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Not all scientists pay to be scientists: PhDs' preferences for publishing in industrial employment☆

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ABSTRACT

It is often assumed that academically trained scientists have a strong taste for science and are willing to "pay" for the ability to openly disclose their research results. However, little is known regarding how scientists considering jobs in industrial R&D make trade-offs between positions that allow publishing on the one hand and positions that do not allow publishing but offer higher pay on the other. Using data on over 1900 science and engineering PhD candidates about to enter the job market, we find that while some are unwilling to give up publishing at virtually any price, over one third of those most likely to seek positions in industrial research are willing to forego publishing for free. We develop a simple model of the "price" scientists assign to publishing in firms and explore potential sources of heterogeneity empirically. We find that the price of publishing increases with individuals' preferences for various benefits from publishing such as peer recognition and contributing to society, but it decreases with their preference for money. Scientists who believe themselves to be of high ability and who train at top tier institutions have a higher price of publishing. Yet, they are more expensive to hire (not less) even if publishing is allowed. We discuss implications for research on the economics of science and on compensating differentials, for managers seeking to attract and retain academically trained personnel, and for firms considering their participation in open science.

1. Introduction

A large stream of innovation research rests on the notion that scientists have a strong desire to participate in "open science" by disclosing and disseminating their research results to the broader scientific community. For example, early work has highlighted potential conflicts between scientists' taste for science and the closed commercial logic of the private sector (Kornhauser, 1962; Miller, 1967; Ritti, 1968). More recent research has suggested that firms may gain a range of benefits from allowing their scientists to participate in open science. In particular, firms adopting open science policies may be better able to attract and retain academically trained scientists (Penin, 2007; Simeth and Raffo, 2013) and they may even be able to extract a wage discount from scientists who are willing to give up pay in exchange for opportunities to engage in open science (Stern, 2004; Gans et al., 2010). Stern (2004), for example, showed that R&D positions that offered a science-oriented environment also offered lower wages, concluding that scientists "pay" to be scientists.[2]

By focusing on characteristics that appear to distinguish scientists from other professionals – such as their taste for science – most of the prior literature has implicitly treated scientists as a homogenous group. Recent research, however, has challenged this simplistic view by demonstrating significant heterogeneity among scientists (Owen-Smith and Powell, 2001; Roach and Sauermann, 2010; Agarwal and Ohyama, 2013). We contribute to this growing stream of work by examining the degree to which scientists differ in the price they assign to publishing opportunities in industrial R&D and by exploring why some value publishing more than others. Insights into these questions have important implications for research on scientific labor markets, for managers seeking to attract

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[2] The notion of "open science" policies may capture a wide range of aspects, including publishing, conference attendance, industry-academia collaborations, etc. In this paper, we focus on publishing as a particularly salient aspect.

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and retain highly educated employees, and for firms considering the adoption of open science policies.

We conceptualize the *price of publishing* as the additional amount of pay that a given scientist requires to make him indifferent between accepting an industrial R&D position that restricts publishing and one that allows it. Drawing on a survey of over 1900 science and engineering PhD candidates preparing to enter the job market, we measure the price of publishing at the level of the individual by eliciting respondents' reservation wages for hypothetical industrial R&D positions that differ only with respect to whether or not they allow publishing. This approach enables us to characterize the full distribution of the price of publishing in a given cohort of PhDs across a broad range of fields. As such, we complement prior work that has focused on average equilibrium compensating differentials emerging in the labor market or that has used smaller and narrower samples (Stern, 2004; Stuart and Liu, 2010).[3] The survey instrument also provides a rich set of measures that allow us to explicitly examine which particular scientists place a higher value on publishing than others. As such, we expand upon prior work that has demonstrated heterogeneity across scientists and has discussed its implications, but remains largely silent as to the underlying sources of this heterogeneity (Roach and Sauermann, 2010; Agarwal and Ohyama, 2013). Perhaps most interestingly, the data allow us to examine the reasons *why* scientists value the opportunity to publish, complementing prior conceptual discussions of the different functions of publishing in the institution of science with unique empirical insights from scientists' perspective.

While some PhDs conform to the stereotype and place a high value on the opportunity to publish when working in industrial R&D, we observe considerable heterogeneity in the price of publishing, with many scientists willing to forego publishing "for free". Moreover, we find that the price assigned to publishing opportunities in firms is significantly lower for those scientists who aspire to positions in industry than for those who would prefer to work in academia. Indeed, a full 37% of those who prefer an industry position price publishing at zero, compared to 12% among those who prefer academic employment. As such, those scientists most likely to enter the private sector appear to place a lower value on publishing than the typical scientist portrayed in prior work.

To gain a deeper understanding of which scientists value publishing more than others, we relate the price of publishing to scientists' preferences for various indirect payoffs from publishing suggested in the prior literature. As predicted, we find that the price of publishing is significantly higher for those scientists with strong preferences for peer recognition or for contributing to the stock of public knowledge. In contrast, the relationship between the price of publishing and scientists' desire for career advancement is weak, possibly suggesting that publications are not seen as a key mechanism for career advancement in industrial R&D. Most interestingly, we also find that the price of publishing is significantly *lower* for those individuals who care strongly about money, likely reflecting that these individuals derive more utility from a given amount of money and need only a small amount of extra pay to compensate for the lack of publishing opportunities. Examining the relationship between the price of publishing and proxies of ability, we find that scientists with higher self-perceived ability and those from top tier institutions have a higher price of publishing. However, they also expect higher wages irrespective of the publishing regime. As such, they are more expensive to hire than other scientists when they are allowed to publish, and they are disproportionally more expensive when publishing is restricted. Finally, we also observe significant differences in the price of publishing across fields of science and engineering, likely reflecting that publications are more important as a mechanism to disclose research results and as a measure of scientists' performance in some fields than in others.

While only a first step toward understanding the extent and possible sources of heterogeneity among scientists, our results speak to the generalizability of common models of scientists' preferences and provide a foundation for future research to better understand scientists' behaviors and choices. Our findings can also have important implications for science and technology-based firms that seek to attract and retain highly educated employees or that consider the adoption of open science policies for various reasons. Finally, by providing deeper insights into how scientists make trade-offs between publishing and pay, this study has implications for the broader human capital literature that examines compensating differentials and trade-offs between other types of job attributes such as pay and social responsibility (Goddeeris, 1988; Auger et al., 2011), pay and freedom (Aghion et al., 2008), or pay and a desirable work location (Campbell et al., 2012).

In the following section, we provide background on the role of publishing in the scientific system and conceptualize publications as a means toward different ends, implying that scientists may value publishing for a variety of reasons. In Section 3, we describe the data and provide descriptive insights into heterogeneity in the price of publishing and in the reasons for publishing. In Section 4, we build on these insights to develop a model that relates the price of publishing to individual characteristics such as preferences for different potential payoffs from publishing as well as ability. This model guides a more systematic regression analysis of the price of publishing in Section 5. Section 6 discusses implications and opportunities for future research.

2. Background

2.1. The institution of science and publications as a means toward different ends

According to the canonical view, the institution of science entails as one of its key elements a reward system that encourages scientists to quickly disclose new knowledge through publication (Merton, 1973; Dasgupta and David, 1994). This system has advantages to the extent that research results have characteristics of a public good, leading to sub-optimal incentives for research in a traditional market system (Stephan, 2012). Moreover, research findings can provide valuable inputs for follow-on research, suggesting that the open disclosure of knowledge may benefit society by allowing researchers to build on existing knowledge in a cumulative fashion (Nelson, 2004; Sorenson and Fleming, 2004). Thus, the publication-based reward system of science has been interpreted as an institutional mechanism designed to encourage both the production and the diffusion of new knowledge (Stephan, 2012).

Individual scientists, however, may not care directly about publishing per se, but rather about the various indirect benefits that can result from publishing one's research. While we cannot consider all possible types of such benefits, several have been prominently featured in prior work. First, publications are often used as a measure of scientists' research ability or performance and as a predictor of

[3] The term "compensating differential" is used widely in the labor economics and human capital literatures 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., Rosen, 1986; Hwang et al., 1992). In prior empirical work, the compensating differential is an equilibrium outcome in the labor market, i.e., it reflects both the supply and the demand side of the labor market. Our focus is on the price each individual scientist assigns to the opportunity to publish, i.e., on the supply side. While compensating differentials observed in the labor market reflect the preferences of the marginal individual and provide limited insights into the preferences of the broader population (Rosen, 1986; Killingsworth, 1987; Aghion et al., 2008), our approach allows us to characterize the distribution of preferences in a cohort of scientists.

future contributions to science.[4] As such, scientists with a larger publication record have a higher value in the scientific labor market, allowing them to obtain positions that offer higher pay (Tuckman and Leahey, 1975; Konrad and Pfeffer, 1990; Stuart and Liu, 2010) but also higher levels of non-pecuniary job attributes such as research freedom or resources for research (Latour and Woolgar, 1979; Stephan, 2012). Therefore, giving up current pay in order to build a stock of publications may be seen as an investment into future job opportunities and higher pay (see Rosen, 1986; Levin and Stephan, 1991; Franco and Filson, 2006). When asked in an open ended question why he would value publishing opportunities in industrial R&D, for example, one of our respondents stated: "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."

Other scholars have emphasized peer recognition or "kudos" as another payoff from publishing (Merton, 1973; Gans et al., 2010). While recognition may in turn result in better jobs or higher pay, scientists may also derive utility from recognition itself.[5] Indeed, prior work in innovation as well as other domains suggests that individuals care strongly about recognition and may "pay" for visible signs of recognition such as the introduction into clubs of best employees (Maslow, 1943; Von Krogh et al., 2012; Larkin, 2013). Finally, apart from the extrinsic rewards provided by the scientific community, scientists may value the open dissemination of knowledge through publications because it allows them to have a greater impact on the advancement of science (Merton, 1973; Dasgupta and David, 1994; Sorenson and Fleming, 2004). In a related vein, Gans and Stern (2010) argue that many scientists subscribe to norms of openness and may feel a "repugnance" toward attempts to limit access to knowledge for private benefit or profit. 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."

While this discussion suggests that publications can provide several indirect payoffs, little is known regarding the reasons for publishing from the scientists' perspective, and whether different reasons for publishing are tied to differences in the price scientists assign to publishing opportunities in industrial employment. Before we examine these questions, however, we discuss why scientists considering positions in industry may face a trade-off between publishing and pay in the first place.

2.2. Trade-offs between publishing and pay in industrial R&D

The canonical view of the institution of science sketched out above is based primarily on studies of academic science. However, scientific labor markets straddle academic and industrial science, and publications also play important roles in industry (Hicks, 1995; Stern, 2004; Sauermann and Stephan, 2013). In particular, many firms look at scientists' publication record as an indicator of research ability and success, resulting in a higher labor market value for industrial scientists who publish prolifically (see Cockburn and Henderson, 1998; Stuart and Liu, 2010). Similarly, even when produced in the context of industrial R&D, publications may allow researchers to gain peer recognition and to contribute to the stock of public knowledge. As such, it is typically assumed that even scientists working in industry value the opportunity to publish and to participate in the reward system of science (Stern, 2004; Penin, 2007; Simeth and Raffo, 2013).

Scientists' preferences for publishing, however, may conflict with the goals of industrial employers, who operate primarily in a market-based system and who often desire to restrict the disclosure of new knowledge (Miller, 1967; Gans et al., 2010). Firms may seek to limit disclosure for various reasons. First, open disclosure reveals potentially valuable information to rivals and likely reduces a firm's ability to appropriate financial returns from its knowledge. As such, many firms consider secrecy the most effective mechanism to protect knowledge assets in a wide range of industries (Cohen et al., 2000).[6] Disclosure may also help competitors in their own efforts to generate new knowledge by providing them with knowledge inputs or a "map" for their search for new knowledge (see Fleming and Sorenson, 2004). In many cases, the financial returns from private knowledge accrue primarily to employers rather than scientists (IPO, 2004; Harhoff and Hoisl, 2007), such that the cost of disclosure are borne mainly by employers, while the benefits of disclosure (e.g., peer recognition and labor market value) accrue primarily to the individual scientists.

On the other hand, firms may also see certain advantages to using a pro-publishing open science regime, including better access to extramural knowledge (Cockburn and Henderson, 1998; Gittelman and Kogut, 2003), strategic benefits when competing against rivals (Penin, 2007; Pacheco-de-Almeida and Zemsky, 2012; Polidoro and Theeke, 2012), or improved coordination with partners (Alexy et al., 2013). Despite these potential benefits of adopting open science policies, at least some firms are likely to put restrictions on the disclosure of research results. As such, scientists face trade-offs between jobs that offer publishing and jobs that limit disclosure but pay a compensating wage differential (Stern, 2004). We now provide first descriptive insights into the price scientists assign to publishing when faced with this trade-off and explore the reasons why they value the opportunity to publish.

3. Data and descriptive results

3.1. Data

We use data from a national survey of PhD candidates at tier one U.S. research universities. Using data from scientists prior to their initial career transition 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 initial job and career choices (Stern, 2004; Aghion et al., 2008; Agarwal and Ohyama, 2013), making scientists facing such choices the most relevant sample to study these issues. Moreover, since virtually all scientists go through extensive academic training, sampling individuals in training provides insights into a large part of the distribution of scientists' preferences in a given cohort, avoiding potential selection biases associated with samples of individuals who have already entered particular career paths or types of jobs.[7]

To obtain a sampling frame, we identified U.S. research universities with large doctoral programs in science and engineering fields

[4] At the same time, the limitations of publications as a measure of performance or contribution to science are well recognized (Merton, 1973; Rennie et al., 1997; Haeussler and Sauermann, 2013).

[5] For simplicity, we conceptualize higher pay and career benefits as resulting from a successful publication record (rather than from peer recognition) and focus on the consumption value of recognition.

[6] Appropriability concerns may be mitigated if knowledge is patented as well as published (Gans et al., 2010). Even with patents as an additional protection mechanism, however, publication is likely to increase the threat of imitation since patents are not very effective in most industries and secrecy is seen by many firms as more effective than legal mechanisms (Cohen et al., 2000).

[7] One may be concerned that PhD candidates might not have much experience with publishing and thus ill-formed preferences regarding publishing policies. Mitigating this concern, we find that over 80% of our cases have at least one publication, and the mean number of publications is 2.46. Dropping those cases without a publication does not change our substantive results.

by consulting the National Science Foundation's (2008) reports on earned doctorates. We selected a subset of 39 universities based primarily on program size while also ensuring variation in private/public status and geographic region. We pre-tested the survey in interviews with junior scientists similar to our target population and collected responses in the spring of 2010, approaching individuals in two ways. First, we collected roughly 30,000 individual names and email addresses from graduate student listings provided on department websites. We invited these individuals to participate in the survey using a four-contact strategy (one invitation, three reminders). Adjusting for 6.3% undeliverable emails, the direct survey approach achieved a response rate of 30%. When individual contact information was not available, we emailed PhD program 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, 85% of our responses were obtained directly from respondents and 15% were obtained through administrators.[8]

For this study, we focus on 1927 PhD candidates who were on the job market (i.e., looking for a full-time job or postdoc position) in the year of the survey or were planning to be on the market within the next year. These respondents are likely to have given more consideration to job and career choices than early-stage students and are also the most relevant population in the context of this study.[9]

3.2. Heterogeneity in the price of publishing and reasons for publishing

We define the price of publishing (PricePub) as the additional amount of pay at which a given scientist is indifferent between taking an industrial R&D position that restricts publishing and a position that allows it, holding all other job attributes constant. Although we conceptualize PricePub as the wage premium a scientist requires to forego publishing, it can also be interpreted as the wage discount a scientist is willing to accept if allowed to publish.[10] To measure the price of publishing, we employ a contingent valuation approach similar to approaches used in economics and the career choice literature (see Cable and Judge, 1994; Slaughter et al., 2006; Blumenschein et al., 2008). In particular, we asked respondents:

"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 minimum starting compensation for you to accept each position?

Job 1: Allowed to publish research results

Job 2: NOT allowed to publish research results"

Respondents indicated their reservation wage for each job using a sliding scale measure with anchors ranging from $0 to $200k. The average reservation wage for a job that does not allow publishing (W_NoPub) is roughly $96k (median $92k), while the average reservation wage for the job that allows publishing (W_Pub) is $78k (median $75k). For comparison, the median salary of recent S&E doctorate recipients in industry was $85k in 2008 (National Science Board, 2012, Table 3–22). Thus, the reservation wages reported by our respondents are in line with actual salary figures.

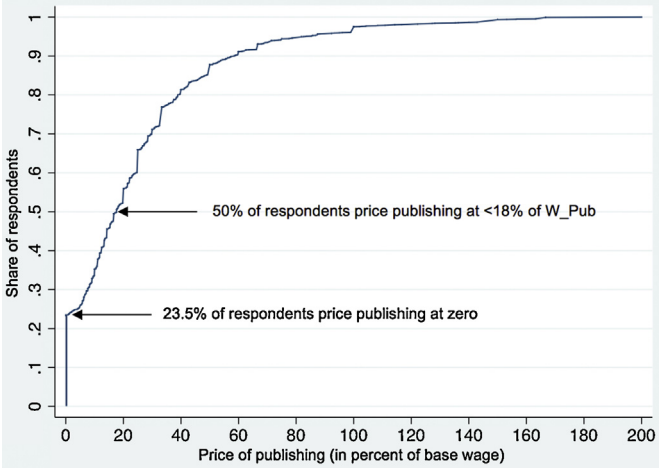

Fig. 1. Cumulative distribution of PricePub%.

We calculate the price of publishing as PricePub = W_NoPub − W_Pub, which is positive when respondents require additional pay to forego publishing, and zero when they are indifferent between the two jobs.[11] The average price of publishing is $18,300. In addition to the absolute measure of PricePub, we also compute a relative measure that expresses PricePub as a percentage of the reservation wage for the job with publishing and thus adjusts for differences in general wage expectations: PricePub% = (PricePub/W_Pub)*100. Using this measure, the price of publishing amounts to a 25% premium over the wage that allows publishing for the average respondent.[12]

Fig. 1 plots the cumulative distribution of PricePub%, showing the share of scientists who value publishing at or below a certain price.

Fig. 1 shows a high degree of heterogeneity across individuals. Particularly notable is that a considerable share of respondents (23.5%) value publishing at zero, i.e., they would not require a wage premium to give up publishing, or, alternatively, they would not be willing to take a wage cut in return for publishing opportunities. This result stands in stark contrast to the notion that all scientists value publishing. At the same time, many scientists do value

[8] The particular way in which survey respondents are approached may lead to sample selection or biased responses. In our context, offering financial incentives may increase the likelihood that individuals with above-average preferences for pay respond, while a survey without financial incentives may primarily attract respondents with above-average non-pecuniary preferences (e.g., interest in research). We randomly assigned respondents into different conditions with respect to incentives but found no significant differences with respect to the key variables used in this study (for details, see Sauermann and Roach (2013)). To assess potential nonresponse bias, we also compared responses of early and late respondents (Rogelberg and Stanton, 2007) but found no significant differences. We nevertheless include controls for survey mode and response time in all regressions.

[9] The largest numbers of respondents in our sample are from U of Washington (5.9%), U of Illinois Urbana-Champaign (5.2%), Purdue U. (5.1%), UC Davis (5%), MIT (4.9%), UC Berkeley (4.7%), Johns Hopkins (4.3%) and U of Wisconsin–Madison (4%).

[10] Given that publishing tends to be the norm rather than the exception in many fields (Stern, 2004; Sauermann and Stephan, 2013), we frame our discussion primarily in terms of a wage premium rather than a wage discount.

[11] We dropped from the sample 3.6% of respondents who indicated a negative price of publishing. Our analysis of open-ended responses suggests that some of them thought that the permission to publish comes with pressure to publish. Other respondents may have interpreted the response scales in the opposite direction, i.e., they thought of the dollar figures as indicators of the value they assign to these jobs rather than the wage they require to take the positions. While we are cautious to interpret negative PricePub as valid, it could indicate that some scientists indeed place a negative value on publishing, perhaps because they see publishing as a burden. Also, a small number of individuals indicated a W_NoPub that was multiple times larger than W_Pub, likely signaling that they were essentially unwilling to take a job that does not allow publishing. To reduce the influence of such outliers and to facilitate graphical analysis, we dropped cases where W_NoPub was more than three times as large as W_Pub (0.1% of cases).

[12] Our question frames opportunities for publishing as dichotomous, yet publishing policies in firms may span 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 (Hicks, 1995; Gittelman and Kogut, 2003; Gans et al., 2010). Our interviews and the open-ended survey responses do not indicate that this framing was a problem for respondents. However, the price scientists assign to "partial" openness is likely to be lower than the price of publishing measured in our study.

Table 1
Functions of publishing.

Panel A				Panel B			
Extremely important function (score of 5)	Category	1	2	Most important function (highest score; incl. ties)	Category	3	4
		Share of respondents	Mean PricePub%			Share of respondents	Mean PricePub%
Recognition	No	69%	22.87**	Recognition	No	46%	23.93 n.s.
	Yes	31%	29.56		Yes	54%	25.81
Job	No	56%	23.12**	Job	No	30%	25.67 n.s.
	Yes	44%	27.30		Yes	70%	24.63
Contribution	No	58%	20.09**	Contribution	No	29%	20.71**
	Yes	42%	31.59		Yes	71%	26.67
Pay	No	88%	25.12 n.s.	Pay	No	75%	26.33**
	Yes	12%	23.72		Yes	25%	20.72

Note: Test of differences in PricePub% across levels of functions using the non-parametric Wilcoxon–Mann–Whitney test.
** Significant at 1%.

publishing, with the median respondent having a price of publishing equivalent to roughly 18% of the base wage. At the top end of the distribution, a small number of PhDs assign a very high price to publishing, indicating a great reluctance to take a job that restricts disclosure.

To gain insights into why scientists value publishing, we asked "To what extent are the following functions of publishing important or unimportant to you personally?"[13] Focusing on the often discussed – but empirically largely unexplored – potential reasons raised earlier, we asked respondents to rate the following functions on a scale ranging from 1 (extremely unimportant) to 3 (neither unimportant nor important) to 5 (extremely important):

- "Publications are a way to earn recognition from my peers and colleagues" (Function recognition).
- "Publications will help me to get and keep a good job" (Function job).
- "Publishing research results allows me to contribute to the advancement of knowledge" (Function contribution).
- "Having publications will lead to higher pay in the future" (Function pay).

Column 1 in Table 1 shows the share of respondents who rated each of these functions as "extremely important". We see that this share is highest for publications as a means to obtain a good job (44%), followed by publications as a means to contribute to public knowledge (42%), gain peer recognition (31%), and to obtain higher pay (12%).[14] Column 2 shows the mean price of publishing for individuals who rate a particular function as extremely important versus those who do not. We find that for recognition, contribution, and job, those who rate this function as extremely important have a significantly higher price of publishing. For pay, the difference is not significant. While this analysis suggests that the price of publishing may depend on the reason why a scientist values publishing, a limitation is that our measures of functions confound the reason for publishing with the importance of publishing.

Column 3 provides insights into the *relative* importance of different functions. In particular, we coded a set of dummy variables indicating whether a particular function received the respondent's highest rating. Since functions were rated independently, we allow for ties, i.e., multiple functions can receive the highest rating from a particular respondent. We find that 71% of respondents rated contribution to the advancement of knowledge as the most important function of publishing, compared to 70% for job, 54% for recognition, and 25% for pay. We again compare the mean of the price of publishing across groups (column 4). Those respondents who state contribution to society as the most important function assign a significantly higher price to publishing in industry than those who do not. Those who see publishing primarily as a means to obtain higher pay in the future have a *lower* price of publishing than those who do not.[15]

3.3. Potential sorting into industry vs. academia

Fig. 1 showed significant heterogeneity in the price individuals assign to the opportunity to publish in industry, including over 20% of respondents who value publishing at zero. This heterogeneity is not only interesting in its own right, but it also implies the need to consider potential sorting and selection effects. In particular, theories of career choice and labor market sorting suggest that individuals will tend to sort into those organizational contexts that offer matching job attributes or incentives, potentially resulting in quite different populations of individuals in different organizational contexts (Rosen, 1986; Agarwal and Ohyama, 2013). In our context, the most interesting question is whether those scientists who care little about publishing are more likely to seek positions in industry than those scientists who care strongly about publishing. In that case, the price of publishing among those scientists entering industry may be much lower than in the overall population of scientists depicted in Fig. 1 and firms may face applicants who assign a relatively low value to the opportunity to publish.

To examine such potential sorting effects, we relate the price of publishing to scientists' career preferences. To obtain a measure for the latter, we asked respondents: "Putting job availability aside, how attractive do you personally find each of the following careers?" Respondents separately rated "University faculty with an emphasis on research or development" and "Job in an established firm with an emphasis on research or development" on scales ranging from 1 (extremely unattractive) to 5 (extremely attractive).[16]

[13] Note that this question did not refer to industry employment specifically but was included as part of a question block asking respondents about their current research activities and work environment.
[14] One may be concerned that the low importance of higher pay as a reason for publishing may reflect social desirability bias (Moorman and Podsakoff, 1992). Somewhat mitigating this concern, we find in Section 5 below that respondents rate salary very important as a job attribute in general, and indeed rate it significantly higher than opportunities to gain peer recognition.
[15] The latter result may be counterintuitive; it reflects that individuals who rate higher future pay as the most important function of publishing generally seem to find publishing less important (Function pay has the lowest average rating). They also express a stronger preference for money in general (see Section 5 for this measure), which, as we will show below, implies a lower price of publishing.
[16] While career preferences are likely to predict actual career transitions, not all graduates may be able to find jobs in the sector they most prefer. In particular,

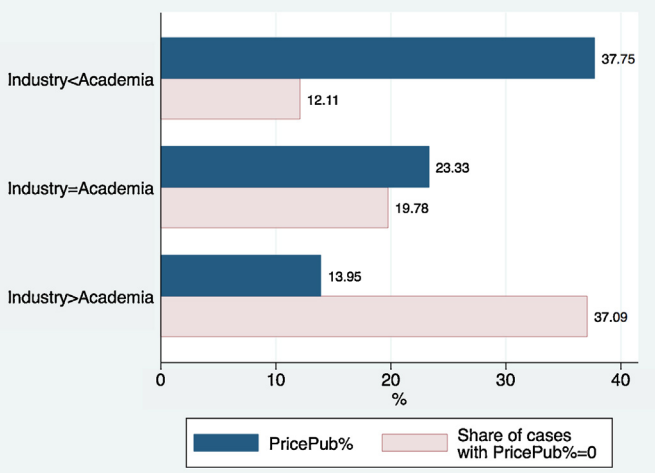

Fig. 2. Average PricePub% and share of respondents with PricePub% = 0 by career preference.

We use these measures to create three dummy variables reflecting the relative attractiveness of the two careers: Industry > Academia (37%), Industry = Academia (28%), and Industry < Academia (35%), respectively. Fig. 2 shows the average PricePub% as well as the share of individuals with a price of 0 for each of the three groups. We observe that scientists who prefer employment in academia assign a relatively high price to publishing opportunities in industry (38% of the base wage), and only a small share of cases has a price of zero. In contrast, the average price of publishing is much lower for those who prefer industry employment (14% of the base wage) and a full 37% of cases value publishing at zero.[17]

Overall, the analyses in this exploratory section revealed significant heterogeneity in both the price of publishing and in the reasons why scientists value publishing. We have also seen that this heterogeneity may have important implications for sorting into industry. Given these results, we now seek to gain a more systematic understanding of potential sources of the observed heterogeneity in the price of publishing. In Section 4, we begin by developing a simple model that relates the price of publishing to a range of individual characteristics such as preferences for indirect payoffs from publishing, preferences for money, as well as researcher ability. In Section 5, we use this model to guide a series of regression analyses.

4. Modeling heterogeneity in the price of publishing

Recall that we define the price of publishing as the additional amount of pay at which a given scientist is indifferent between taking an industrial R&D position that restricts publishing and one that allows it, holding all other job attributes constant. To model potential determinants of the price of publishing, we begin with a basic linear utility function similar to that employed by Stern (2004), which considers publishing itself as an argument. The utility scientist i derives from job j can be written as:

$$U_{ij} = \lambda_{ij} + \alpha_i \gamma_i \mathrm{Pub}_j + \theta_i w_j, \quad (1)$$

where α_i is scientist *i*'s preference for publishing, Pub_j is the permission to publish in job j, γ_i is the scientist's research ability, θ_i is the scientist's preference for pay, and w_j is the wage offered by job w_j. Consistent with prior literature (see Goddeeris, 1988; Hwang et al., 1992; Stern, 2004), a stronger preference for a particular benefit increases the utility derived from a unit of that particular benefit. For example, a scientist with a stronger preference for pay, θ_i, derives a greater utility from an additional unit of money. In line with Stern's (2004) argument, a scientist with higher research ability, γ_i, will produce more and better publications if he is allowed to publish and thus will derive greater utility from the permission to publish. Finally, the term λ_{ij} captures the utility derived by scientist i in job j from job attributes other than pay or publishing.

Reflecting our earlier exploratory findings regarding the reasons for publishing, we now consider more explicitly that publications can serve as the means toward obtaining a range of indirect benefits such as peer recognition or career advancement. Distinguishing these different benefits is important because scientists are likely to differ in their preferences for them, potentially leading to differences in the value they place on publishing. As such, Eq. (2) replaces publishing with a (limited) number of indirect benefits that may result from publishing:

$$U_{ij} = \lambda_{ij} + \gamma_i(\alpha_{1i}\mathit{Recog}_j + \alpha_{2i}\mathrm{Career}_j + \alpha_{3i}\mathrm{Contr}_j + \theta_i \mathrm{Pay}_j) + \theta_i w_j, \quad (2)$$

where Recog_j is the peer recognition expected from producing publications in job j, Career_j are non-pecuniary career benefits expected from publications, Contr_j is the contribution to the advancement of science expected from publications, and Pay_j is the (additional) amount of money a scientist expects to appropriate in the labor market due to having publications.[18] If a job does not permit publishing, these indirect payoffs are zero. The parameters α_1, α_2, and α_3 reflect the scientist's preferences for recognition, career advancement, and contribution to science, respectively. Note that Pay_j is weighted by the same preference for pay as the current wage, i.e., current wage and (discounted) future pay are assumed to be substitutes.

To derive a scientist's price of publishing, we now determine the wage premium, $\mathrm{PricePub}_i$, that is required to equate the utilities from two jobs that differ only with respect to whether or not they allow publishing. Assuming that job 1 does not offer publishing (all indirect payoffs from publishing are zero) and job 2 does offer publishing, $\mathrm{PricePub}_i$ has to satisfy the following equation:

$$\underbrace{\lambda_{i1} + \theta_i(w_1 + \mathrm{PricePub}_i)}_{U_{i1}} = \underbrace{\lambda_{i2} + \gamma_i(\alpha_{1i}\mathrm{Recog}_2 + \alpha_{2i}\mathrm{Career}_2 + \alpha_{3i}\mathrm{Contr}_2 + \theta_i \mathrm{Pay}_2) + \theta_i w_2}_{U_{i2}}. \quad (3)$$

Further assuming that the jobs are the same except for publishing and the wage premium, we set $\lambda_{i1} = \lambda_{i2}$ and $w_1 = w_2$ to obtain:[19]

in many fields of science, the number of PhDs seeking tenure track academic positions far outstrips the number of such positions actually available (Sauermann and Roach, 2012; Stephan, 2012). As such, even some of the individuals expressing strong preferences for academic employment may enter industry or other non-academic careers.

[17] Using a small sample of scientists, Roach and Sauermann (2010) provide earlier evidence of sorting based on publishing preferences by showing a positive correlation between the importance of publishing and the perceived attractiveness of an academic career. However, that study provides no insights into the price scientists assign to publishing opportunities or into potential sources of heterogeneity.

[18] At the time the scientist considers a job offer with the permission to publish, the various indirect payoffs from publishing lie in the future. As such, the terms included in Eq. (2) should be understood as discounted, expected payoffs. For example, Pay_j is the discounted future flow of money the scientist expects to obtain in the labor market due to having publications (see Tuckman and Leahey, 1975; Stuart and Liu, 2010). Similarly, while actual publication output depends on objective ability, expected publication output will depend primarily on the scientist's self-assessment of his own ability. For simplicity, we abstract from differences in discount rates across individuals or across types of benefits.

[19] Our focus is on the pay *differential* required to make the scientist indifferent between two positions that differ only with respect to publishing policies. As such, we do not explicitly model the determinants of the base wage, w_j, which may include a variety of factors such as labor market conditions as well as the scientist's ability

Table 2
Variable descriptions and summary statistics.

Variable	Used in section	Corresponds to in Eq. (4)	Description	Scale	Mean	SD	Min	Max
Dependent variables								
W_Pub	3, 5		Minimum starting compensation to accept job with publishing	Cont.	78.07	21.42	30	200
W_NoPub	3, 5		Minimum starting compensation to accept job without publishing	Cont.	96.37	30.60	30	200
PricePub	3, 5	PricePub	PricePub = W_NoPub − W_Pub	Cont.	18.30	20.61	0	125
PricePub%	3, 5		PricePub% = (PricePub/W_Pub) * 100	Cont.	24.94	28.95	0	200
Independent variables								
Function recognition	3		Importance of functions of publishing: recognition from peers and colleagues	5 pt.	4.02	0.91	1	5
Function job	3		Importance of functions of publishing: getting and keeping a good job	5 pt.	4.26	0.82	1	5
Function contribution	3		Importance of functions of publishing: contribute to advancement of knowledge	5 pt.	4.28	0.75	1	5
Function pay	3		Importance of functions of publishing: higher pay in the future	5 pt.	3.40	1.00	1	5
Industry < academia	3, 5		Attractiveness of career in established firm < attractiveness of career in academia	Dummy	0.35		0	1
Industry = academia	3, 5		Attractiveness of career in established firm = attractiveness of career in academia	Dummy	0.28		0	1
Industry>academia	3, 5		Attractiveness of career in established firm > attractiveness of career in academia	Dummy	0.37		0	1
Imp. recognition	5	α_1	When thinking about ideal job, how important is. . .: recognition from research community	5 pt.	3.51	0.89	1	5
Imp. career	5	α_2	When thinking about ideal job, how important is. . .: opportunities for career advancement	5 pt.	4.26	0.58	1	5
Imp. contribution	5	α_3	When thinking about ideal job, how important is. . .: contributing to society	5 pt.	4.16	0.69	1	5
Imp. pay	5	θ	When thinking about ideal job, how important is. . .: financial income (e.g., salary, bonus)	5 pt.	3.97	0.71	1	5
Imp. recognition high	5	α_1	Imp. recognition > 4	Dummy	0.08		0	1
Imp. career high	5	α_2	Imp. career > 4	Dummy	0.33		0	1
Imp. contribution high	5	α_3	Imp. contribution > 4	Dummy	0.30		0	1
Imp. salary high	5	θ	Imp. salary > 4	Dummy	0.19		0	1
Abilityself	5	γ	Self-assessed ability relative to peers	Cont.	6.54	1.63	0	10
NRC btm	5		PhD program NRC ranked below 50	Dummy	0.26		0	1
NRC top 50	5		PhD program NRC ranked top 50–21	Dummy	0.44		0	1
NRC top 20	5		PhD program NRC ranked top 20	Dummy	0.31		0	1
Control variables								
Life sciences	5		Field of current PhD program: life sciences	Dummy	0.38		0	1
Chemistry	5		Field of current PhD program: chemistry	Dummy	0.11		0	1
Physics	5		Field of current PhD program: physics	Dummy	0.12		0	1
Engineering	5		Field of current PhD program: engineering	Dummy	0.28		0	1
Computer sciences	5		Field of current PhD program: computer sciences	Dummy	0.11		0	1
Job avail. academia	5		Subjective availability of faculty positions in academia	Cont.	40.89	26.00	0	100
Job avail. industry	5		Subjective availability of R&D positions in established firms	Cont.	61.76	23.29	0	100
Male	5		Gender: male	Dummy	0.61		0	1
Age	5		Age	Cont.	28.61	3.02	22	45
US citizen	5		US citizenship status	Dummy	0.70		0	1
Response mode/time	5		Response mode (direct vs. through admin) and round in which response was received	Dummies				

$$\text{PricePub}_i = \gamma_i(\alpha_{1i}\text{Recog}_2 + \alpha_{2i}\text{Career}_2 + \alpha_{3i}\text{Contr}_2 + \theta_i\text{Pay}_2)/\theta_i. \quad (4)$$

Eq. (4) suggests that PricePub will increase with (self-assessed) ability (γ_i) as well as preferences for peer recognition, career advancement, and contribution to science (α_1, α_2, and α_3). This result is intuitive – individuals who expect to generate a higher number of publications or who derive more utility from the indirect benefits resulting from a given publication will require a larger amount of money to offset the utility loss due to publishing restrictions. Less intuitively, Eq. (4) also predicts a *negative* relationship between the preference for pay, θ_i, and PricePub, which reflects two opposing effects of a stronger θ_i. One the one hand, scientists who care strongly about money derive greater utility from the indirect financial benefits that publications can yield in the labor market. On the other hand, scientists with a strong preference for money also derive a greater utility from the wage premium paid to compensate for the lack of publishing and, as such, a smaller wage premium will be sufficient to offset a given amount of utility lost due to publishing restrictions. As per equation 4, the net effect of these two mechanisms will generally be a negative relationship between the preference for pay and the price of publishing (i.e.,

(Stern, 2004). This simplification mirrors our empirical strategy to measure PricePub as the difference between two reservation wages (i.e., individual differences in overall wage expectations are subtracted out).

$\delta PricePub_i/\delta\theta_i < 0$).[20] Note that Eq. (4) also suggests that the price of publishing should be higher in fields where publishing is expected to result in higher levels of indirect benefits, e.g., where publications are more strongly tied to peer recognition (larger $Recog_2$) or career advancement (larger $Career_2$).

Overall, this simple model provides a number of insights. First, it predicts that the price of publishing will be higher for individuals who believe to be of higher ability. Second, the price of publishing will increase with scientists' preferences for nonpecuniary payoffs from publishing, i.e., preferences for recognition, career advancement, or contribution to science. Finally, the price of publishing will decrease with the importance a scientist assigns to money.[21] We now examine these relationships as well as other potential sources of heterogeneity in the price of publishing in a regression framework.

5. The price of publishing in a regression framework

5.1. Variables

Our main dependent variable is the price of publishing (PricePub), the difference between a respondent's reservation wage for the position that does not allow publishing and the position that does. Section 3.2 above provides a detailed discussion of this measure. In the following, we introduce additional variables. Descriptive statistics and correlations are reported in Tables 2 and 3.

5.1.1. Preferences for pay and indirect benefits from publishing

To measure preferences for pay and potential indirect benefits from publishing, we asked respondents: "When thinking about an ideal job, how important is each of the following factors to you?" Respondents rated the items "Financial income (e.g., salary, bonus)", "Contributing to society through my research", "Receiving recognition from the research community", and "Opportunities for career advancement" on scales ranging from 1 (not at all important) to 5 (extremely important). Note that this set of preference measures is different from the measures of the functions of publishing discussed in Section 3. The measures used here capture general preferences for various types of benefits, regardless of publishing, and were included in a part of the survey focusing on job and career choices. As such, these measures correspond closely to the preferences in our theoretical model (Section 4) and, unlike the measures used in Section 3, do not confound different reasons for publishing with the importance assigned to publishing.

For auxiliary analyses, we also use dichotomized measures indicating whether a respondent rated a particular benefit "extremely important" (coded as 1) or not (coded as 0). These measures allow for a more intuitive interpretation of estimates and are also more robust to inter-personal differences in respondents' interpretations of intermediate values of the rating scale. Using the dichotomized measures, Table 4 shows the mean PricePub and PricePub% for respondents with high versus low preferences for the four benefits. As predicted, we find that the price of publishing is significantly higher for those with stronger preferences for recognition and

[20] Individuals with a strong preference for pay may well ask for higher levels of overall wages. However, we are not concerned with wage levels per se but with the amount of money that creates the same utility as the opportunity to publish.

[21] While our model builds on the Stern (2004) model, we make some fundamental changes. In particular, we introduce different indirect payoffs from publishing as well as individual-level heterogeneity in scientists' preferences. In Stern's model, preferences for a science oriented job environment were assumed to be the same for all individuals (see his FN 13) and preferences for pay were absent (i.e., also assumed to be homogenous). These changes allow us to derive the price of publishing at the level of each individual scientist, while Stern focuses on the wages and compensating differentials emerging in labor market equilibrium.

Table 3
Correlations.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	PricePub	1																	
2	W_Pub	0.0593*	1																
3	W_NoPub	0.7153*	0.7401*	1															
4	Imp. recognition	0.2963*	0.1112*	0.2775*	1														
5	Imp. career	0.0193	0.1180*	0.0956*	0.1938*	1													
6	Imp. contribution	0.1222*	0.0167	0.0940*	0.2163*	0.1854*	1												
7	Imp. pay	−0.1394*	0.1260*	−0.0057	0.0517*	0.3845*	−0.0468*	1											
8	Abilityself	0.1253*	0.1264*	0.1729*	0.2610*	0.2326*	0.1004*	0.0983*	1										
9	NRC btm	−0.0823*	−0.1126*	−0.1343*	0.0324	0.0595*	0.0070	0.0538*	0.0568*	1									
10	NRC top 50	0.0268*	−0.0510*	−0.0176	−0.0376	−0.0420*	0.0122	−0.0439	−0.0192	−0.5177*	1								
11	NRC top 20	0.0492*	0.1617*	0.1463*	0.0097	−0.0113	−0.0197	−0.0039	−0.0332	−0.3921*	−0.5841*	1							
12	Industry< academia	0.3200*	−0.0455*	0.1837*	0.2658*	−0.1005*	0.0649*	−0.2239*	0.1005*	−0.0537*	0.0137	0.0362	1						
13	Industry= academia	−0.0233*	0.0332	0.0075	0.0611*	−0.0292*	−0.0168*	0.0192*	0.0047	0.0092	0.0057	−0.0148	−0.4598*	1					
14	Industry> academia	−0.2950*	0.0142	−0.1889*	−0.3200*	0.1267*	−0.0485*	0.2037*	−0.1039*	0.0446	−0.0189	−0.0220	−0.5615*	−0.4767*	1				
15	Life sciences	0.0713*	−0.2981*	−0.1607*	−0.0027	0.0330	0.0555*	−0.0326	0.0620*	0.0709*	0.0919*	−0.1661*	0.1410*	−0.0611*	−0.0826*	1			
16	Chemistry	−0.0978*	−0.0242*	−0.0828*	−0.0348*	0.0460*	0.0066	0.0750*	0.0025	0.0916*	−0.1100*	0.0313*	−0.0991*	−0.0527*	0.1472*	−0.2793*	1		
17	Physics	0.0326*	−0.0905*	−0.0414*	−0.0341*	−0.1003*	−0.1005*	−0.0938*	−0.0692*	0.1161*	−0.0528*	−0.0534*	0.0938*	−0.0333*	−0.0618*	−0.2893*	−0.1328*	1	
18	Engineering	−0.0808*	0.2331*	0.1087*	0.0040*	0.0362*	0.0600*	0.0579*	−0.0135*	−0.1300*	−0.0848*	0.2145*	−0.1254*	0.0463*	0.0810*	−0.4811*	−0.2208*	−0.2287*	1
19	Computer sciences	0.0697*	0.2464*	0.2195*	0.0689*	−0.0447*	−0.0732*	−0.0105	−0.0073	−0.1373*	0.1442*	−0.0248	−0.0364	0.1161*	−0.0721*	−0.2764*	−0.1269*	−0.1314*	−0.2186*

* Significant at 5%.

Table 4
PricePub and PricePub% across categories of independent variables.

Variable	Category	PricePub	PricePub%
Imp. recognition	Low	17.41**	24.05**
	High	29.05	35.70
Imp. career	Low	18.03 n.s.	25.25 n.s.
	High	18.87	24.30
Imp. contribution	Low	16.85**	23.01**
	High	21.73	29.50
Imp. pay	Low	19.62**	27.17**
	High	12.65	15.37
Abilityself	Btm	13.92**	19.00**
	Top 50	17.47	24.37
	Top 20	22.03	28.48
NRC ranking	Btm	15.42**	22.11*
	Top 50	18.93	26.19
	Top 20	19.83	25.55

Note: Test of differences in the price of publishing across categories of preference measures using Wilcoxon–Mann–Whitney test. Joint tests of differences across categories of Abilityself/NRC ranking using OLS with robust standard errors.
* Significant at 5%.
** Significant at 1%.

contribution to society. This result is consistent with the model developed in Section 4, suggesting that stronger preferences for indirect benefits from publishing should increase the utility derived from the opportunity to publish, resulting in a larger price assigned to publishing. Also as predicted, Table 4 shows that the price of publishing is *lower* for those individuals with a strong preference for pay. Recall from Section 4 that individuals with strong preferences for pay place a higher value on future financial benefits resulting from publications but they also place a high value on the wage premium paid in return for publishing restrictions; the net effect is a negative relationship between the preference for pay and the wage premium required to give up publishing.

5.1.2. Self-assessed research ability and PhD program quality

Our model suggests that PhDs' assessment of their own ability should drive the price they assign to publishing when considering job options. To measure self-assessed ability, we asked respondents: "How would you rate your research ability relative to your peers in your specific field of study?" (Abilityself). The slider scale ranged from 0 (least skilled, lowest percentile) to 10 (most skilled, highest percentile). The average of Abilityself (6.54) is somewhat higher than the mean of the scale (5), which could reflect higher objective ability in our sample of students at tier 1 research institutions but may also reflect overconfidence. Even if Abilityself partly reflects overconfidence, however, we expect it to increase the price of publishing (see Larkin et al., 2012). Table 3 shows a positive and significant correlation between PricePub and self-assessed ability ($r = 0.13$, $p < 0.01$). In Table 4, we trichotomize this measure and report the mean price of publishing for each category. As predicted, we find that PricePub is significantly higher for individuals who believe themselves to be at the top of the ability distribution.

We supplement self-assessed ability with an objective measure of the quality of respondents' PhD program, using the rankings published by the National Research Council (2010). More specifically, we use the 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.[22] Using this measure, we classified programs into three broad categories: NRC top 20 (ranking in the top 20), NRC top 50 (ranking between 21 and 50) and NRC btm (ranking below 50). Abilityself and the NRC ranking provide complementary insights. In particular, it is likely that PhDs focus on a local reference group when making self-assessments (see Greenberg et al., 2007) such that Abilityself may reflect primarily perceived ability differences within a given PhD program or within a smaller set of peer universities. In contrast, the NRC ranking focuses on quality differences across the whole range of programs and likely proxies for a broader set of factors such as research activity, the quality of research training as well as other department characteristics such as resources. The NRC ranking is a particularly interesting complement to self-assessed ability because program quality can be an important factor in the job market and research intensive firms often have a strong interest in hiring PhDs graduating from top programs (Stephan et al., 2005). Table 4 shows that the price of publishing increases with program quality, with particularly large differences between respondents in programs in the top 50 or top 20 versus those in programs ranked below 50.

5.1.3. Control variables

Since perceived labor market conditions may shape wage expectations, we asked respondents "What do you think is the probability that a PhD in your field can find the following positions after graduation (and any potential Post-docs)?" Respondents indicated subjective probabilities for "University faculty with an emphasis on research or development" and "Job in an established firm with an emphasis on research or development", respectively. We also control for respondents' field of study as well as demographic characteristics including age, gender, and U.S. citizenship status. Finally, we include a set of dummy variables indicating whether a survey response was elicited indirectly via a departmental administrator or, alternatively, after which of the four direct survey contacts a response was received (see Section 3.1).

5.2. Main regression results

Our featured regressions use the price of publishing (PricePub) as the dependent variable and are estimated using OLS (Table 5). We allow for heteroskedasticity and intraclass correlations by clustering standard errors at the level of the university. Supplementary analyses using PricePub% and different estimation techniques are presented in Section 5.4.

Model 1 includes control variables and the measures of preferences. Consistent with the descriptive results in Table 4, we find that the importance of recognition and of contribution to society have positive relationships with the price of publishing. However, we find no effect of the preference for career advancement. Using the model developed in Section 4 as our guide, a potential interpretation of these results is that in the context of industrial R&D, publications are seen primarily as a mechanism to gain peer recognition and to contribute to the stock of public knowledge, but not as an important mechanism to advance in one's career. Reinforcing our finding in Table 4, model 1 shows a strong negative relationship between the preference for pay and the price assigned to publishing. This result is consistent with the notion that strong preferences for pay increase the utility an individual derives from a compensating wage premium, thus reducing the amount of money required to offset the lack of publishing opportunities.[23]

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

[23] The negative coefficient of the preference for pay does not imply that financial benefits from having publications are absent. Such benefits may well be present, and individuals with a stronger preference for pay will derive a higher utility from such benefits. However, as shown in Section 4, preferences for pay also increase the

Table 5
Price assigned to publishing opportunities in industry.

	1 OLS PricePub	2 OLS PricePub	3 OLS PricePub	4 OLS PricePub	5 OLS PricePub	6 OLS PricePub	7 OLS PricePub
Imp. recognition	6.432**		6.076**		4.242**		
	[0.511]		[0.514]		[0.458]		
Imp. career	0.714		0.477		1.374+		
	[0.790]		[0.764]		[0.773]		
Imp. contribution	1.755*		1.774*		1.752*		
	[0.694]		[0.690]		[0.691]		
Imp. pay	−4.248**		−4.163**		−2.806**		
	[0.614]		[0.588]		[0.568]		
Abilityself		1.494**	0.805**		0.587**	1.355**	0.910**
		[0.214]	[0.223]		[0.211]	[0.229]	[0.222]
NRC top 50		3.674**	3.619**		2.987**	3.405**	2.743**
		[1.063]	[0.998]		[0.980]	[1.044]	[0.981]
NRC top 20		6.713**	6.056**		4.870**	6.643**	5.018**
		[1.266]	[1.143]		[1.086]	[1.211]	[1.085]
Industry = academia				−9.761**	−7.339**		−8.222**
				[1.225]	[1.221]		[1.272]
Industry > academia				−15.921**	−11.230**		−13.677**
				[1.154]	[1.207]		[1.238]
Imp. recognition high						9.200**	5.344**
						[1.982]	[1.834]
Imp. career high						0.992	2.474*
						[0.931]	[0.999]
Imp. contribution high						3.874**	3.110*
						[1.256]	[1.252]
Imp. pay high						−7.743**	−5.140**
						[0.824]	[0.917]
Chemistry	−6.203**	−7.310**	−6.034**	−3.922**	−3.919**	−6.394**	−3.582**
	[1.302]	[1.088]	[1.113]	[1.273]	[1.122]	[1.115]	[1.141]
Physics	−0.201	0.588	0.574	−0.848	0.436	1.337	0.838
	[1.797]	[1.790]	[1.679]	[1.808]	[1.668]	[1.781]	[1.717]
Engineering	−4.288**	−5.392**	−5.020**	−2.271*	−3.225**	−4.955**	−2.779**
	[1.031]	[0.942]	[0.868]	[1.091]	[0.886]	[0.922]	[0.904]
Computer sciences	0.562	0.126	0.038	1.868	1.437	0.344	1.767
	[1.972]	[2.047]	[1.827]	[2.193]	[1.857]	[2.017]	[2.016]
Job avail. academia	−0.004	0.008	0.001	0.001	−0.002	0.006	0.001
	[0.018]	[0.019]	[0.019]	[0.018]	[0.019]	[0.019]	[0.019]
Job avail. industry	0.005	−0.004	−0.005	0.017	0.001	−0.012	−0.003
	[0.021]	[0.022]	[0.021]	[0.022]	[0.021]	[0.021]	[0.021]
Male	1.051	−0.013	0.710	−0.265	0.176	0.585	−0.040
	[0.941]	[1.030]	[0.981]	[1.052]	[1.059]	[1.027]	[1.075]
Age	0.135	0.270+	0.223	0.073	0.158	0.252+	0.167
	[0.151]	[0.155]	[0.143]	[0.152]	[0.139]	[0.146]	[0.139]
US citizen	−0.233	−2.991*	−0.480	−2.741*	−0.916	−2.381	−2.212+
	[1.435]	[1.337]	[1.404]	[1.218]	[1.307]	[1.442]	[1.311]
Response mode/time	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.
Constant	−2.366	−1.435	−10.782*	24.627**	−3.48	−0.749	11.765*
	[5.373]	[4.703]	[5.099]	[4.733]	[4.649]	[4.575]	[4.587]
Observations	1927	1927	1927	1927	1927	1927	1927
R-squared	0.134	0.060	0.148	0.137	0.190	0.102	0.169
df	17	16	20	15	22	20	22

Note: OLS, standard errors clustered at the level of the university in brackets.
Omitted categories: NRC btm, industry < academia, life sciences.
+ Significant at 10%.
* Significant at 5%.
** Significant at 1%.

Model 2 shows that the price of publishing increases with scientists' self-assessed ability and with the quality of the PhD program. More concretely, a one-point increase in Abilityself (e.g., from top 30% to top 20% in the subjective ability distribution) increases the price of publishing by roughly $1500. Individuals in a top-20 program have a roughly $6700 higher price of publishing than those in a program ranked below 50.[24]

Model 4 examines whether the price of publishing is related to career preferences. Consistent with Fig. 2 (Section 3.3), we find that individuals who prefer industry employment assign a significantly lower price to publishing in firms than those who prefer

utility derived from a compensating wage premium paid in return for publishing restrictions, with a negative net effect on the price of publishing.

[24] In addition to a larger wage premium to forego publishing, high ability individuals may also require higher base wages; we will examine this possibility in Section 5.3.

a career in academia. This result may reflect that individuals with strong preferences for money and weak preferences for publishing seek to self-select into industrial R&D, which tends to offer higher pay but also offers less openness (see Roach and Sauermann, 2010; Agarwal and Ohyama, 2013). At the same time, this finding may reflect that individuals who want to work in academia assign a higher value to publishing in firms because publications might give them the option to return to academia.[25] Either way, the key insight is that those individuals who are most likely to seek industrial R&D positions tend to have the lowest price of publishing.

Model 5 includes all measures jointly. The coefficients of the ability measures remain highly significant but are somewhat smaller than in the baseline, largely reflecting that ability is correlated with career preferences, i.e., individuals with higher Abilityself and those in top ranked programs are more likely to express strong preferences for an academic career path. We also find that the preference for career advancement is now marginally significant and positive.

In models 6 and 7, we use the dichotomized measures of preferences instead of the original ratings. The qualitative results are unchanged, except that the preference for career advancement now also has a significant positive coefficient. More specifically, respondents who find career advancement extremely important have a $2474 higher price of publishing than those who do not.

Table 5 also shows interesting field differences in the price of publishing. In particular, we find that the price of publishing is significantly higher in the life sciences (omitted category) than in chemistry and engineering.[26] These field differences may reflect otherwise unobserved differences in the indirect payoffs respondents expect from publishing, i.e., that publications are more important as a mechanism to disclose research results or as a measure of scientists' performance in some fields than in others (see our discussion of Eq. (4) in Section 4). While we can only speculate at this point, one potential driver of such field differences is that more "applied" fields such as engineering or chemistry may rely not only on publications but also on patents or even physical artifacts to disclose or embody research results (Allen, 1977; Sauermann and Stephan, 2013). Similarly, this finding may reflect that labor markets are more competitive in the life sciences than in other fields, increasing the importance of establishing a publication record as an indicator of research ability (see Freeman et al., 2001; Stephan, 2012).[27]

5.3. Reservation wages

Recall that PricePub is the difference between W_NoPub and W_Pub. To examine how independent variables affect the price of publishing via the former versus the latter, we now analyze the two reservation wages separately. We estimate these models using multivariate regression, i.e., two OLS regressions are estimated simultaneously and the error terms are allowed to have nonzero correlations (Table 6).

Model 1 includes the preferences for money and indirect benefits from publishing. The preference for career advancement has a positive relationship with both wages. While the coefficient is somewhat larger in the regression of W_NoPub, the difference is not statistically significant, consistent with the observation that the preference for career advancement had only a marginally significant effect on PricePub in Table 5. In contrast, the coefficient of the preference for recognition is much larger in the regression of W_NoPub than in the regression of W_Pub ($F(1,1909) = 140.64$, $p < 0.01$), consistent with a large positive coefficient in our featured regressions of PricePub. The preference for pay has a positive relationship with W_Pub, suggesting that individuals who care strongly about money generally ask for higher base levels of salary. However, the preference for pay has a negative relationship with W_NoPub, which likely reflects two offsetting effects: individuals with a strong preference for pay generally desire higher salaries but also require a smaller wage premium to offset the lack of publishing since a stronger preference for pay increases the utility gained from a given wage premium.

Model 2 shows that PhDs with higher self-assessed ability and those from top tier programs expect higher levels of wages regardless of the publishing regime. However, the coefficients are larger in the regressions of W_NoPub than of W_Pub ($F(3,1910) = 17.39$, $p < 0.01$). As a result, the reservation wage for the job without publishing increases faster with ability/program quality than the reservation wage for the job with publishing, resulting in a positive net effect of these measures on the price of publishing. Thus, high ability scientists are likely to be generally more "expensive" to hire than lower ability scientists, even if they are allowed to publish, and this premium is further amplified in jobs that do not allow publishing. Finally, model 3 also includes the measures of career preferences. Individuals who prefer academia to industry ask for similar wages when publishing is allowed[28] but ask for significantly higher wages when publishing is restricted.

5.4. Supplementary analyses and robustness checks

Table 7 reports a series of supplementary analyses and robustness checks. In models 1 and 2, we use PricePub% (the price of publishing as a percentage of W_Pub) rather than the absolute PricePub measure. The results regarding the measures of preferences are very similar to the featured regressions. Abilityself and PhD program quality also continue to have significant positive coefficients. However, these coefficients are somewhat weaker than in the baseline models. This observation likely reflects that high ability individuals generally ask for higher wages (see Section 5.3) and that a given absolute PricePub represents a smaller share of the base wage for them. Interestingly, the PricePub% regressions also show a negative coefficient for computer scientists, i.e., their price of publishing is lower than that of life scientists in relative terms but not in absolute terms (we saw no effect in Table 5), likely due to significantly higher overall wage expectations among computer scientists (see Table 6).

[25] In the words of one of our respondents: "Publishing could be seen as a form of compensation. If I ever wanted to leave that company, I would have a publication record as proof of my accomplishments if I wanted to start at another company, or attempt to get back into academia."

[26] Our results are based on a PhD sample and do not necessarily generalize to scientists or engineers across all degree types. Pursuing a PhD is more common among life scientists than among engineers (National Science Board, 2012), suggesting that the engineers in our sample may be more selected with respect to ability or academic orientation than the life scientists. As such, the differences in the price of publishing may be even larger between the "average" life scientist and the "average" engineer. While field differences are not the focus of this paper, our results complement prior work on differences in the motives and innovative activities of scientists versus engineers (Ritti, 1968; Allen, 1977; Gruber et al., 2013).

[27] In unreported analyses, we explored whether there are field differences in the relationships between PricePub and featured independent variables by estimating key regressions separately for our largest fields, the life sciences and engineering. The results are similar to those using the pooled sample and we find no significant differences across fields.

[28] One might expect that individuals who prefer academic employment ask for higher wages to work in a sector that they find less desirable (industry). While our regressions suggest that individuals with a preference for academia do not ask for higher pay in industrial R&D compared to those aspiring to industry employment, they do ask for more pay than what they are likely to receive when employed in academia since salaries are generally lower in academia than in industry (Agarwal and Ohyama, 2013; Sauermann and Stephan, 2013).

Table 6
Reservation wages.

	1		2		3	
	a W_Pub	b W_NoPub	a W_Pub	b W_NoPub	a W_Pub	b W_NoPub
Imp. recognition	1.683**	8.115**			1.187*	5.429**
	[0.541]	[0.792]			[0.580]	[0.834]
Imp. career	2.810**	3.524**			2.236*	3.611**
	[0.859]	[1.256]			[0.868]	[1.247]
Imp. contribution	−0.004	1.750+			0.018	1.770+
	[0.680]	[0.995]			[0.675]	[0.969]
Imp. pay	2.185**	−2.063*			2.196**	−0.610
	[0.679]	[0.992]			[0.687]	[0.987]
Abilityself			1.627**	3.121**	1.249**	1.836**
			[0.277]	[0.410]	[0.287]	[0.413]
NRC top 50			0.601	4.276*	1.012	3.999*
			[1.124]	[1.666]	[1.119]	[1.608]
NRC top 20			5.227**	11.940**	5.470**	10.340**
			[1.230]	[1.823]	[1.229]	[1.766]
Industry = academia					−0.874	−8.213**
					[1.144]	[1.644]
Industry > academia					0.321	−10.908**
					[1.173]	[1.686]
Chemistry	5.193**	−1.011	5.344**	−1.966	4.916**	0.997
	[1.517]	[2.218]	[1.523]	[2.259]	[1.533]	[2.203]
Physics	2.228	2.027	2.149	2.737	2.869+	3.305
	[1.517]	[2.219]	[1.519]	[2.253]	[1.515]	[2.178]
Engineering	12.971**	8.683**	12.466**	7.075**	12.279**	9.055**
	[1.234]	[1.804]	[1.261]	[1.870]	[1.268]	[1.822]
Computer sciences	19.376**	19.938**	19.378**	19.504**	19.627**	21.064**
	[1.632]	[2.387]	[1.646]	[2.441]	[1.648]	[2.368]
Job avail. academia	−0.017	−0.021	−0.008	0.000	−0.014	−0.015
	[0.018]	[0.026]	[0.018]	[0.027]	[0.018]	[0.026]
Job avail. industry	0.117**	0.122**	0.109**	0.105**	0.106**	0.107**
	[0.021]	[0.031]	[0.021]	[0.031]	[0.021]	[0.030]
Male	3.346**	4.397**	2.607**	2.594+	2.810**	2.985*
	[0.976]	[1.427]	[0.976]	[1.447]	[0.976]	[1.402]
Age	0.135	0.269	0.210	0.481*	0.238	0.396+
	[0.151]	[0.221]	[0.151]	[0.224]	[0.151]	[0.216]
US citizen	−1.046	−1.280	−1.950+	−4.941**	−1.192	−2.107
	[1.057]	[1.546]	[1.024]	[1.519]	[1.061]	[1.525]
Response mode/time	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.
Constant	34.228**	31.862**	47.341**	45.906**	26.371**	22.891*
	[6.470]	[9.461]	[5.371]	[7.964]	[6.656]	[9.564]
Observations	1927	1927	1927	1927	1927	1927
R-squared	0.201	0.163	0.204	0.142	0.219	0.21
Parameters	18		17		23	
Correlation residuals	0.73		0.71		0.73	

Note: Columns "a" regress the reservation wage for the job with publishing and columns "b" regress the reservation wage for the job without publishing. All models are estimated using multivariate regression. Standard errors in brackets.
Omitted categories: NRC btm, industry < academia, life sciences.
+ Significant at 10%
* Significant at 5%.
** Significant at 1%.

In models 3 and 4, we use quasi-maximum likelihood Poisson as an alternative estimation technique, which is consistent for integer and continuous non-negative outcomes, so long as the conditional mean is correctly specified (Santos Silva and Tenreyro, 2006). The results are robust.

Our featured regressions showed that the price of publishing differs significantly between those who prefer a research career in industry and those who prefer a research career in academia. In Models 5–10, we examine whether there are also differences in the relationships between the price of publishing and independent variables by estimating models separately for those who prefer a career in academia and those who prefer a career in industry or are indifferent. We find that the preference for pay has a somewhat smaller negative effect among those aspiring to a career in industry, perhaps indicating that these individuals expect higher financial payoffs from publishing in industry. The measures of ability and program quality have a positive association with the price of publishing in both samples but the coefficients tend to be larger among those who prefer academic employment. However, none of these differences in coefficients between subsamples are statistically significant.[29]

[29] Not all respondents will eventually work in industrial or academic research, and individuals who seek to enter other careers – such as in consulting, teaching, or government research – may have a particularly low price of publishing in firms. In a robustness check, we restricted the sample to those individuals who rated research in industry or academia among their most attractive careers, dropping 21.7% of cases who found some other career more attractive. Dropping these cases leads to only small changes in the overall distribution of PricePub, which now has a mean of $19.1k, with 21.7% of individuals stating a PricePub of zero (compared to $18.3k and

Table 7
Supplementary analyses.

	Full sample				Industry < academia			Industry ≥ academia		
	1 OLS PricePub%	2 OLS PricePub%	3 Poisson PricePub	4 Poisson PricePub	5 OLS PricePub	6 OLS PricePub	7 OLS PricePub	8 OLS PricePub	9 OLS PricePub	10 OLS PricePub
Imp. recognition	7.612**	5.052**	0.399**	0.285**	6.243**		5.391**	4.482**		4.485**
	[0.663]	[0.575]	[0.033]	[0.030]	[1.136]		[1.300]	[0.529]		[0.549]
Imp. career	−0.377	0.877	−0.002	0.053	2.064		1.999	0.573		0.486
	[1.191]	[1.173]	[0.044]	[0.046]	[1.927]		[1.808]	[0.676]		[0.655]
Imp. contribution	2.368*	2.337*	0.113**	0.110**	1.884		1.778	1.621**		1.684**
	[0.922]	[0.907]	[0.043]	[0.041]	[1.635]		[1.535]	[0.488]		[0.494]
Imp. pay	−6.414**	−4.522**	−0.211**	−0.148**	−4.672**		−4.572**	−2.132**		−2.137**
	[0.824]	[0.796]	[0.028]	[0.028]	[1.440]		[1.383]	[0.441]		[0.433]
Abilityself	0.769*	0.464	0.042**	0.031*		2.040**	1.416*		0.660**	0.189
	[0.315]	[0.293]	[0.013]	[0.013]		[0.598]	[0.622]		[0.206]	[0.202]
NRC top 50	4.910**	4.030*	0.200**	0.162**		5.260+	4.749+		1.661	2.243*
	[1.798]	[1.776]	[0.063]	[0.062]		[2.608]	[2.697]		[1.077]	[0.964]
NRC top 20	7.223**	5.569**	0.324**	0.255**		7.710*	6.780*		3.532**	4.002**
	[1.934]	[1.840]	[0.070]	[0.066]		[2.908]	[3.037]		[1.204]	[1.097]
Industry = academia		−10.184**		−0.304**						
		[1.642]		[0.053]						
Industry > academia		−15.669**		−0.632**						
		[1.528]		[0.061]						
Chemistry	−10.219**	−7.265**	−0.360**	−0.244**	−5.383	−4.922	−5.059	−4.266**	−4.389**	−4.291**
	[1.483]	[1.477]	[0.081]	[0.077]	[3.532]	[3.542]	[3.376]	[1.266]	[1.347]	[1.216]
Physics	−0.449	−0.640	0.043	0.029	−1.536	−1.078	−0.822	0.471	0.697	1.036
	[2.550]	[2.560]	[0.084]	[0.083]	[3.251]	[2.738]	[3.032]	[2.023]	[2.214]	[2.000]
Engineering	−10.527**	−8.026**	−0.255**	−0.162**	−3.359	−5.237*	−4.209+	−2.360+	−2.204	−3.079*
	[1.347]	[1.356]	[0.049]	[0.049]	[2.647]	[2.475]	[2.481]	[1.242]	[1.394]	[1.364]
Computer sciences	−6.345**	−4.401+	−0.002	0.068	6.878	5.132	6.076	0.060	0.523	−0.543
	[2.267]	[2.240]	[0.087]	[0.089]	[4.485]	[4.422]	[4.399]	[1.786]	[2.112]	[1.816]
Job avail. academia	0.016	0.012	0.000	0.000	0.007	0.003	0.008	−0.011	0.003	−0.005
	[0.026]	[0.026]	[0.001]	[0.001]	[0.041]	[0.044]	[0.044]	[0.018]	[0.018]	[0.018]
Job avail. industry	−0.056+	−0.047	0.000	0.000	−0.042	−0.037	−0.052	0.038	0.033	0.031
	[0.033]	[0.033]	[0.001]	[0.001]	[0.044]	[0.041]	[0.043]	[0.026]	[0.026]	[0.025]
Male	−0.891	−1.636	0.028	0.003	−1.064	−2.590	−1.695	1.284	0.532	1.256
	[1.213]	[1.311]	[0.054]	[0.057]	[1.888]	[2.002]	[1.957]	[1.112]	[1.127]	[1.147]
Age	0.316	0.225	0.012+	0.008	−0.144	−0.043	−0.016	0.248+	0.336*	0.290+
	[0.213]	[0.200]	[0.007]	[0.007]	[0.343]	[0.329]	[0.329]	[0.142]	[0.154]	[0.145]
US citizen	−1.078	−1.682	−0.013	−0.039	−0.166	−2.403	−0.538	−1.279	−3.503**	−1.569
	[1.703]	[1.591]	[0.073]	[0.068]	[2.753]	[2.299]	[2.713]	[1.067]	[1.218]	[1.100]
Response mode/time	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.
Constant	3.04	13.215+	0.956**	1.384**	8.121	12.46	−4.952	−10.739*	−2.889	−14.394*
	[7.801]	[7.154]	[0.270]	[0.248]	[11.864]	[10.176]	[10.467]	[5.179]	[5.084]	[5.394]
Observations	1927	1927	1927	1927	677	677	677	1250	1250	1250
R-squared	0.145	0.187			0.076	0.052	0.091	0.12	0.049	0.128
df	20	22	20	22	17	16	20	17	16	20

Note: Clustered standard errors in brackets.
Omitted categories: NRC btm, industry < academia, life sciences.
+ Significant at 10%
* Significant at 5%
** Significant at 1%.

Although not presented in Table 7, we also considered the possibility that respondents may associate different publishing policies with differences in other job attributes, such as intellectual freedom or the nature of R&D, even though the reservation wage question stated that the positions differ only with respect to opportunities to publish. Our analysis of open-ended responses suggests that only a very small number of individuals associated publishing with other job attributes, and excluding these individuals from the analysis does not change our results. However, this approach is clearly limited and we cannot rule out that some respondents associated other "open science" characteristics with jobs that permit publishing. To the extent that this is the case, PricePub should be interpreted as the price assigned not just to publishing but to an open science atmosphere in a more general sense (see Stern, 2004).

6. Discussion

We draw on survey data from over 1900 science and engineering PhD candidates to examine the price they assign to publishing opportunities in industrial R&D. We find significant heterogeneity across individuals; while over 20% of PhDs are willing to give up publishing "for free", others would require a considerable wage premium to forego publishing opportunities. When asked why they valued publishing, scientists expressed a range of different reasons, suggesting that it is useful to conceptualize publishing as a means toward different ends. In an effort to understand which scientists place a higher value on publishing than others, we find that the price of publishing increases with scientists' preferences

23.5% for the full sample). Regression models using this smaller sample show very similar relationships as our featured models (available upon request).

for indirect benefits from publishing such as peer recognition or contributing to the advance of science, but it decreases with their preference for money. The price of publishing is higher for individuals who believe they have high research ability, and for those training at top tier departments, likely reflecting that these individuals expect to produce more publications if allowed to publish. However, even if allowed to publish, high ability scientists demand higher wages than those of lower ability. Finally, scientists may sort systematically based on their price of publishing; those scientists who assign the lowest value to publishing in firms are most likely to seek positions in industrial R&D.

Our results should be seen in light of important limitations. First, we elicited the price of publishing by asking respondents to state reservation wages for hypothetical positions with different job attributes. Although similar hypothetical scenarios have been used in economics and the career choice literature (see Cable and Judge, 1994; Slaughter et al., 2006; Blumenschein et al., 2008), a potential concern is that stated reservation wages may not be reliable indicators of the amount of money scientists would require in a realistic salary negotiation. Somewhat mitigating this concern, we showed in Section 3.2 that the stated reservation wages are close to actual starting salaries of science and engineering PhDs in industry. A related concern is that scientists may place a different value on publishing in our study than they would when choosing among real jobs. While we have no comparison data from real settings (the price of publishing is typically unobserved at the individual level), we do not expect a systematic bias due to the hypothetical nature of our question. More importantly, since our primary interest is in the distribution of the price of publishing and in potential sources of individual differences, potential biases that influence all respondents in similar ways should not affect our key results.

Second, a concern with measures drawn from the same survey instrument is that relationships between variables may be spurious due to common methods bias (Podsakoff et al., 2003). To mitigate common methods bias, we used different question formats including rating scales, slider scales, as well as open-ended questions. We also placed questions regarding dependent and independent variables on different pages of the survey questionnaire and separated them by unrelated questions. Moreover, our key dependent variable (PricePub) is a first difference and any common methods bias inherent in the reservation wage measures should be subtracted out. Common methods bias is not a concern regarding the NRC ranking since this measure was obtained from an independent data source.

Finally, our results are based on cross-sectional data and should be interpreted as correlational rather than causal in nature. In particular, while the results are consistent with a model in which ability and preferences for various indirect payoffs from publishing drive the price of publishing, they do not formally establish the direction of causality. Even if interpreted as descriptive and correlational in nature, however, our results have important implications, to which we now turn.

Our finding of a wide dispersion of the price of publishing across individuals suggests that the "representative" scientist implicit in much of the prior literature is not necessarily a good representation of most contemporary scientists (see also Shapin, 2008). As such, additional research is needed to understand the nature and sources of individual differences in scientists' preferences, not just as they relate to publishing but to other kinds of job attributes and incentives as well. Moreover, our insights into the distribution of the price of publishing provide a useful basis for future work seeking to understand more clearly how scientists with heterogeneous preferences sort into different employment sectors, and, within a given sector, match with employers offering different bundles of job attributes (see Killingsworth, 1987). For example, our results suggest that firms seeking to restrict publishing may be able to avoid paying a wage premium if they hire those scientists who assign little or no value to the opportunity to publish (low end of the distribution in Figure 1). However, our results also suggest that these scientists are unlikely to be among the highest ability researchers, potentially offsetting higher value appropriation via limited disclosure with lower value creation.[30]

Our finding that many scientists care little about publishing suggests that the use of open science policies in industry may not necessarily reflect firms' attempts to accommodate the desires of potential employees. Rather, firms may also adopt such policies to realize various knowledge-related productivity benefits that can result from an interaction with the broader scientific community (Cockburn and Henderson, 1998; Stern, 2004). Our results suggests that firms who seek to gain such productivity advantages can benefit from trying to attract specifically those scientists who place a high value on openness (high end of the distribution in Fig. 1) since these scientists are likely to engage more actively with the scientific community and may also be of higher ability. One way to attract high ability scientists with strong preferences for publishing is to not just allow publishing but to provide explicit publishing incentives. Consistent with this idea, some science-based firms explicitly tie publication output to financial or promotion-related rewards (Cockburn and Henderson, 1998; Stern, 2004; Stuart and Liu, 2010). Such publishing incentives can serve a sorting function but may also motivate employees to exert high research effort and to actually publish their results (Lazear, 2000). Moreover, recent work by Lacetera and Zirulia (2012) suggests that incentives for publishing may be particularly effective if scientists have strong "intrinsic" preferences for publishing because preferences and incentives can act as complements.

There may also be important implications of our finding that scientists value publishing for different reasons. For example, if a scientist "pays" for publishing because she truly values open knowledge disclosure and contributing to the advancement of science, an employer pursuing an open science strategy may indeed be able to enjoy the benefits of lower labor costs in the long term. In contrast, if the scientist accepts a wage discount in return for publishing because she expects that publications lead to higher pay in the future, she will seek to recoup that investment at later points. In the words of one of our respondents, "Publishing allows you to publicly document your research success. This is GREAT for resume building and can be used as leverage for salary negotiations". Relatedly, understanding reasons for publishing may also inform managers regarding what kinds of benefits scientists would most readily accept to compensate for publishing restrictions. For example, a scientist who values publishing primarily as a means to advance his career may readily forego publishing if the employer offers attractive internal career opportunities or provides opportunities to build general human capital. In contrast, a scientist who values publishing because he has a strong desire to contribute to the stock of public knowledge may not see career related benefits as suitable substitutes. Thinking beyond the context of industrial R&D, our insights into PhDs' reasons for publishing may also be useful in understanding the scientific community's recent efforts to foster open access publishing initiatives (Leptin, 2012).[31] Similarly,

[30] Not all firms seek to hire "star" researchers – some primarily need employees with a solid science background and a broader range of research and non-research skills that meet the needs of a commercial R&D lab (Murray and Hsi, 2007).

[31] There may be interesting parallels between the price of publishing examined in this study and the publication fees many scientists are willing to pay to have their articles appear in open-access journals rather than traditional journals with pay walls.

the open ended responses showing that some scientists express a strong adherence to the norm of openness and a resistance to the commercialization of scientific knowledge also provide support for Gans and Stern (2010), who suggest such attitudes as a potential impediment to the development of commercial markets for ideas.

Although our study focuses on industry employment where choices between publishing and pay are most salient, similar choices may be important in academia as well. For example, academic scientists' increasing attention toward the commercialization of research outcomes has raised concerns over publication delays and the incomplete disclosure of research results (Blumenthal, 2003; Slaughter and Rhoades, 2004; Rothaermel et al., 2007). Our findings regarding individual differences in the price of publishing as well as differences in the reasons for publishing may provide a useful starting point for future research on the trade-offs researchers are willing to make between disclosure and financial returns in the particular context of academic science.

Finally, this study also speaks to a broader literature on compensating differentials and the trade-offs employees make between pay and non-pecuniary job characteristics such as social responsibility (Goddeeris, 1988; Auger et al., 2011), job location (Campbell et al., 2012), or autonomy on the job (Aghion et al., 2008; Lacetera, 2009). First, our results highlight the need to consider not only employees' preferences for non-pecuniary job attributes but also those for money. For example, relatively large observed wage discounts in "socially responsible" firms may not only reflect that certain employees care strongly about social responsibility, but also that they care little about money. Second, it seems important to gain a deeper understanding of the reasons why individuals value certain nonpecuniary job attributes. For example, Aghion et al.'s (2008) model focuses on scientists' desire for freedom as such and posits that organizations that restrict freedom have to pay higher wages. We suspect that some individuals may derive utility from freedom itself (Deci and Ryan, 1985), while others may value freedom for its indirect benefits, e.g., because it allows them to work on problems that they find interesting 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 employers have to pay to limit researcher freedom and how researchers use the freedom they are given.

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