omitted category. Note that the use of a simple ratio of the preference measures would be inappropriate because the measures are interval scales rather than ratio scales (Nunnally, 1978).

**Reasons to publish.** We asked respondents "To what extent are the following functions of publishing important or unimportant to you personally?". Respondents rated the following reasons on a 5-point scale ranging from 1 (extremely unimportant) to 5 (extremely important).

- Publications are a way to earn recognition from my peers and colleagues (REASON_RECOG)
- Having publications will lead to higher pay in the future (REASON _PAY)
- Publishing research results allows me to contribute to the advancement of knowledge (REASON _CONTR)

To get at the relative nature of reasons reflected in proposition 3, we created dummy variables indicating which of the two hypothesized reasons –pay or contribution to the advancement of knowledge– was judged as more important. The resulting measures are REASONPAY>REASONCONTR and

[8] Some firms not only allow publishing but provide explicit incentives for publishing (Henderson & Cockburn, 1994; Liu & Stuart, 2010; Stern, 2004). Although a preceding question in our survey explicitly defined "compensation" as "including salary, bonuses and stock options", some of our respondents may have thought of the reservation wages as base salary excluding bonuses. In that case, a lower compensation for the job with publishing could reflect respondents' willingness to forego fixed pay for performance-based pay. However, we did not find any evidence of this rationale in our analysis of open-ended responses, where we explicitly ask respondents why they would be willing to accept lower pay for a job with publishing.

REASONCONTR>REASONPAY; cases with the same rating for both reasons are in the omitted category.

**Ability and quality of research training.** Our conceptual discussion suggests that it is primarily a respondent's subjective (self-perceived) research ability that should drive his preference for publishing and the required wage premium. Thus, we asked respondents to rate their own ability in response to the following question "How would you rate your research ability relative to your peers in your specific field of study?" (ABILITYSELF). The scale ranged from 0 (least skilled, lowest percentile) to 10 (most skilled, highest percentile). The average rating in our sample (6.48) is somewhat higher than the mean of the scale (5), which could reflect that we sampled individuals in tier 1 research institutions. At the same time, prior work suggests that self-ratings of ability may also reflect overconfidence (cf. Camerer & Lovallo, 1999). Even if ABILITYSELF partly reflects overconfidence, however, it should have a positive association with RWP since our conceptual discussion predicts that it is scientists' own perception of their ability (biased or not) that determines how much of a wage premium they ask for to give up publishing.

To obtain an objective and survey-independent measure of research training, we draw on the recent rankings of PhD program quality published by the National Research Council (NRC, 2010). We matched the schools and subfields in our sample to the list of PhD programs ranked by NRC and use NRC's ranking of a program's "research activity", which reflects factors such as the average number of publications per faculty, citations, as well as grants and awards.[9] While the NRC ranking does not directly measure the quality of students' training or their ability, we suggest that it is a useful proxy under the assumption that more research active programs provide their students with better research training. Since low ranking scores indicate high quality (e.g., rank=1 indicates the top program in a field), we reverse code the measure such that high scores reflect high program quality.

ABILITYSELF and the NRC ranking are likely to capture different aspects of ability and training. For example, when judging their own ability, respondents may focus on a "local" reference

[9] The NRC data as well as detailed descriptions of the data collection and ranking procedure are available at http://www.nap.edu/rdp/. Note that NRC does not publish one single research ranking for a program but a probabilistic range including a 5$^{th}$ percentile and a 95$^{th}$ percentile ranking. We averaged the two rankings to obtain a single measure.

group of peers within their departments rather than the broader population of PhD students (cf. Greenberg, Ashton-James, & Ashkanasy, 2007), while the NRC rankings provide insights into quality differences across departments. Moreover, the NRC rankings are likely to reflect not only individuals' ability but also other department-level factors such as resources for research. NRC rankings may also be correlated with otherwise unobserved factors such as general norms and socialization with respect to openness. Thus, the two measures may potentially yield complementary insights.

**Control variables.** Our control variables include age (AGE), gender (MALE), U.S. citizenship status (USCITIZEN), and field of study (10 life sciences subfields including cell/molecular biology, biochemistry/biophysics, neuroscience, ecology, genetics, microbiology, immunology, developmental biology, pharmacology, and other biological/life sciences).

## 4 Results

Table 1 provides summary statistics and table 2 shows the correlations. The average reservation wage for a job in an established firm that allows publishing is $71.09k. The average reservation wage for a job that does not allow publishing is $93.65k, resulting in an average required wage premium of $22.56k.[10] However, there is considerable heterogeneity in the required wage premium and 19% of individuals indicated a RWP of zero, i.e., that they would forego the opportunity to publish for free.

### 4.1 Predictors of the required wage premium

We report regressions of the required wage premium (RWP) in table 3. Given that RWP takes on only non-negative values[11], we use Poisson quasi-maximum likelihood estimation to test our hypotheses.

[10] The median annual salary of PhD life scientists employed in private for-profit organizations in the U.S. was $103,900 in 2006 (National Science Foundation, 2006, Table 55). NSF does not make publicly available the starting salaries of PhD life scientists in industry. However, based on the published distribution of PhD life scientists' salaries by work experience across all employment sectors (Table 53), we estimate the starting salaries to be around $75k-$80k per annum. Thus, the reservation wages reported by our respondents are roughly consistent with actual salary figures.

[11] We dropped a small number of respondents (3.8%) who indicated a *negative* required wage premium. An analysis of open-ended responses suggests that some of them assumed that the ability to publish comes with *pressure* to publish. Other respondents seemed to have conceptualized the reservation wage scales in the opposite direction, i.e., they thought of the dollar figures as indicators of the value they assign to these jobs. While we are cautious to interpret negative RWP as valid, it could indicate that some scientists indeed place a negative value on the ability to publish, perhaps because they conceive of this

Poisson QML is consistent for either integer or continuous non-negative data, so long as the conditional mean is correctly specified (Santos Silva & Tenreyro, 2006; Wooldridge, 1997). Although there is little evidence of overdispersion in our measures, we also estimated negative binomial regression models with qualitatively identical results (these and other robustness checks are reported below). We allow for heteroskedasticity and intraclass correlations by clustering standard errors at the level of the university.

Model 2 shows that the wage premium a scientist requires to give up publishing increases with his preference for publishing and decreases with the preference for salary, consistent with hypotheses 1 and 2. Thus, the required wage premium largely reflects preferences for publishing, but also how much an individual cares about money. Individuals who care less about money, holding their preference for publishing constant, require a greater premium to give up publishing. In model 3 we replace the scale-based measures of preferences for publishing and pay with the dummy variables that indicate which of the two preferences is stronger (the omitted group is when the two preferences are equal). As expected, we find that RWP increases as publishing becomes more important *relative* to money.

We next include measures of the different reasons for publishing (model 4) while explicitly controlling for the importance of publishing per se. The extent to which publishing is valued because it may result in higher future pay has a significant negative coefficient. Recall our earlier discussion that for individuals who see publications primarily as a way to get higher-paying jobs, money and publications may be better substitutes, reducing the required wage premium. On the other hand, we find that RWP increases significantly when publishing is valued as a mechanism to contribute to public knowledge, possibly reflecting that current salary is not a good substitute for that function of publishing. The extent to which publishing is valued because it may result in peer recognition does not have a significant coefficient. This result may reflect that recognition is an intermediate outcome and may relate to a variety of qualitatively different ultimate objectives (see above) such that this reason has no clear cut effect on

"option" as a burden. Also, a small number of individuals indicated reservation wages for the job without publishing that were multiple times larger than the reservation wages for jobs with publishing, likely signaling that they were essentially unwilling to take a job that does not allow publishing (see also the quotes below). To reduce the effect of such outliers on our analysis, we dropped cases where RESWAGE_NOPUB was more than three times as large as RESWAGE_PUB (1.5% of cases).

the substitutability between money and publishing. Model 5 includes the dummy variables indicating which reason is relatively more important and is the most straightforward test of proposition 3. Consistent with our prediction, scientists who value publishing primarily because it results in higher future pay have a lower RWP than those who value publishing primarily as a mechanism to advance public knowledge, with the difference being equivalent to roughly 32% of the wage premium of the omitted group.

Models 6-8 show that the required wage premium increases with scientists' subjective ability and with the quality of their research training, consistent with proposition 4. More concretely, a one-standard deviation higher rating of ABILITYSELF is associated with a 7.9% higher required wage premium, while a one-standard deviation higher NRC ranking is associated with an 8.4% higher required wage premium. In model 9, we examine the extent to which the effects of ability and training are mediated by scientists' preferences by additionally including the preference measures (cf. Baron & Kenny, 1986). As expected, the coefficient of ABILITYSELF becomes insignificant. Thus, scientists who believe they are at the top of the ability distribution require a larger wage premium because they have a stronger preference for publishing. Further supporting proposition 5, we show below that ABILITYSELF is a strong predictor of the preference for publishing. However, we observe no mediation of the effect of the NRC ranking, i.e., students at higher-ranked departments require a larger wage premium, but not because they have a stronger preference for publishing. While we cannot identify which particular mechanism underlies the relationship between the NRC ranking and the required wage premium, it has important implications for managers who often seek to attract scientists trained at top institutions (see below).

In table 4, we use RWP_PERCENT, i.e., the wage premium expressed as a percentage of the reservation wage of the job with publishing. This measure ranges from 0% to 200% and we use a Poisson QML model with clustered standard errors. The qualitative results are very similar to those obtained using the absolute wage premium. One notable exception is that the measures of ability and training are only marginally significant in most specifications (e.g., $Chi^2(2)=5.76$, $p=0.056$ in model 8), suggesting that they increase the required wage premium in absolute terms but not relative to the base wage (RESWAGE_PUB). The following section provides insights into possible reasons for this difference.

### 4.2 Predictors of reservation wages

While the required wage premium is our key outcome of interest, the regressions of RWP do not reveal the extent to which independent variables affect the required wage premium via changes in the reservation wage that restricts publishing (RESWAGE_NOPUB) versus the reservation wage that allows publishing (RESWAGE_PUB). To provide additional insights, we analyze the two reservation wages separately in table 5. Given that we examine two dependent variables at the same time, we estimate these models using multivariate regression, i.e., the two models are estimated simultaneously and the error terms are allowed to have nonzero correlations (Edwards, 1995).

Model 1 shows that the preference for publishing has no significant effect on RESWAGE_PUB but it has a positive effect on RESWAGE_NOPUB, resulting in a positive required wage premium. This observation is consistent with our argument that individuals with a strong preference for publishing "lose" more utility when publishing is restricted, thus requiring a larger amount of pay to offset that utility loss. The importance of salary increases RESWAGE_PUB, likely reflecting that individuals who care strongly about salary generally ask for higher levels of salary. The preference for salary does not significantly affect RESWAGE_NOPUB, which likely reflects that individuals with a strong preference for money desire higher salaries generally but also require a smaller wage premium to offset the lack of publishing. Thus, a strong preference for money increases the reservation wage for the job with publishing (the baseline in the trade-off question) but does not increase the reservation wage for the job without publishing, leading to a smaller required wage premium. The reasons why scientists value publishing affect the required wage premium primarily via RESWAGE_NOPUB, although the effects on the two reservation wages are generally weaker than on the resulting required wage premium.

Finally, model 3 shows that the ability measures increase both reservation wages but have a larger effect on the reservation wage for the job without publishing, resulting in a positive net effect on the required wage premium in absolute terms (see our discussion of table 3). However, given the higher

levels of both wages, the wage premium is not significantly larger in percentage terms – as reflected in the lack of significant effects of ability and training in regressions of RWP_PERCENT (table 4).

### 4.3 Supplementary analyses

In a first set of auxiliary analyses (table 6, models 1 and 2), we examine in more detail the mediation process captured in proposition 5 by regressing the measures of preferences on the measures of ability and training (Baron & Kenny, 1986). We find that ABILITYSELF strongly increases the preference for publishing but not that of salary. The NRC ranking has no association with either of the preference measures. These results reinforce our earlier conclusion that the preference for publishing mediates the effect on the required wage premium of ABILITYSELF but not of the NRC ranking.

Second, we consider the possibility that the value a scientist assigns to future payoffs from publishing depends on his risk preferences. More specifically, risk aversion may decrease the current value of uncertain future payoffs and thus the wage premium required to give up publishing (cf. Becker, 1962). To measure risk preferences, we asked respondents to rate on a 10 point scale the relative attractiveness of a sure bet (100% chance of winning $1000) and of a risky gamble with the same expected payoff (50% chance of winning $2000). Using this measure as a proxy for risk aversion (models 3 and 4), we find that risk-averse scientists require a smaller absolute wage premium to give up publishing. This effect disappears once we control for the preference for publishing, consistent with the idea that risk-averse scientists place a lower value on future payoffs, which leads to a weaker preference for publishing, which leads to a smaller required wage premium. We find no significant interaction effects between risk preferences and other featured variables.

Third, we examined whether preferences for publishing and money interact with the different reasons for publishing (not reported in table 6). It is conceivable, for example, that individuals who see publishing primarily as a means towards higher pay require a larger wage premium if they also care strongly about pay. Our analyses did not show any significant interaction terms. However, our measures

of preferences have only a relatively small number of levels (5 points) and more fine-grained measures may be needed to detect any existing moderating effects.

### 4.4 Robustness checks

In a first set of robustness checks, we estimate our models using negative binomial regression rather than Poisson QML. The results are very similar (table 6, models 5-7). Second, the use of the Poisson QML model is less common for continuous non-negative variables such as RWP_PERCENT, even though it is technically appropriate. Thus, we employ tobit as an alternative technique. Models 8-10 in table 6 show results very similar to those in our featured analyses. Third, RWP shows some bunching around certain "round" values, e.g., $5k, $10k, etc. To address this uneven distribution, we divided RWP into even intervals of $5k each. The resulting variable, RWP5, can be analyzed using ordered probit regression which exploits only the ordering of data points, but does not rely on the exact distance between data points (Models 11-13). The results are very similar to our featured results except that the NRC ranking measure is only marginally significant ($Chi^2(1)=2.90$, $p=0.09$ in model 13).

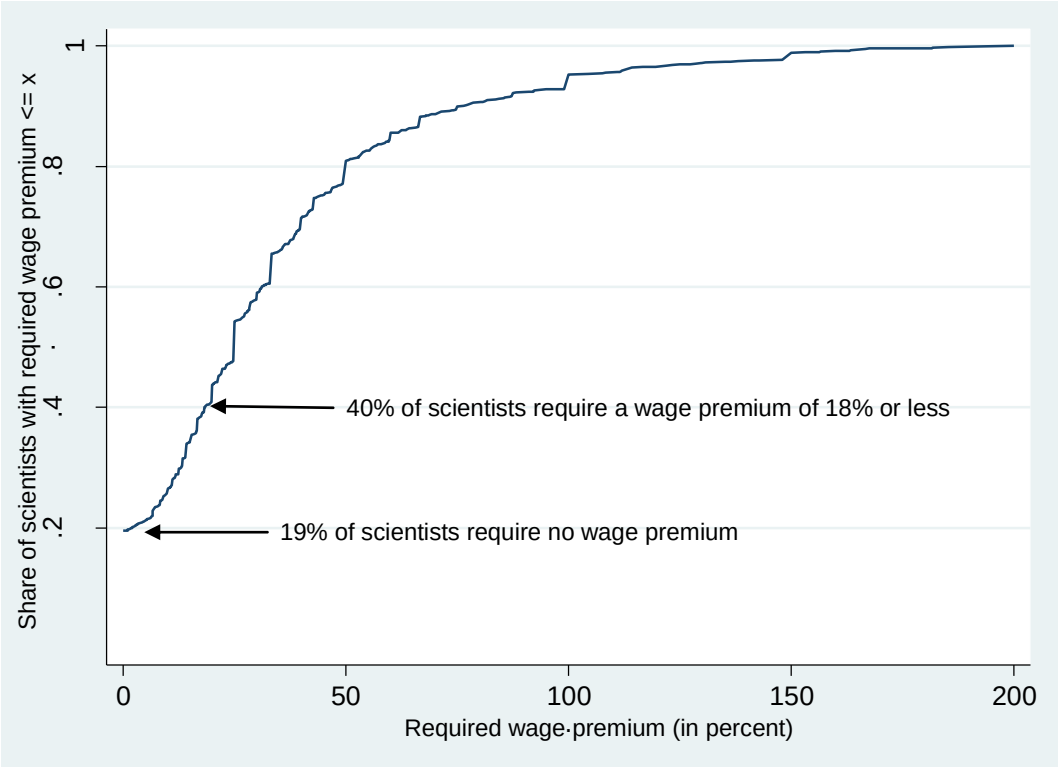
Finally, we entertain the possibility that respondents may have associated differences in job attributes other than the opportunity to publish with the two jobs, even though the question clearly stated that "the positions differ only with respect to your opportunities to publish". As discussed earlier (see footnote 11), our main analysis already excludes a small number of individuals who may have associated publishing opportunities with negatively valued *pressure* to publish, as reflected in a negative required wage premium. It is also possible, however, that respondents associated positively valued job attributes such as research freedom, trust, or a generally more "open" atmosphere with the job that permits publishing. Our analysis of open-ended responses (we asked individuals why they would be willing to accept lower wages for a job that allows them to publish) shows that a small number of individuals (2.6%) indeed made such connections. We excluded these individuals from the analysis but did not find noticeable differences in our results.

## 5 Distribution of RWP, sorting, and compensating differentials

While most of our empirical analysis thus far has focused on the sources of heterogeneity in scientists' required wage premium, we suggest that knowledge about the distribution of required wage premia can serve as a useful starting point for the consideration of a variety of important outcomes. To illustrate, we will show how the equilibrium compensating differential in the labor market between jobs that offer publishing versus those that do not depends on both the distribution of preferences in the population of scientists and on the number of jobs with and without publishing.

Figure 1 plots the cumulative distribution of the required wage premium in percent (RWP_PERCENT). Thus, the graph shows the share of scientists who are willing to give up publishing for a particular wage premium (or less). For example, figure 1 shows that 19% of respondents would be willing to give up publishing without any additional financial compensation and 40% of scientists would be willing to give up publishing for a wage premium of 18% or less.

**Figure 1: Cumulative distribution of RWP_PERCENT**



If sorting is perfect, i.e., if those individuals with the lowest RWP are the first to take jobs that restrict publishing, 19% of positions could restrict publishing without having to pay any compensating differential. If 40% of jobs restrict publishing, we would expect an equilibrium compensating differential of approximately 18%, and so forth.

Of course, perfect sorting with respect to preferences for publishing is a stark abstraction. For example, matching has to occur simultaneously also with respect to other dimensions such as job location or specialized skills. Moreover, since ability and RWP are correlated, firms that wish to restrict publishing may hire individuals with a higher than necessary RWP if they believe higher productivity offsets the cost of the compensating differential. Finally, to the extent that there is a shortage of positions that allow publishing, scientists with a strong preference for publishing may not have an outside option and may be forced to take positions that limit publishing even if those jobs do not offer the "required" wage premium.

Notwithstanding these complexities, our discussion of figure 1 highlights several general points. First, there is considerable heterogeneity in scientists' preferences, and it seems impossible to identify a "representative" scientist. Any one data point – such as the equilibrium compensating differential, which reflects the preferences of the marginal individual – is a poor measure of what wage premium "scientists" generally require to give up publishing. Second, if one uniform equilibrium compensating differential prevails in the labor market, many scientists working in firms that restrict publishing will earn considerable rents because the compensating differential will be larger than their individual required wage premium (Rosen, 1986). Third, equilibrium compensating differentials may change if the distribution of preferences changes or if the mix of positions changes. For example, compensating differentials will decrease, ceteris paribus, as more and more firms offer publishing opportunities to their scientific employees and fewer firms rely on "closed science" (Hackett, 1990; Vallas & Kleinman, 2008). Finally, sorting will result in very different kinds of scientists working in jobs that limit publishing and those that do not. For instance, if firms are more likely to restrict publishing than academic institutions, then scientists at the higher end of the distribution in figure 1 will sort into academia while scientists at the lower end will sort into industry. As a consequence, firm scientists would have significantly weaker

average preferences for publishing than academics. This latter point suggests that insights gained about scientists in the context of academic science may not as readily generalize to scientists working in industry as sometimes assumed.

At this point, it is useful to relate our results to the influential work of Stern (2004), who analyzed 164 job offers received by a sample of biological scientists. Stern found that jobs that permitted publishing offered approximately 20% lower salaries than jobs that did not (implying a 25% premium paid by jobs that restricted publishing). This effect was reduced to approximately 9% (a 10% premium) when other important job characteristics such as research freedom were held constant (Stern (2004), Table 3). We are not aware of comprehensive data on the publishing policies of various types of employers, but a recent estimate suggests that roughly 70% of research-active PhD level life scientists in industry publish (Sauermann & Stephan, 2010), i.e., the share of industry positions not permitting publishing is likely below 30%. Applying this share of 30% (which does not account for different publishing policies in other employment sectors) to figure 1 predicts a wage premium of 13%, which is quite close to Stern's (2004) estimates. This simple exercise clearly does not account for a range of factors that would have to be considered in a more systematic analysis of equilibrium compensating differentials.[12] However, it shows how our results relate to Stern's important study and also suggest that the magnitude of required compensating differentials reported by our respondents is roughly consistent with empirical findings in prior work.

## 6 Summary and Implications

This paper seeks to provide insights into scientists' preferences for publishing and the trade-offs scientists make between the opportunity to publish and larger financial returns associated with limited

[12] For example, roughly 9% of individuals holding PhDs in life sciences fields are unemployed or employed only part time (National Science Foundation, 2006, Table 29). Some PhDs also leave research to pursue alternative careers. To the extent that these individuals come primarily from the lower end of the RWP distribution, equilibrium compensating differentials are likely to be larger than implied by figure 1. Moreover, while we conceptualize publishing policies as dichotomous, it is likely that even firms that "allow" publishing impose certain restrictions, and scientists may require a positive (but smaller) wage premium in those cases. Finally, our simple calculations assume perfect matching of jobs and individuals along the publishing dimension, which is unlikely to be the case in reality (see above).

disclosure. Complementing prior work that has shown that scientists have preferences for publishing and that such preferences can have important economic consequences, our focus is on understanding sources of heterogeneity across scientists. We first predict how the wage premium a scientist requires to give up publishing will be related to (1) the scientist's preferences for money and for publishing, (2) different reasons why the scientist may value publishing, and (3) the scientist's research ability. We then test our predictions using data from 1,400 junior life scientists.

We find that scientists assign very different "prices" to the ability to publish when employed in a firm. The average required wage premium is 33%, but roughly 19% of scientists are happy to give up publishing "for free" while some are unwilling to accept jobs that do not allow them to publish. Our efforts to understand sources of heterogeneity in the required wage premium yield several insights. First, we find that the wage premium does not only increase with scientists' preference for publishing, but is also larger for those scientists who care little about money (controlling for the preference for publishing). Second, we find that scientists who value publishing primarily as a currency in the labor market require a smaller wage premium, ceteris paribus, than scientists who value publishing as a mechanism to advance science, presumably because money and publications are closer substitutes for the former scientists than for the latter. Third, we find that scientists' subjective ability as well as the quality of their graduate education are positively associated with the preference for publishing and the required wage premium.

Our results complement prior work on scientists' disclosure choices and on the interactions between scientists and their employers (e.g., Cockburn & Henderson, 1998; Gans et al., 2010a; Stern, 2004). Our results support the general notion that scientists value publishing, but they also suggest that future work should consider heterogeneity in scientists' preferences. A significant share of scientists appear to have quite weak preferences for publishing; indeed, some scientists seem to view publishing as a burden rather than a benefit. This heterogeneity has implications for theoretical work that relies more or less explicitly on the notion that scientists value publishing (e.g., Gans et al., 2010b). In particular, the size of hypothesized effects is likely to be different in the presence of heterogeneity and sorting than when homogeneous preferences are assumed, as illustrated in section 5 above. Moreover, once

heterogeneity is considered, selection and sorting are key mechanisms that need to be considered theoretically and that can serve as important levers from a managerial and policy perspective.

Regarding firm policy, our results suggest that firms may be able to keep research results secret without having to pay large compensating differentials if they are able to attract those scientists who care little about publishing. At the same time, this strategy faces the problem that preferences for publishing have a positive relationship with ability, i.e., firms that seek to benefit from a low preference for publishing may also suffer from a lower ability of their workforce. Conversely, firms trying to recruit top scientists are unlikely to succeed without offering publishing opportunities.

While it is commonly thought that firms try to limit disclosure, thereby giving rise to tensions between scientists' preferences for publishing and the secrecy concerns of their employers, it is not always in firms' best interest to minimize disclosure. Firms may derive various strategic benefits from publishing, including productivity benefits in their own research efforts (Cockburn & Henderson, 1998; Ding, 2011; Parchomovsky, 2000; Penin, 2007; Stern, 2004). Given that a significant number of scientists seem to care little about publishing, it is – at least in principle – conceivable that some firms have a *stronger* preference for publishing than some of their scientific employees. This argument is the opposite of the common stereotype, but it is consistent with the observation that a significant number of firms not only allow publishing, but have introduced incentive systems that explicitly encourage scientists to publish (Henderson & Cockburn, 1994; Stern, 2004; Zucker, Darby, & Brewer, 1998). As such, future work may benefit from a more nuanced analysis of goal differences between scientists and firms, recognizing that goal conflict (or the lack thereof) may vary across individual scientists.

When scientists do have a strong preference for publishing, it may be important to understand why. If scientists "pay" to publish (Stern, 2004) because they truly value open knowledge disclosure and contributing to the advancement of science, employers may indeed be able to enjoy the benefits of lower labor cost. If, on the other hand, the willingness to accept a wage discount is primarily based on considerations of signaling and future pay, scientists who "pay" to publish today may require higher wages tomorrow or may leave the organization to pursue alternative jobs. Similarly, it has been suggested

that patents and commercial achievements increasingly result in recognition from scientific peers (Audretsch, Boente, & Krabel, 2009; Dasgupta & David, 1987). For scientists who care about publishing primarily as a means to achieve peer recognition, patents may increasingly occupy a similar role as publications. Since patents also potentially provide a financial benefit, those scientists may move towards more "closed" science. For scientists who see publishing primarily as a mechanism to advance science and who value the open disclosure of results per se, patenting is unlikely to be a substitute for publishing. While these conjectures are very preliminary, they point towards the potential value of thinking about publishing not as an end in itself but as a path towards a variety of indirect outcomes about which scientists ultimately care.

Although our study focuses on industry employment where the trade-offs between publishing and pay are most salient, such trade-offs may be increasingly important in academia as well. While it is unlikely that academics will give up publishing completely, growing attention to research commercialization has raised concerns over publication delays and the selective (versus full) disclosure of research results (cf. Blumenthal et al., 1986; Hackett, 1990; Slaughter & Rhoades, 2004; Stephan & Levin, 1996). Our conceptual discussion may provide a useful starting point for future research on the trade-offs scientists are willing to make between disclosure and pay in the particular context of academia.

Future research may complement our "supply side" perspective by examining the interplay between supply side and demand side (i.e., employing organizations), considering also the costs and benefits of publishing from the firm's perspective (cf. Agarwal & Ohyama, 2010; Gans et al., 2010b; Jovanovic, 1979; McCall, 1990). Particularly interesting are the dynamics between employers and employees as scientists build a publication record over time. Publications may effectively convert firm-specific human capital into general human capital (Liu & Stuart, 2010), increasing outside job opportunities over time. This could potentially lead firms to reduce their investments into prolific publishers (cf. Becker, 1962) and to avoid assigning them to projects that are critical to the firm.

Second, while we focus on the trade-off between pay and publishing, future work may apply our approach to study the trade-offs scientists (and employees more generally) make between other sets of job

attributes such as pay and the opportunity to do social good (Besley & Ghatak, 2005; Goddeeris, 1988) or pay and autonomy on the job (Aghion et al., 2008; Lacetera, 2009). With respect to the latter, Aghion et al. (2008) develop a theoretical model in which industry has to offer a wage premium relative to academia because industry jobs cannot offer as much researcher freedom as academia. Generalizing our discussion in section 5, we expect that the size and perhaps even existence of that wage premium depends critically on the distribution of scientists' preferences for freedom. Similarly, we suspect that some individuals intrinsically value freedom and self-determination per se (Deci & Ryan, 1985) while others may value freedom for its indirect benefits, e.g., because it allows them to work on problems that they find important or because it allows them to focus on building valuable human capital and reputation in a particular domain. Different reasons, in turn, may predict how much firms have to pay to limit researcher freedom and how researchers use the freedom they are given.

The work on researcher freedom highlights that jobs are characterized by not only two attributes (e.g., pay and publishing or pay and freedom), but by a vector of multiple job attributes that may be interrelated. Indeed, Stern's study (2004, table 3) showed that some of the wage discount associated with jobs that allowed publishing was explained by the fact that those same jobs also gave scientists more freedom to pursue their own research agendas. Thus, future work is needed that considers choices and market outcomes involving a larger number of interdependent job attributes and preferences. Such interdependencies may also mean that employers have to offer complex sets of job attributes if they seek to attract researchers with a strong "taste for science".

Finally, we simplified our analysis by considering opportunities for publishing as dichotomous – hypothetical jobs in our study either allowed publishing or they did not. It may be useful, however, to conceptualize disclosure as a continuum that involves intermediate levels of openness such as the disclosure of some results but not others, disclosure with a delay, or combinations of patenting and publishing (Gans et al., 2010a; Gittelman & Kogut, 2003; Hackett, 1990; Hicks, 1995). Explicitly considering these nuances may provide novel insights into how employers and scientists reconcile some of the tensions between open disclosure and financial returns.

**Table 1: Summary Statistics**

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| RWP (required wage premium) | 22.56 | 23.82 | 0 | 129 |
| RESWAGE_PUB | 71.09 | 22.12 | 30 | 200 |
| RESWAGE_NOPUB | 93.65 | 34.84 | 30 | 200 |
| RWP_PERCENT | 33.00 | 34.52 | 0 | 200 |
| PREFERENCE SALARY | 3.94 | 0.71 | 1 | 5 |
| PREFERENCE PUBLISHING | 3.78 | 0.98 | 1 | 5 |
| REASON PAY | 3.59 | 0.96 | 1 | 5 |
| REASON CONTRIBUTE | 4.38 | 0.70 | 1 | 5 |
| REASON RECOGNITION | 4.10 | 0.85 | 1 | 5 |
| ABILITYSELF | 6.48 | 1.59 | 1.9 | 10 |
| NRC RESEARCH RANKING | -40.29 | 25.46 | -136 | -1 |
| MALE | 0.41 | 0.49 | 0 | 1 |
| AGE | 28.15 | 3.31 | 21 | 45 |
| USCITIZEN | 0.81 | 0.39 | 0 | 1 |

**Table 2: Correlations**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 **RWP_PUB** | 1.0000 | | | | | | | | | | | | |
| 2 **RESWAGE_PUB** | 0.1487* | 1.0000 | | | | | | | | | | | |
| 3 **RESWAGE_NOPUB** | 0.7782* | 0.7367* | 1.0000 | | | | | | | | | | |
| 4 **RWP_PERCENT** | 0.9192* | -0.1176* | 0.5538* | 1.0000 | | | | | | | | | |
| 5 **PREFERENCE SALARY** | -0.1686* | 0.0901* | -0.0580* | -0.2021* | 1.0000 | | | | | | | | |
| 6 **PREFERENCE PUBLISHING** | 0.3737* | 0.0178 | 0.2668* | 0.3787* | -0.1133* | 1.0000 | | | | | | | |
| 7 **REASON PAY** | -0.0613* | -0.0209 | -0.0552* | -0.0658* | 0.3924* | 0.1170* | 1.0000 | | | | | | |
| 8 **REASON CONTRIBUTE** | 0.2299* | 0.0188 | 0.1691* | 0.2131* | -0.1035* | 0.3982* | 0.0983* | 1.0000 | | | | | |
| 9 **REASON RECOGNITION** | 0.0939* | 0.0189 | 0.0762* | 0.0997* | 0.1029* | 0.3044* | 0.3508* | 0.2913* | 1.0000 | | | | |
| 10 **ABILITYSELF** | 0.0846* | 0.1901* | 0.1785* | 0.0274 | 0.0628* | 0.1704* | 0.1021* | 0.1561* | 0.1064* | 1.0000 | | | |
| 11 **NRC RESEARCH RANKING** | 0.0710* | 0.0483 | 0.0792* | 0.0650* | -0.0778* | 0.0149 | -0.0569* | 0.0509 | -0.0012 | -0.0382 | 1.0000 | | |
| 12 **MALE** | 0.0642* | 0.1056* | 0.1110* | 0.0223 | 0.0623* | -0.0159 | 0.0315 | 0.0187 | -0.0153 | 0.1542* | -0.0641* | 1.0000 | |
| 13 **AGE** | 0.0440 | -0.0133 | 0.0217 | 0.0567* | -0.0416 | 0.0978* | -0.0132 | 0.0642* | -0.0835* | -0.0013 | -0.0541* | 0.1162* | 1.0000 |
| 14 **USCITIZEN** | -0.0493 | -0.0255 | -0.0499 | -0.0399 | -0.0864* | -0.1009* | -0.0419 | -0.0472 | -0.1382* | -0.1582* | 0.1658* | -0.0813* | -0.1097* |

Note: *=significant at 5%

**Table 3: Scientists' required wage premium to give up publishing**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Poisson | Poisson | Poisson | Poisson | Poisson | Poisson | Poisson | Poisson | Poisson | Poisson |
| | rwp | rwp | rwp | rwp | rwp | rwp | rwp | rwp | rwp | rwp |
| PREF_PUBLISHING | | 0.463** | | 0.435** | 0.453** | | | | 0.464** | 0.452** |
| | | [0.023] | | [0.029] | [0.025] | | | | [0.023] | [0.025] |
| PREF_SALARY | | -0.184** | | -0.127** | -0.148** | | | | -0.179** | -0.145** |
| | | [0.025] | | [0.032] | [0.029] | | | | [0.026] | [0.029] |
| PREFPAY>PREFSALARY | | | -0.786** | | | | | | | |
| | | | [0.068] | | | | | | | |
| PREFPUB>PREFSAL | | | 0.289** | | | | | | | |
| | | | [0.059] | | | | | | | |
| REASON_PAY | | | | -0.085** | | | | | | |
| | | | | [0.028] | | | | | | |
| REASON_CONTRIBUTE | | | | 0.190** | | | | | | |
| | | | | [0.046] | | | | | | |
| REASON_RECOGNITION | | | | -0.011 | | | | | | |
| | | | | [0.035] | | | | | | |
| REASONCONTR>REASONPAY | | | | | 0.171** | | | | | 0.166** |
| | | | | | [0.058] | | | | | [0.059] |
| REASONPAY>REASONCONTR | | | | | -0.152 | | | | | -0.153 |
| | | | | | [0.140] | | | | | [0.138] |
| ABILITYSELF | | | | | | 0.048** | | 0.048** | 0.008 | 0.009 |
| | | | | | | [0.015] | | [0.015] | [0.015] | [0.015] |
| NRC RANKING | | | | | | | 0.003* | 0.003* | 0.003* | 0.003* |
| | | | | | | | [0.001] | [0.001] | [0.001] | [0.001] |
| MALE | 0.140* | 0.166** | 0.167** | 0.165** | 0.166** | 0.119* | 0.143** | 0.122* | 0.162** | 0.162** |
| | [0.055] | [0.052] | [0.051] | [0.051] | [0.051] | [0.056] | [0.054] | [0.055] | [0.053] | [0.052] |
| AGE | 0.007 | -0.002 | -0.001 | -0.003 | -0.003 | 0.008 | 0.008 | 0.009 | 0 | -0.001 |
| | [0.011] | [0.009] | [0.010] | [0.009] | [0.009] | [0.011] | [0.011] | [0.011] | [0.009] | [0.009] |
| US CITIZEN | -0.13 | -0.043 | -0.087 | -0.04 | -0.044 | -0.101 | -0.152 | -0.122 | -0.058 | -0.058 |
| | [0.080] | [0.085] | [0.082] | [0.074] | [0.081] | [0.081] | [0.078] | [0.079] | [0.084] | [0.080] |
| Subfield (9) | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. |
| Constant | 3.105** | 2.166** | 3.534** | 1.691** | 2.050** | 2.776** | 3.129** | 2.799** | 2.098** | 1.987** |
| | [0.465] | [0.564] | [0.666] | [0.541] | [0.556] | [0.507] | [0.462] | [0.506] | [0.578] | [0.570] |
| Observations | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 |
| Chi-Square | 82.177 | 1360.777 | 1125.76 | 1448.029 | 2090.966 | 84.475 | 115.125 | 120.276 | 1569.654 | 2546.246 |
| LL | -18458.028 | -15586.174 | -16004.63 | -15339.546 | -15448.595 | -18372.601 | -18384.688 | -18298.848 | -15509.511 | -15378.312 |
| df | 12 | 14 | 14 | 17 | 16 | 13 | 13 | 14 | 16 | 18 |

Note: RWP is the required wage premium, computed as RWP=RESWAGE_NOPUB-RESWAGE_PUB. Models estimated using Poisson QML regression with standard errors clustered at the level of the university. Standard errors in brackets; *=significant at 5%, **=significant at 1%. PREFPUB=PREFSAL and REASON_PAY=REASON_CONTR are the omitted categories in models 3, 5, and 10.

**Table 4: Required wage premium (in percent)**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Poisson | Poisson | Poisson | Poisson | Poisson | Poisson | Poisson | Poisson | Poisson | Poisson |
| | rwp_perc. | rwp_perc. | rwp_perc. | rwp_perc. | rwp_perc. | rwp_perc. | rwp_perc. | rwp_perc. | rwp_perc. | rwp_perc. |
| PREF_PUBLISHING | | 0.462** | | 0.439** | 0.454** | | | | 0.472** | 0.464** |
| | | [0.025] | | [0.028] | [0.026] | | | | [0.025] | [0.025] |
| PREF_SALARY | | -0.218** | | -0.172** | -0.186** | | | | -0.211** | -0.180** |
| | | [0.028] | | [0.033] | [0.031] | | | | [0.027] | [0.030] |
| PREFPAY>PREFSALARY | | | -0.762** | | | | | | | |
| | | | [0.075] | | | | | | | |
| PREFPUB>PREFSAL | | | 0.352** | | | | | | | |
| | | | [0.059] | | | | | | | |
| REASON_PAY | | | | -0.073* | | | | | | |
| | | | | [0.030] | | | | | | |
| REASON_CONTRIBUTE | | | | 0.135** | | | | | | |
| | | | | [0.045] | | | | | | |
| REASON_RECOGNITION | | | | 0.005 | | | | | | |
| | | | | [0.038] | | | | | | |
| REASONCONTR>REASONPAY | | | | | 0.181** | | | | | 0.173** |
| | | | | | [0.059] | | | | | [0.060] |
| REASONPAY>REASONCONTR | | | | | -0.04 | | | | | -0.049 |
| | | | | | [0.136] | | | | | [0.133] |
| ABILITYSELF | | | | | | 0.014 | | 0.014 | -0.026 | -0.025 |
| | | | | | | [0.014] | | [0.014] | [0.014] | [0.014] |
| NRC RANKING | | | | | | | 0.003 | 0.003 | 0.003* | 0.003* |
| | | | | | | | [0.001] | [0.001] | [0.001] | [0.001] |
| MALE | 0.054 | 0.083 | 0.082 | 0.082 | 0.082 | 0.049 | 0.057 | 0.051 | 0.095* | 0.094* |
| | [0.047] | [0.046] | [0.045] | [0.046] | [0.046] | [0.049] | [0.047] | [0.048] | [0.046] | [0.046] |
| AGE | 0.011 | 0.002 | 0.003 | 0.002 | 0.002 | 0.011 | 0.013 | 0.013 | 0.003 | 0.003 |
| | [0.011] | [0.009] | [0.009] | [0.008] | [0.009] | [0.011] | [0.011] | [0.011] | [0.009] | [0.009] |
| US CITIZEN | -0.116 | -0.031 | -0.073 | -0.026 | -0.034 | -0.108 | -0.134* | -0.125 | -0.06 | -0.061 |
| | [0.069] | [0.071] | [0.068] | [0.062] | [0.066] | [0.069] | [0.067] | [0.066] | [0.068] | [0.063] |
| Subfield (9) | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. |
| Constant | 3.201** | 2.413** | 3.586** | 2.037** | 2.289** | 3.107** | 3.223** | 3.128** | 2.534** | 2.410** |
| | [0.380] | [0.468] | [0.580] | [0.477] | [0.468] | [0.411] | [0.379] | [0.413] | [0.479] | [0.477] |
| Observations | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 |
| Chi-Square | 74.192 | 1240.727 | 1364.642 | 1338.354 | 1572.196 | 81.844 | 95.241 | 98.705 | 1539.685 | 1620.406 |
| LL | -25531.283 | -21166.308 | -21736.74 | -20959.996 | -21000.506 | -25520.849 | -25454.084 | -25443.456 | -21055.287 | -20900.239 |
| df | 12 | 14 | 14 | 17 | 16 | 13 | 13 | 14 | 16 | 18 |

Note: RWP_PERCENT is the required wage premium expressed as percentage of RESWAGE_PUB. Models estimated using Poisson QML regression with standard errors clustered at the level of the university. Standard errors in brackets; *=significant at 5%, **=significant at 1%.

**Table 5: Reservation Wages**

| | 1a | 1b | 2a | 2b | 3a | 3b | 4a | 4b | 5a | 5b |
|---|---|---|---|---|---|---|---|---|---|---|
| | mvreg | | mvreg | | mvreg | | mvreg | | mvreg | |
| | resw_pub | resw_nopub | resw_pub | resw_nopub | resw_pub | resw_nopub | resw_pub | resw_nopub | resw_pub | resw_nopub |
| PREF_PUBLISHING | 0.822 | 9.409** | 0.648 | 9.064** | | | 0.203 | 8.750** | 0.053 | 8.429** |
| | [0.612] | [0.930] | [0.622] | [0.944] | | | [0.610] | [0.933] | [0.620] | [0.945] |
| PREF_SALARY | 2.482** | -1.873 | 2.652** | -0.92 | | | 2.311** | -1.98 | 2.455** | -1.067 |
| | [0.844] | [1.284] | [0.880] | [1.336] | | | [0.832] | [1.271] | [0.867] | [1.323] |
| REASONCONTR>REASONPAY | | | -0.378 | 3.527 | | | | | -0.42 | 3.402 |
| | | | [1.329] | [2.018] | | | | | [1.307] | [1.995] |
| REASONPAY>REASONCONTR | | | -3.625 | -4.197 | | | | | -3.298 | -3.942 |
| | | | [2.277] | [3.457] | | | | | [2.241] | [3.418] |
| ABILITYSELF | | | | | 2.431** | 3.507** | 2.371** | 2.626** | 2.351** | 2.600** |
| | | | | | [0.374] | [0.590] | [0.379] | [0.580] | [0.380] | [0.579] |
| NRC RANKING | | | | | 0.086** | 0.156** | 0.089** | 0.158** | 0.090** | 0.157** |
| | | | | | [0.026] | [0.041] | [0.026] | [0.040] | [0.026] | [0.040] |
| MALE | 4.211** | 8.119** | 4.257** | 8.169** | 3.308** | 6.052** | 3.192** | 7.023** | 3.243** | 7.081** |
| | [1.217] | [1.850] | [1.217] | [1.848] | [1.209] | [1.904] | [1.208] | [1.846] | [1.209] | [1.844] |
| AGE | -0.069 | -0.144 | -0.074 | -0.158 | 0.006 | 0.216 | 0.02 | -0.01 | 0.017 | -0.025 |
| | [0.183] | [0.279] | [0.183] | [0.278] | [0.181] | [0.284] | [0.181] | [0.276] | [0.181] | [0.276] |
| US CITIZEN | -0.037 | -1.249 | 0.054 | -1.169 | 0.237 | -2.647 | 0.562 | -0.991 | 0.631 | -0.923 |
| | [1.534] | [2.333] | [1.535] | [2.331] | [1.524] | [2.401] | [1.531] | [2.339] | [1.532] | [2.337] |
| Subfield (9) | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. |
| Constant | 59.558** | 71.972** | 59.683** | 68.988** | 57.756** | 73.971** | 47.202** | 58.212** | 47.478** | 55.475** |
| | [12.009] | [18.257] | [12.050] | [18.291] | [11.246] | [17.716] | [11.966] | [18.283] | [12.008] | [18.321] |
| Observations | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 |
| R-squared | 0.029 | 0.095 | 0.031 | 0.1 | 0.058 | 0.058 | 0.064 | 0.118 | 0.065 | 0.122 |
| Parameters | 15 | | 17 | | 15 | | 17 | | 19 | |

Note: Columns "a" regress the reservation wage for a job with publishing and columns "b" regress the reservation wage for a job without publishing. All models are estimated using multivariate regression. Standard errors in brackets; *=significant at 5%, **=significant at 1%.

## Table 6: Supplementary Analyses and Robustness Checks

| | 1<br>oprobit<br>pref_pub | 2<br>oprobit<br>pref_sal | 3<br>Poisson<br>rwp | 4<br>Poisson<br>rwp | 5<br>nbreg<br>rwp | 6<br>nbreg<br>rwp | 7<br>nbreg<br>rwp | 8<br>tobit<br>rwp_perc | 9<br>tobit<br>rwp_perc | 10<br>tobit<br>rwp_perc | 11<br>oprobit<br>rwp5 | 12<br>oprobit<br>rwp5 | 13<br>oprobit<br>rwp5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PREF_PUBLISHING | | | | 0.461** | 0.479** | 0.464** | | 17.042** | 16.696** | | 0.509** | 0.497** | |
| | | | | [0.023] | [0.034] | [0.034] | | [1.009] | [1.027] | | [0.023] | [0.024] | |
| PREF_SALARY | | | | -0.183** | -0.224** | -0.188** | | -9.010** | -7.600** | | -0.204** | -0.160** | |
| | | | | [0.025] | [0.031] | [0.034] | | [1.405] | [1.450] | | [0.031] | [0.031] | |
| REASONCONTR>REASONPAY | | | | | | 0.166** | | | 6.892** | | | 0.193** | |
| | | | | | | [0.052] | | | [2.111] | | | [0.051] | |
| REASONPAY>REASONCONTR | | | | | | -0.152 | | | -1.88 | | | -0.143 | |
| | | | | | | [0.128] | | | [4.160] | | | [0.118] | |
| ABILITYSELF | 0.120** | 0.028 | | | | | 0.046** | | | 0.609 | | | 0.038** |
| | [0.020] | [0.022] | | | | | [0.014] | | | [0.517] | | | [0.013] |
| NRC RANKING | -0.001 | -0.002 | | | | | 0.003* | | | 0.089 | | | 0.003 |
| | [0.001] | [0.001] | | | | | [0.001] | | | [0.058] | | | [0.001] |
| RISK AVERSION | | | -0.026* | -0.018 | | | | | | | | | |
| | | | [0.012] | [0.012] | | | | | | | | | |
| MALE | -0.104 | 0.099 | 0.129* | 0.160** | 0.194** | 0.199** | 0.127* | 3.193 | 3.223 | 1.551 | 0.167** | 0.170** | 0.1 |
| | [0.064] | [0.066] | [0.055] | [0.051] | [0.053] | [0.054] | [0.058] | [1.830] | [1.867] | [2.044] | [0.056] | [0.057] | [0.057] |
| AGE | 0.026** | -0.014 | 0.006 | -0.003 | -0.009 | -0.008 | 0.008 | -0.04 | -0.052 | 0.484 | -0.008 | -0.009 | 0.007 |
| | [0.007] | [0.011] | [0.010] | [0.009] | [0.009] | [0.009] | [0.009] | [0.368] | [0.369] | [0.424] | [0.010] | [0.010] | [0.010] |
| US CITIZEN | -0.256** | -0.207* | -0.107 | -0.028 | -0.148 | -0.144 | -0.146 | -4.198 | -4.217 | -7.798** | -0.175 | -0.174 | -0.248** |
| | [0.059] | [0.091] | [0.084] | [0.090] | [0.090] | [0.083] | [0.076] | [2.839] | [2.651] | [2.776] | [0.094] | [0.089] | [0.083] |
| Subfield (9) | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. | incl. |
| Constant | | | 3.243** | 2.264** | 2.614** | 2.465** | 2.827** | 4.082 | -1.508 | 19.774 | | | |
| | | | [0.442] | [0.553] | [0.534] | [0.526] | [0.461] | [17.929] | [17.769] | [15.493] | | | |
| Observations | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 | 1,400 |
| Chi-Square | | | 93.36 | 1543.21 | 843.97 | 873.85 | 115.30 | | | | | | |
| LL | | | -18399.83 | -15558.08 | -5602.38 | -5597.53 | -5698.98 | | | | | | |
| df | 14 | 14 | 13 | 15 | 14 | 16 | 14 | 14 | 16 | 14 | 11 | 11 | 11 |
| alpha | | | | | 1.356 | 1.334 | 1.587 | | | | | | |

Note: RWP5 is RWP coded in intervals of $5k each. Standard errors in brackets; *=significant at 5%, **=significant at 1%.

**REFERENCES**


Agarwal, R., & Ohyama, A. 2010. Industry or academia, basic or applied? Career choices and earnings trajectories of scientists, *Working Paper*.

Aghion, P., Dewatripont, M., & Stein, J. 2008. Academic freedom, private-sector focus, and the process of innovation. *RAND Journal of Economics*, 39(3): 617-635.

Allen, T. J., & Katz, R. 1992. Age, education and the technical ladder. *IEEE Transactions on Engineering Management*, 39(3): 237-245.

Arrow, K. J. 1962. Economic welfare and the allocation of resources for invention. In R. R. Nelson (Ed.), *The Rate and Direction of Inventive Activity*: NBER / Princeton University Press.

Audretsch, D., Boente, W., & Krabel, S. 2009. Why do scientists collaborate with firms?, *Working Paper*.

Austin, A. 2002. Preparing the next generation of faculty: Graduate School as socialization into the academic career. *Journal of Higher Education*, 73(1): 94-122.

Baron, J., & Spranca, M. 1997. Protected values. *Organizational Behavior and Human Decision Processes*, 70: 1-16.

Baron, R. M., & Kenny, D. A. 1986. The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 51(6): 1173-1182.

Beattie, J., & Barlas, S. 2001. Predicting perceived differences in tradeoff difficulty. In E. Weber, J. Baron, & G. Loomes (Eds.), *Conflict and tradeoffs in decision making*

Becker, G. 1962. Investment in human capital: A theoretical analysis. *Journal of Political Economy*, 70(5): 9-49.

Besley, T., & Ghatak, M. 2005. Competition and incentives with motivated agents. *American Economic Review*, 95(3): 616-636.

Blumenthal, D., Gluck, M., Louis, K., & Wise, D. 1986. University-industry research relationships in biotechnology: Implications for the university. *Science*, 232: 1361-1366.

Brown, C. 1980. Equalizing Differences in the Labor Market. *Quarterly Journal of Economics*, 94(1): 113-134.

Camerer, C., & Lovallo, D. 1999. Overconfidence and excess entry: An experimental approach. *American Economic Review*, 89(1): 306-318.

Cockburn, I. M., & Henderson, R. M. 1998. Absorptive capacity, coauthoring behavior, and the organization of research in drug discovery. *Journal of Industrial Economics*, 46(2): 157-182.

Dasgupta, P., & David, P. (Eds.). 1987. *Information disclosure and the economics of science and technology*. New York: New York University Press.

Dasgupta, P., & David, P. A. 1994. Toward a New Economics of Science. *Research Policy*, 23(5)

Deci, E. L., & Ryan, R. M. 1985. *Intrinsic motivation and self-determination in human behavior*. New York: Plenum.

Diamond, A. 1986. What is a citation worth? *The Journal of Human Resources*, 21(2): 200-215.

Dillman, D. A., Smyth, J., & Christian, L. 2009. *Internet, mail, and mixed-mode surveys* (3rd edition ed.): John Wiley & Sons, Inc.

Ding, W. W. 2011. The impact of founders' professional-education background on the adoption of open science by for-profit biotechnology firms. *Management Science*.

Edwards, J. 1995. Alternatives to difference scores as dependent variables in the study of congruence in organizational research. *Organizational Behavior and Human Decision Processes*, 64(3): 307-324.

Galton, F. 1874. *English Men of Science: Their Nature and Nurture*. London: Macmillan.

Gans, J., Murray, F., & Stern, S. 2010a. Contracting Over the Disclosure of Scientific Knowledge: Intellectual Property Protection and Academic Publication, *MIT Working Paper*.

Gans, J., Murray, F., & Stern, S. 2010b. Contracting over the disclosure of scientific knowledge: Intellectual property protection and academic publication, *Working Paper*.

Gibbons, R. S., & Katz, L. F. 1992. Does Unmeasured Ability Explain Inter-Industry Wage Differentials? *Review of Economics and Statistics*, 59(3): 515-535.
Gittelman, M., & Kogut, B. 2003. Does good science lead to valuable knowledge? Biotechnology firms and the evolutionary logit of citation patterns. *Management Science*, 49(4): 366-382.
Goddeeris, J. 1988. Compensating differentials and self-selection: An application to lawyers. *Journal of Political Economy*, 96(2): 411-428.
Greenberg, J., Ashton-James, C., & Ashkanasy, N. 2007. Social comparison processes in organizations. *Organizational Behavior and Human Decision Processes*, 102(1): 22-41.
Groves, R., & Peytcheva, E. 2008. The impact of nonresponse rates on nonresponse bias. *Public Opinion Quarterly*, 72(2): 167-189.
Hackett, E. J. 1990. Science as a vocation in the 1990s. *Journal of Higher Education*, 61(3): 241-279.
Hamilton, B. H. 2000. Does entrepreneurship pay? An empirical analysis of the returns to self-employment. *Journal of Political Economy*, 108(3): 604-631.
Harhoff, D., & Hoisl, K. 2007. Institutionalized incentives for ingenuity - Patent value and the German Employees' Inventions Act. *Research Policy*, 36: 1143-1162.
Heckman, J., Matzkin, R., & Nesheim, L. 2010. Nonparametric identification and estimation of nonadditive hedonic models. *Econometrica*, 78(5): 1569-1591.
Henderson, R., & Cockburn, I. 1994. Measuring Competence - Exploring Firm Effects in Pharmaceutical Research. *Strategic Management Journal*, 15: 63-84.
Hicks, D. 1995. Published papers, tacit competencies and corporate management of the public/private character of knowledge. *Industrial and Corporate Change*, 4: 401-424.
Huang, K., & Murray, F. 2009. Does patent strategy shape the long-run supply of public knowledge? Evidence from human genetics. *Academy of Management Journal*, 52(6): 1193-1221.
Hwang, H., Reed, W. R., & Hubbard, C. 1992. Compensating wage differentials and unobserved productivity. *Journal of Political Economy*, 100(4): 835-858.
IPO. 2004. Employee inventor compensation practices survey. Washington, DC.: Intellectual Property Owners Association.
Jovanovic, B. 1979. Job matching and the theory of turnover. *Journal of Political Economy*, 87(5): 972-990.
Killingsworth, M. 1987. Heterogeneous preferences, compensating wage differentials, and comparable worth. *Quarterly Journal of Economics*, 102(4): 727-742.
Konrad, A., & Pfeffer, J. 1990. Do you get what you deserve? Factors affecting the relationship between productivity and pay. *Administrative Science Quarterly*, 35: 258-285.
Lacetera, N. 2009. Different missions and commitment power in R&D organizations: Theory and evidence on industry-university alliances. *Organization Science*, 20(3): 565-582.
Lacetera, N., Cockburn, I., & Henderson, R. 2004. Do firms change capabilities by hiring new people? A study of the adoption of science-based drug discovery. *Advances in strategic management*
Landis, J., & Koch, G. 1977. The measurement of observer agreement for categorical data. *Biometrics*, 33: 159-174.
Latour, B., & Woolgar, S. 1979. Laboratory life: The social construction of scientific facts. *Sage*
Levin, S. G., & Stephan, P. E. 1991. Research Productivity Over the Life Cycle: Evidence for Academic Scientists. *American Economic Review*, 81(1): 114-132.
Liu, C., & Stuart, T. 2010. Boundary spanning in a for-profit research lab: An exploration of the interface between commerce and academe, *Working Paper*.
Luce, M., Payne, J., & Bettman, J. 1999. Emotional trade-off difficulty and choice. *Journal of Marketing Research*, 36(2): 143-159.
Lykken, D. T., Bouchard, T. J., McGue, M., & Tellegen, A. 1993. Heritability of interests: A twin study. *Journal of Applied Psychology*, 78(4): 649-661.
McCall, B. P. 1990. Occupational matching: A test of sorts. *Journal of Political Economy*, 98(1): 45-69.
Merton, R. K. 1957. Priorities in Scientific Discovery: A Chapter in the Sociology of Science. *American Sociological Review*, 22(6): 645-659.

Merton, R. K. 1973. *The sociology of science: Theoretical and empirical investigations*. Chicago: University of Chicago Press.
Miller, G. A. 1976. Professionals in Bureaucracy: Alienation among Industrial Scientists and Engineers. *American Sociological Review*, 32(5): 755-768.
Moorman, R. H., & Podsakoff, P. M. 1992. A Metaanalytic Review and Empirical-Test of the Potential Confounding Effects of Social Desirability Response Sets in Organizational-Behavior Research. *Journal of Occupational and Organizational Psychology*, 65: 131-149.
Murray, F., & O'Mahony, S. 2007. Exploring the foundations of cumulative innovation: Implications for Organization Science. *Organization Science*, 18(6): 1006-1021.
National Science Foundation. 2003. Survey of Doctorate Recipients 2003.
National Science Foundation. 2006. Survey of Doctorate Recipients, Data Tables.
National Science Foundation. 2008. Survey of Earned Doctorates.
Nelson, R. 2004. The market economy, and the scientific commons. *Research Policy*, 33(3): 455-471.
NRC. 2010. *A data-based assessment of research-doctorate programs in the United States*. Washington, DC: National Academies Press.
Nunnally, J. C. 1978. *Psychometric Theory* (2nd ed.): McGraw-Hill.
Parchomovsky, G. 2000. Publish or perish. *Michigan Law Review*, 98(4): 926-952.
Penin, J. 2007. Open knowledge disclosure: An overview of the evidence an economic motivations. *Journal of Economic Surveys*, 21(2): 326-348.
Podsakoff, P. M., MacKenzie, J. Y., & Lee, J. Y. 2003. Common methods bias in behavioral research: A critical review and recommended remedies. *Journal of Applied Psychology*, 88(5): 879-903.
Roach, M., & Sauermann, H. 2010. A taste for science? PhD scientists' academic orientation and self-selection into research careers in industry. *Research Policy*, 39(3): 422-434.
Rosen, S. 1986. The theory of equalizing differences. In O. Ashenfelter, & R. Layard (Eds.), *Handbook of Labor Economics*: 641-692: North-Holland.
Santos Silva, J., & Tenreyro, S. 2006. The log of gravity. *Review of Economics and Statistics*, 88(4)
Sauermann, H., & Cohen, W. 2010. What makes them tick? Employee motives and industrial innovation. *Management Science*, 56(12): 2134-2153.
Sauermann, H., & Stephan, P. E. 2010. Twins or Strangers? Differences and Similarities between Academic and Industrial Science, *NBER Working Paper #16113*.
Shanmugam, K. R. 2001. Self selection bias in the estimates of compensating differentials for job risks in India. *Journal of Risk and Uncertainty*, 22(3): 263-275.
Shepard, H. A. 1956. Nine Dilemmas in Industrial Research. *Administrative Science Quarterly*, 1(3)
Slaughter, S., & Rhoades, G. 2004. *Academic Capitalism and the New Economy: Markets, State, and Higher Education*. Baltimore: Johns Hopkins University Press.
Sorenson, O., & Fleming, L. 2004. Science and the diffusion of knowledge. *Research Policy*, 33
Stephan, P. 2010. The economics of science. In B. Hall, & N. Rosenberg (Eds.), *Handbook of the Economics of Innovation*, Vol. 1: 218-273: North Holland.
Stephan, P. E. 2004. Rober K. Merton's perspective on priority and the provision of the public good knowledge. *Scientometrics*, 60(1): 81-87.
Stephan, P. E., & Levin, S., G. 1996. Property rights and entrepreneurship in science. *Small Business Economics*, 8: 177-188.
Stern, S. 2004. Do scientists pay to be scientists? *Management Science*, 50(6): 835-853.
Tuckman, H., & Leahey, J. 1975. What is an article worth? *Journal of Political Economy*, 83(5): 951-967.
Vallas, S. P., & Kleinman, D. L. 2008. Contradiction, convergence, and the knowledge economy: The confluence of academic and commercial biotechnology. *Socio-Economic Review*, 6(283-311).
Wooldridge, J. 1997. Quasi-Likelihood methods for count data. In M. Pesaran, & P. Schmidt (Eds.), *Handbook of Applied Econometrics*, Vol. 2: 352-406. Oxford: Blackwell.
Zucker, L. G., Darby, M. R., & Brewer, M. B. 1998. Intellectual human capital and the birth of US biotechnology enterprises. *American Economic Review*, 88(1): 290-306.