NBER WORKING PAPER SERIES

DO SCIENTISTS PAY TO BE SCIENTISTS?

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Working Paper 7410
http://www.nber.org/papers/w7410

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
October 1999

I would like to thank those biologists and postdoctoral administrators who participated in the survey for their time and thoughtfulness. By prior consent, names of specific institutions are withheld from the final analysis. John Abowd, Joshua Gans, Rebecca Henderson, Richard Nelson, Lynne Zucker, Eric von Hippel, as well as seminar participants at the NBER Summer Institute, the MIT IO Lunch, and the Sloan/Harvard Management of Technology seminar provided useful suggestions. Kwanghui Lim, in conjunction with undergraduate research assistants Amalia Miller, Vanessa Bhark, Allison Neizmik, and Sarah Huber, provided extraordinary research assistance. This research was completed while a Health and Aging Fellow at the National Bureau of Economic Research, whose hospitality is gratefully acknowledged. All errors and omissions are my own. The views expressed herein are those of the authors and not necessarily those of the National Bureau of Economic Research.

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JEL No. J32, J44, L76, O31, O32

ABSTRACT

This paper evaluates the relationship between wages and the scientific orientation of R&D organizations. Science-oriented firms allow researchers to publish in the scientific literature and pursue individual research agendas. Adoption of a Science-oriented research approach (i.e., Science) is driven by two distinct forces: a "taste" for Science on the part of researchers (a Preference effect) and R&D productivity gains arising from earlier access to discoveries (a Productivity effect). The equilibrium relationship between wages and Science reflects the relative salience of these effects: the Preference effect contributes to a negative compensating differential while the Productivity effect raises the possibility of rent-sharing between firms and researchers. In addition, because the value of participating in Science is increasing in the prestige of researchers, Science tends to be adopted by those firms who employ higher-quality researchers. This structural relationship between the adoption of Science and unobserved heterogeneity in researcher ability leads to bias in the context of hedonic wage and productivity regressions which do not account for such effects. This paper exploits a novel field-based empirical approach to substantially overcome this bias. Specifically, prior to accepting a specific job offer, many scientists receive *multiple job offers*, making it possible to calculate the wage-Science curve for individual scientists, controlling for ability level. The methodology is applied to a sample of postdoctoral biologists. The results suggest a strong negative relationship between wages and Science. For example, firms who allow their employees to publish extract, on average, a 25% wage discount. The results are robust to restricting the sample to non-academic job offers, but the findings depend critically on the inclusion of the researcher fixed effects. The paper's conclusion, then, is that, conditional on scientific ability, scientists do indeed *pay* to be scientists.

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I. Introduction

Since the seminal work of Nelson (1959) and Arrow (1962), economists have attempted to understand the economics of abstract knowledge production. To the extent that abstract knowledge serves as a non-rivalrous input into technological innovation, its production plays a critical (and much-studied) role in the process of economic growth (Romer, 1990). A critical insight from that literature is that, because knowledge production is costly to monitor and subject to expropriation, the level of production is inefficiently low in the absence of alternative institutions. Of course, several important institutions supporting the appropriability of knowledge (from trade secrecy to prizes to patents) have been identified and investigated, both theoretically and empirically (Wright, 1983; Levin et al, 1987). However, as persuasively argued by Dasgupta and David (1994), the institution perhaps most closely associated with the historical production of abstract knowledge – Science – remains largely unexplored by economists.

This paper is motivated by this relative neglect and the possibility that the adoption of a science-oriented research approach by private firms has important consequences for economic quantities such as wages, R&D productivity and profits. Consider some of the ways in which a science-oriented research approach differs from purely commercially-motivated knowledge production: (a) scientific research involves the formulation and testing of theories (which may but need not have commercial application) (b) the predominant incentives to produce such knowledge depends on establishing intellectual priority (i.e., being first to make a discovery), but (c) since the outputs of scientific research are disclosed publicly in academic journals (and with few formal intellectual property claims) the rewards associated with intellectual priority are primarily non-pecuniary in nature, such as in the receipt of *credit* by future researchers.[1] These distinctive characteristics of the science-oriented research approach (i.e., of Science) raise an important question: to the extent that Science specifically shuns non-disclosure, tight control over intellectual property, and monopolization in the use of novel scientific knowledge, why do researchers (particularly in private firms) participate in Science at all?

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[1] Science is defined more precisely, and the nature of the reward system discussed much more carefully, in Section II. Overall, the perspective here draws on central insights from both the history and sociology of science (Kuhn, 1962; Merton, 1973) as well as the "new" economics of science (Rosenberg, 1990; Dasgupta and David, 1994).

This paper considers two alternative, but not mutually exclusive, explanations for this phenomena. First, researchers may have intrinsic preferences for interacting with discipline-specific scientific communities and for receiving recognition from their peers for discoveries. While the precise mechanism by which such profession-specific values are internalized is open to debate (e.g., a hallmark of graduate-level scientific training is the emphasis placed on the contributions to scientific research by senior academics), researcher sensitivity to the scientific reward system may be important for understanding the economic behavior of scientists. Simply put, scientists may have a "taste" for Science (Merton, 1973; David and Dasgupta, 1994).[2] Second, participation in Science may be motivated by the benefits, in terms of technological innovation, to private firms themselves. Firms who adopt Science may gain earlier and more detailed access to new scientific discoveries and so may be purchasing a "ticket of admission" which pays itself off in terms of higher R&D productivity and a higher rate of technological innovation (Cohen and Levinthal, 1990; Rosenberg, 1990).

At one level, there is no inherent conflict between these two hypotheses. It is possible that scientists possess a taste for Science (referred to as the Preference effect), and, at the same time, some firms participate in Science in order to capture spillovers (referred to as the Productivity effect). However, these two perspectives do offer competing economic implications, most notably for the employment relationship: whereas the Preference effect contributes to a negative compensating differential between Science and wages, the Productivity effect raises the possibility of rent-sharing between firms and researchers (and so a positive association between wages and Science). In addition, the relationship between wages and Science may reflect a skill bias: under the "winner-take-all" nature of the scientific reward system, the expected benefits to Science (both from the perspective of individual researchers as well as the firms which employ them) will be higher for higher-ability researchers and so firms who employ scientists of higher ability will tend to adopt Science as well. In other words, the relationship between scientist wages and Science will be determined according to a set of economic forces (compensating differentials,

[2] In contrast to most studies of on-the-job amenities (which examine the value placed on characteristics such as safety, pension benefits, etc… (see Hamermesh (1984) or Viscusi (1993) for reviews), a "taste" for Science is most likely concentrated among individuals in research-oriented careers, perhaps reflecting their educational training or more fundamental sources of heterogeneity across different types of professional workers.

rent-sharing, and returns to talent) which govern equilibrium labor market outcomes more generally (Rosen, 1986; Stephan, 1996).

After a brief review of the "new" economics of science in Section II, Section III develops this logic more precisely by presenting a simple economic model incorporating (a) the Preference effect, (b) the Productivity effect, and (c) a distribution of talent among scientists. In line with the previous discussion, the model incorporates both the potential for skill bias in Science and the potential for rent-sharing among firms and scientists (dividing up the quasi-rent associated with participation in Science). This model is used to derive the equilibrium relationship between Science and wages, scientist quality, and firm performance. Two key results stand out: (a) the relationship between wages and Science depends on the relative salience of the Preference and Productivity effects (as determined by the degree of rent-sharing) and (b) the adoption of Science will be more likely as firms expect to have access to higher-ability researchers. An important consequence of these findings is that prior empirical investigations of the relationship between R&D productivity and Science may be subject to biases resulting from the compensating differentials effect and the selectivity associated with the heterogeneous distribution of scientific ability.

These theoretical insights motivate the heart of the paper, the development and implementation of an empirical methodology which allows for the consistent evaluation of the relationship between wages and Science. In particular, a principal contribution of this paper is the introduction of a novel field-based method to control for the presence of unobserved heterogeneity in the context of equalizing differences wage studies and so reduce the likelihood of bias in such research. Specifically, I exploit the fact that, prior to accepting a specific offer, many professionals receive *multiple job offers*. Each offer is composed of a wage offer and (observed to the employee) job characteristics. Since a formal job offers confers a legal responsibility on the firm, such offers will not be made unless the firm is willing to employ the worker under the proposed package. As well, in equilibrium, firms will not make offers which have a zero probability of acceptance. In other words, using samples drawn mainly from individuals who are seeking their first full-time employment, we are able to calculate different wage-Science curves *for randomly selected workers at a point in time.* By surveying candidates about detailed characteristics of their multiple job offers (e.g., "Does this job give you permission to publish in the scientific literature?"), it is therefore possible to estimate the relationship between wages and Science, even after fully taking into account any heterogeneity across individuals in the sample (through the inclusion of person-specific fixed effects). As such, the estimates reported here likely overcome the biases associated with earlier work in labor economics which either examines cross-sections of employees or focuses attention exclusively on job-switching behavior.[3]

This survey-based methodology is applied to a sample of life sciences researchers (i.e., biologists) who are (just) completing a job search.[4] PhD biologists (e.g., those completing their first postdoctoral fellowship at a top-tier medical center or university) participate in a (moderately formal) job market in which they attempt to garner long-term employment. While we can control for several differences among job which do not relate to its scientific orientation (such as the impact on their career, or whether the job is in a start-up firm), the analysis is conditioned on a set of research-oriented job offers, all of which use the candidate's specialized biology background. However, the jobs differ in terms of the degree to which the candidate can participate in Science, either through the publication process or through the ability to choose (or continue to work on) an individual research agenda. Critically, the job market for biologists is fluid enough so that, prior to accepting particular job offers, some candidates do receive multiple job offers.

While the sample size is relatively small, the data point to several important findings. Most importantly, there seem to be a broad tradeoff between offered wages and the scientific orientation of firms. Offers which contain science-oriented provisions, ranging from permission (or incentives) to publish in the scientific literature, to flexibility to choose or continue research projects, are associated with lower monetary compensation and starting wages. For example, firms who do not allow their employees to publish offer, on average, a 25% wage premium.

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[3] Rather than reviewing the voluminous literature in labor economics on the correct specification and sources of possible bias in hedonic wage estimation here, I defer this discussion until Section IV wherein there is a discussion of the relationship between the methodology proposed here and prior treatments, including work by, among others, Rosen (1974), Brown (1980), Duncan and Holmlund (1983), Rosen (1986), Hwang et al (1992), Gibbons and Katz (1992), Abowd and Lemieux (1993), van Reenen (1996), and Hwang, et al (1998).
[4] We gather several distinct types of information about each scientist and each offer. In addition to standard demographic information, we collect information about the candidate's job market experience and their information about each of their job offers. We collect both *ordinal* data, which involves comparisons for given characteristics across job offers as well as *cardinal* data, which involves concrete quantitative information about each job.

These results are robust to several different types of controls (including job type), as well as restricting our sample only to those job offers from the non-academic sector. However, the findings do depend critically on controlling for individual heterogeneity; simple cross-sectional comparisons result in a significant upward bias to the measured relationship between wages and Science and so underestimate the size of the compensating differential paid by individual researchers to participate in Science.

Overall, the contribution of this paper arises from (a) incorporating the two central hypotheses from the "new" economics of Science into an economic model of wages and participation in Science, (b) estimating the relationship between wages and the scientific orientation of R&D organizations using a novel empirical methodology which controls for unobserved heterogeneity in scientist ability, and (c) therefore providing an assessment of the relative impact of researcher preferences, firm incentives and the distribution of scientific talent on scientific labor markets. Perhaps the most surprising finding of this study is that a job characteristic which is closely tied to a profession-specific value system (i.e., a community-imposed norm) has a significant quantitative impact. In other words, this paper provides new empirical evidence, grounded in an equilibrium theory of utility and profit maximization, about the economic impact of Science: specifically, scientists do indeed *pay* to be scientists.

II. The "New" Economics of Science

Science is a distinctive institution in at least three ways: as a knowledge production system, as an input into technological innovation, and as a reward system. The first distinguishing aspect of Science is that it produces two extremely specialized types of knowledge: potentially testable theories and empirical tests of these theories (Kuhn, 1963). While the contribution to the theory-testing dynamic is the primary criteria by which scientists evaluate the value of new knowledge, Science serves a second function as a knowledge stock upon which firms draw for technological innovation. The knowledge and techniques produced by Science often have commercial applications which are unrelated to the initial theory-testing motivation which spurred their development (Rosenberg, 1974). In other words, Science is an important source of knowledge spillovers. This uneasy relationship between Science as a knowledge production process and as an input into technological innovation is mediated by the third characteristic feature of Science: the priority-based reward system. To receive credit for the intellectual priority of their scientific discoveries, scientists publicize their findings as quickly as possible and retain no formal intellectual property over their ideas (Merton, 1957; Dasgupta and David, 1994). The priority-based system allocates rewards primarily according to the discovery's contribution to Science (i.e., to the theory-testing dynamic); the benefits to identifying the *commercial* value of a scientific theory are (mostly) limited to the financial gains from its exploitation. To the extent that scientists value the rewards associated with scientific priority, this reward system provides incentives for scientists to expend effort on the formulation and testing of discipline-specific theories.

While sociologists and historians of science debate the relative importance of these three aspects of Science, each helps to identify Science as an economic institution which is distinct from a commercially-motivated knowledge production system.[5] For example, while most economic analysis of knowledge production emphasizes the importance of institutions such as intellectual property, trade secrecy or entry barriers in ensuring the incentives for innovation (Nelson, 1959; Arrow, 1962; Levin et al, 1987; Kremer, 1998), the scientific incentive system specifically rejects non-disclosure, tight control over intellectual property, or monopolization in the use of novel scientific knowledge (Dasgupta and David, 1994).[6] With this contrast in mind, I define participation in Science to (a) be distinguishable from commercially motivated knowledge production, (b) involve the formulation and testing of theories (which may but need not result in commercial spillovers), and (c) result in public disclosure of findings in academic journals and forums.[7]

As first noted by the sociologist Merton (1973), the effectiveness of the priority-based

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[5] One might also distinguish Science by several other key aspects (e.g., that its primary locus is in universities which serve as a key contributor to more general human capital investments and training, its long-term responsiveness to overall societal needs, etc…). However, for present purposes, I focus on the small number of most salient elements which will distinguish scientist behavior from more traditional economic models of the research process.
[6] Perhaps surprisingly, then, Science turns out to be an extremely influential source of commercially relevant knowledge, at least in the long term (Rosenberg, 1982).
[7] Obviously, this is an extremely "stylized," conceptualization of the structure of Science as a knowledge production system. While acknowledging that the structure of scientific communities is more subtle and dynamic than conceptualized here, the simple approach pursued here does allow for the development of key testable hypotheses which

system depends critically on the sensitivity of scientists to its unique rewards: credit by future researchers who build on their discoveries, establishment of a reputation for ability among colleagues, employment by and membership in prestigious institutions, and access to resources to do further scientific research. Even if one accounts for career concerns, the priority-based system seems to rely on intrinsic valuation of its reputational rewards: not only is the income profile for scientists relatively flat but many of the most important rewards (e.g., the Nobel Prize or membership in elite scientific societies) are granted only at extremely late stages in the career. Of course, if scientists do value these rewards, they will logically also place implicit value on activities which help ensure intellectual credit for discoveries. In particular, scientists will attempt to construct an individual research *agenda*, including the freedom to (a) prioritize their research activities and (b) pursue a given research topic over a long period of time. Simply put, for the priority-based system to be effective, scientists must display a "taste" for Science.[8]

The priority-based reward system (and the associated "taste" for Science) generate several implications which can resolve key empirical puzzles about Science both as a knowledge production system and as an input into technological innovation. For example, the history of Science is marked by near-simultaneous discovery of the same finding by multiple sets of researchers;[9] as pointed out first by Merton (1973), the priority-based reward system results quite naturally in "racing" between teams of researchers, each attempting to establish a claim of priority over the others.[10, 11]

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relate directly to central features of the underlying phenomena.

[8] As a profession-specific value, a "taste" for Science is likely concentrated among individuals in research-oriented careers. However, Science is not the only profession which may place intrinsic value on profession-specific goals. Physicians claim to value the Hippocratic Oath, and private law firms often espouse "justice" as a goal of their practice. Scott Morton and Poldony (1999) suggest that intrinsic preferences for "quality" in the California wine industry may impact the structure of product market competition.

[9] An almost endless number of cases of multiples exist (Lamb and Easton, 1985), ranging from the dispute between Newton and Leibniz over calculus (Merton, 1973) to the "race" to discover the DNA structure (Watson, 1968) to the simultaneous development in 1973 of option theory by Black and Scholes and Merton's son Robert J. Merton.

[10] To the extent that Science provides no rewards for "second-place" and key questions are articulated in advance of their resolution, "science" races may be empirically more salient than patent races (Stern, 1995).

[11] Other more subtle implications of the priority-based system can also be derived, including (a) the existence of "invisible colleges" whereby scientists value the opinion of researchers who work on similar problems outside of their home institution (Price and Beaver, 1966), and (b) professional investments to "adjudicate" priority claims, even by individuals with no direct stake in who receives credit (Zuckerman and Merton, 1971). Stephan (1996) and Dasgupta and David (1994) discuss some of the potential economic impact of these effects.

From the perspective of this paper, a more central implication of the priority-based reward system is that its expected rewards are increasing in researcher ability. Since intellectual priority is determined as the result of time-dependent “winner-take-all” contests, a relatively small number of the most able scientists are able to receive credit for the lion’s share of important discoveries (Cole and Cole, 1973). Over time, scientists with prior successes are able to attract greater resources (money, students, etc…) and be more fully informed about novel opportunities for progress on particular topics or phenomena (e.g., through coauthorships or participation at scientific meetings). This dynamic feedback between past success and the probability of future success (referred to as the Matthew Effect in the sociology of science (Merton, 1973)) suggests that the value of participation in Science is increasing in ability.

Perhaps surprisingly, little formal economic analysis (and even less empirical work) exists concerning the priority-based reward system.[12] However, two recent streams of mostly informal research have begun to address the distinct economic implications of the sociological evidence. In the first stream, David and Dasgupta (1987; 1994) explore the Mertonian insight directly and evaluate how the assumption that scientists (as a group) are attempting to maximize the flow of new knowledge influences the economic efficiency of the priority-based reward system.[13] Dasgupta and David argue that, relative to a system in which knowledge production is rewarded purely by monetary rents, the priority-based reward system is relatively efficient. On the one hand, the priority-based system discourages shirking, since lower effort is directly associated with lower probability of reward. On the other hand, the system encourages maximal knowledge diffusion, since scientists will spend effort publicizing their results in order to achieve as much credit as possible for their ideas. Given that scientists are attempting to maximize the rate of production and diffusion of scientific knowledge, the priority-based reward system is an extremely effective mechanism for achieving their goals.[14]

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[12] On the other hand, there are a host of studies which examine scientists’ behavior in order to evaluate some other aspect of economic theory unrelated to knowledge production per se (e.g., Freeman’s seminal studies of scientific labor markets (1976) or Levin and Stephan’s careful test of Becker’s life-cycle human capital model (1991)). See Stephan (1996) for an extremely informative synthesis of this work.

[13] In other words, they examine the reward system’s social efficiency, conditional on a taste for scientific progress.

[14] David and Dasgupta acknowledge several important inefficiencies associated with Science, most notably the possibility of overinvestment and overnarrowness in research due to racing effects. As well, it is useful to emphasize

While Dasgupta and David evaluate the efficiency properties of Science from the scientist's perspective, Rosenberg (1990), Cohen and Levinthal (1989, 1990) and Arora and Gambardella (1994) examine how profit-maximizing firms might exploit Science for their own purposes. Specifically, given that one of the distinctive features of Science is its tendency to produce knowledge spillovers, then it may be worthwhile for a private firm to adopt a Science-oriented research approach in order to gain earlier and more detailed access to new discoveries. While scientific results are public in the sense that they are available in scientific journals, being able to evaluate the importance of novel scientific discoveries and being aware of results prior to their formal publication depends on participation in Science. In other words, private firms who would like to exploit novel scientific knowledge must purchase a "ticket of admission" which pays itself off in terms of higher R&D productivity and a higher rate of technological innovation (Rosenberg, 1990).[15]

At one level, there is no inherent conflict between these two propositions in the "new" economics of science. It is possible that scientists possess a taste for participating in Science (referred to as the Preference hypothesis), and, some firms may find it worthwhile to have their researchers participate in Science in order to capture the expected benefits associated with spillovers (referred to as the Productivity hypothesis).[16] However, the economic impact of these two effects do differ, most notably for their impact on the employment relationship. While the Preference effect will contribute to a negative association between Science and wages (i.e., there will be a compensating differential), the Productivity effect will contribute to a positive association between Science and wages (to the extent that firms and researchers engage in "rent-sharing").

However, prior empirical work, which has focused almost exclusively on the relationship between Science and *performance*, has mostly (a) confounded these effects with each other and

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that their analysis is primarily normative and does not focus on the empirical manifestations of the taste for Science.

[15] More precisely, if a commercial "prize" is available to the first firm who translates a scientific advance into a novel technology, then firms have incentives to gain early access to results and to be able to assess the importance of novel discoveries; according to many observers, participation in Science by at least some members of the firm's research staff seems to be an efficient way to achieve these goals (Hicks, 1995).

[16] A fully specified model might place limits on the share of activity attributable to the profit-maximizers, insofar as this group may tend to exhibit free-riding in the absence of intrinsic preferences. Conditions for the existence of a priority-

(b) confounded both effects with the possibility that Science-oriented firms simply employ better researchers. Consider the evidence from the biotechnology and pharmaceutical industries cited in favor of the Productivity hypothesis. Pharmaceutical and biotechnology firms differ quite markedly in terms of their scientific orientation (Gamberdella, 1995; Cockburn, Henderson, and Stern, 1999),[17] and these differences are correlated with differences in performance (Henderson and Cockburn, 1994; Gambardella, 1995; Zucker and Darby, 1996; 1998). While it is true that such evidence is consistent with the Productivity hypothesis (as emphasized by the literature), these findings are equally consistent with the Preference hypothesis. Specifically, to the extent that a "taste" for Science is reflected in the labor market for scientists, then those firms who offer a scientifically oriented research environment will be able to offer lower wages, conditional on scientist quality. The presence of a compensating differential implies that those (inframarginal) firms who adopt Science will earn a quasi-rent which may be reflected in profits.[18]

In addition, estimates of the empirical impact of Science are confounded with the possibility that science-oriented firms employ more able scientists. This correlation between Science and researcher ability arises from the internal logic of the priority-based reward system. On the one hand, higher-quality researchers may be willing to trade off more income to earn the higher expected "prestige" rewards associated with their ability. On the other hand, firms who employ higher-quality scientists may find participating in Science more attractive; with their better reputations, these researchers will gain better access to the external scientific community, be invited to more prestigious and cutting-edge conferences, coauthor with higher-quality university researchers, and be asked to review or referee more important discoveries (Zucker and Darby, 1996).[19] Consequently, without detailed controls for scientist ability, empirical assessments of the

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based equilibrium is an interesting area for future work but beyond the scope of the current paper.

[17] For example, some firms, such as Genentech, closely resemble a university biology department (i.e., firm scientists collaborate with university researchers, publish in the public scientific hierarchy, and are promoted according to their external scientific reputation); other firms specifically eschew Science (i.e., according to one executive, "why should I let my people publish? It's just a waste of time that could be spent in the search for new drugs." (Cockburn, Henderson, and Stern, 1999).

[18] Henderson and Cockburn (1994) acknowledge this possibility. Given that science-oriented firms are indeed taking advantage of a costly-to-imitate resource advantage, both the Preference and Productivity hypotheses are consistent with their more general interpretation that such effects provide evidence for firm-specific "competence."

[19] Zucker and Darby (1996) and Zucker, Darby and Brewer (1998) present evidence that biotechnology firms are more successful if they employ or interact (through copublication) with "star" researchers. While this evidence highlights the

impact of Science on performance may be biased upwards since Science may be associated with the higher performance associated with higher-ability researcher distributions.

To sum up, the "new" economics of science is centered around explaining the economic consequences of the priority-based reward system, and, in particular, the motivation for participation in Science by profit-maximizing firms. Two alternative theories have emerged: (a) the Preference hypothesis, or a "taste" for Science, and (b) the Productivity hypothesis, resulting from the close linkage between Science and technological innovation. To the extent that both are consistent with participation by at least some firms in Science, prior research has not cleanly distinguished between these alternatives. However, the two theories do offer separable implications, specifically for the employment relationship. Scientifically oriented firms should be able to recruit researchers at a discount under the Preference hypothesis; under the Productivity hypothesis, Science-oriented firms will likely share some of the positive rents associated with their superior knowledge production. Disentangling the relative salience of these competing effects will depend, however, on controlling for differences in researcher quality. The remainder of this paper explores the wedge between these two theories more closely.

III. A Simple Economic Model of Science and Wages

This section builds on the qualitative discussion and develops a simple economic model incorporating (a) a taste for Science, (b) the Productivity effect, (c) a distribution of talent among scientists, and (d) rent-sharing between firms and scientists. This model is used to derive the equilibrium relationship between Science and wages, scientist quality, and firm performance. In the next section, these results are used to demonstrate the expected bias in empirical work which does not account for differences in talent and motivates the development of the multiple job offers methodology.

The model is composed of two stages. In the first stage, firm j chooses whether to adopt a scientific orientation for its R&D department (SCI = 1, else SCI = 0).[20] In the second stage,

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potential importance of the human capital distribution, they do not explicitly distinguish the underlying economic forces leading to such a bias or the impact of these structural characteristics on economic observables.

[20] As discussed in Section II, participation in Science involves doing research which involves the formulation and

firms hire a single researcher with observable ability γ_i. As noted earlier, the population of researchers is subject to an extremely skewed distribution of talent and so this variance is directly incorporated into the model. For firm j, the quality of worker i (the most attractive scientist who applies for a job at firm j) is drawn from a firm-specific distribution, $g_j(g)$, bounded below at zero and with mean $\bar{g}_j$.[21] Each scientist's utility from a job offer is a function of the offered wage and the preference for a science-oriented research environment:[22]

$$U_i = \quad a_0 + a_S\, g_i SCI_j + w_j \qquad (1)$$

Scientists of higher ability place higher value on a science-oriented research environment; as discussed earlier, this interaction is strongly implied by the internal logic of the priority-based reward system and the ever-increasing rewards from "prestige."[23] Firms, on the other hand, earn profits according to the ability of hired scientists, the wages paid to these employees (w_j), and their scientific orientation:

$$p_{i,j} = \quad g_i(b_0 + b_S\ SCI_j) - w_{i,j} - d\ SCI_j \qquad (2)$$

While firms pay a fixed fee to adopt a scientific orientation,[24] the benefits that the firm receives from adopting a scientific orientation depends on the quality of the scientist. Like our assumption about the interaction in (1), the interaction in (2) is motivated by the nature of the priority-based reward system: higher-quality scientists will have better access to the external

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testing of theories and results in public disclosure of findings through the academic publication process; however, science-oriented firms, in achieving the goals of Science, will also tend to (a) allow researchers discretion in choosing new research projects or continuing old ones and (b) tend to base promotion decisions on a researcher's external scientific reputation. The model does not distinguish between the elements of this bundle of characteristics.

[21] Alternatively, one could assume that the firm employs N researchers of known quality with mean ability $\bar{g}_{\mathrm{j}}$.

[22] To highlight the relationship between the wages from research jobs and scientific orientation, I adopt Rosen's hedonic characteristics approach (1974; 1986) and further assume that (a) each scientist supplies one unit of labor inelastically, (b) there is a competitive (no search cost) labor market for jobs where SCI=0, (c) all firms observe the same information about each scientist, (d) firms cannot verify the characteristics of competing job offers (until they are accepted), and (e) except for differences in talent, all scientists share the same utility function. As such, the model abstracts away from some of the more subtle issues which arise in the context of hedonic wage determination when (a) workers' preferences for nonpecuniary characteristics are heterogeneous (Hwang, et al, 1992) or (b) the nonpecuniary characteristic has continuous support, all jobs require substantial search, and firms differ in the cost of providing the nonpecuniary benefit (Hwang, et al (1998)).

[23] As well, this interaction could represent a "reduced-form" income effect (Weiss, 1976; Sattinger, 1977).

[24] One could imagine δ as the per-scientist cost of sending scientists to conferences, financing a staff to approve scientific articles, or the budget for discretionary research activities (e.g., specialized materials or equipment).

scientific community and will be able to monitor external developments more skillfully than less-talented colleagues. In other words, the benefits from Science are skill-biased.

Firms who adopt Science earn a quasi-rent, which is increasing in γ_i. However, if (a) the firm faces a search cost for new scientists and (b) scientists can (credibly) threaten to receive additional job offers from other science-oriented firms, then scientists may extract some of this quasi-rent in wage bargaining.[25] To account for this possibility, I follow recent work on rent-sharing and incorporate a "rent-splitting" parameter, $f \in (0,1)$, which determines the allocation of the quasi-rent between scientist and firm (Abowd and Lemieux, 1993; van Reenen, 1996). As a result, the second stage wage equilibrium is given by:

$$w^{*}_{i,j} = g_i b_0 + g_i (f\, b_S - a_S)\, SCI_j \qquad (3)$$

Equation (3) describes the empirical relationship between wages and scientific orientation, conditional on the quality of scientists. As long as the compensating differential parameter, α_S, is larger (smaller) than that part of the quasi-rent extracted by the scientist, then wages will be decreasing (increasing) in the scientific orientation of the firm. As well, (3) implies the solution to firm j's first stage problem of whether to adopt Science in the first place:

$$SCI_j = 1 \; iff \; \bar{g}_j > \frac{d}{(1-f)\, b_S - a_S} \qquad (4)$$

This latter condition suggests that a key characteristic of Science – that better scientists earn proportionally higher benefits from engagement in Science – implies a structural positive relationship between the firm's expected ability to recruit high-quality scientists and its adoption of a science-oriented research strategy. Finally, equations (3) and (4) can be used to characterize the relationship between Science and performance. Specifically, plugging (3) and (4) into (2) and examining the expected "boost" to performance associated with those firms who are observed to adopt Science in equilibrium:

$$E(p_{SCI=1} - p_{SCI=0}) = E(g \mid SCI = 1)((1-f)\, b_S + a_S) - d \qquad (5)$$

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[25] More precisely, each scientist's bargaining position depends on (a) her outside option associated with the competitive market in non-science-oriented jobs, (b) the *average* expected cost of searching out another science-oriented offer and (c) the expected cost to the firm of finding another job candidate of similar expected value. The presence of these competing sources of bargaining power can yield a rent-sharing equilibrium (Mortensen, 1990; Abowd and Lemieux,

Firms who expect to face a more favorable human capital pool will adopt Science and both earn some portion of the quasi-rent and pay lower quality-adjusted wages. In other words, the performance effects of an advantage in access to talent are "magnified" through its impact on both the Preference and Productivity effects.[26]

IV. An Empirical Model of Science and Wages

Both the wage and performance equations are functions of the Productivity and the Preference parameters, α_S and β_S; consistent estimation of either (3) or (5) can therefore provide insight into the precise motivation for and welfare implications of the adoption of Science. Whereas π is increasing in both parameters, α_S and β_S exert competing effects on w^*. As such, examining the labor market for scientists seems like a fruitful place to begin distinguishing the relative importance of these two effects.[27] However, a central issue for empirical work is that the potential for bias from heterogeneity in worker ability is likely to be important in the current context. Not only is the adoption of Science predicted to covary with researcher ability according to the underlying theory (see (4)), but the distribution of scientific ability is well-known to be extremely skewed (Stephan, 1996). This paper addresses this problem by introducing a novel empirical methodology which exploits the fact that in job markets for "novice" professionals (i.e., no prior career-oriented job experience), many candidates receive *multiple job offers* prior to accepting a single employment offer. By observing more than one combination of wages and job characteristics for each of these "novice" job candidates, this sample construction allows us (ideally) to construct different points on the wage-characteristics curve *for a randomly selected worker at a point in time.* By exploiting the specific institutions of professional labor markets, this methodology likely leads to a substantial reduction in the bias associated with unobserved heterogeneity.

Consider an empirical wage equation which does not account for ability heterogeneity:

1993; Hwang, et al, 1998).

[26] This magnification effect may help explain why firms who locate near universities are consistently found to (a) organize in a different fashion and (b) experience higher rates of R&D productivity.

[27] I am not aware of any earlier empirical studies in the economics of science which have attempted to disentangle these parameters, or the relative importance of the talent effect in biasing cross-sectional results.

$$w_{i,j} = q_0 + q_S\, SCI_j + e_{i,j} \qquad (6)$$

If ability, γ_i, is uncorrelated with the adoption of SCI, then $E(\hat{q}_S) = \bar{g}(f\, b_S - a_S)$, or the relative salience of the preference versus productivity effect, evaluated at the mean ability level. However, according to (4), SCI will only be adopted by those firms who expect a sufficiently high draw on ability and so $E(\hat{q}_S - \bar{g}(f\, b_S - a_S)) = \dfrac{E(g \mid SCI = 1) - \bar{g}}{1 - \Pr(SCI = 1)} > 0$.[28] This bias combines two sources of bias identified in earlier applications. On the one hand, higher-ability individuals will tend to "consume" higher levels of positively valued hedonic characteristics. While earlier work has attributed such covariation to wealth effects (Weiss, 1976; Sattinger, 1977; Rosen, 1986) or the impact of heterogeneous preferences (Hwang et al, 1992), the current application motivates this bias from the nature of a prestige-based reward system. On the other hand, the potential for "skill bias" from new technologies and the associated bias for productivity studies is well-established (Berman, Bound, and Griliches, 1994; Autor, Katz, and Krueger, 1998; Entorf and Kramarz, 1998). In the current application, of course, Science is not a technology per se but an organizational practice whose benefits to the firm are likely to be higher for higher-quality workers.

Prior research has pursued two distinct approaches for overcoming the bias arising from unobserved heterogeneity: (a) ability-associated control and (b) the exploitation of panel data. While the use of control variables is often effective for settings where workers are relatively homogenous or easily distinguished by observable characteristics such as educational attainment or experience variates (see, e.g., Hamermash, 1984; Rosen, 1986; Kostiuk, 1990; Viscusi, 1993), this approach will be of limited value for studying scientific labor markets since most demographics are unlikely to distinguish between different scientists (e.g., there will be no variation in educational attainment in a pool of PhD recipients).

The most popular alternative to the use of control variables is to exploit the use of the

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[28] Similarly, the model predicts a positive bias associated with not controlling for the higher level of human capital in Science-oriented firms in a performance equation. In the model, $p_j = j_0 + j_S SCI_j + e_j$, $E(\hat{j}_S) = E(g \mid SCI = 1)((1-f)\, b_S + a_S) - d > \bar{g}((1-f)\, b_S + a_S) - d$, where the latter term is the performance benefits from Science, accounting for researcher ability.

panel data at the individual level. By including a fixed effect for each individual, empirical identification within a panel relies only on within-person variance in job characteristics and so controls for the main source of bias described above. The principal way to observe within-person variance in job characteristics is to restrict empirical analysis to "job switchers" (i.e., individuals who switched their employment from one type of firm to another over the span of the observed panel (Brown, 1980; Duncan and Holmlund, 1983)).[29] However, as discussed by Gibbons and Katz (1992), studies of job switchers are subject to their own biases. Job switching is (generally) endogenous and reflects (a) a population of individuals who are badly "matched" in their current positions and (b) may have gained a particularly high level of unobserved skills which are valued on the labor market. Consequently, empirical work which focuses exclusively on job switchers may tend to overstate the benefits from job moving for the *average* worker. More generally, while panel data substantially overcomes the initial source of derived bias, current methods for gathering panel samples are subject to important selectivity biases themselves.

Recognizing the centrality of ability in scientific labor markets (and the consequent potential for a large amount of bias), this paper introduces a novel field-based methodology, based on the process by which professional labor markets operate, which likely reduces the above-mentioned biases. For most graduate or postdoctoral scientific researchers, a job search involves sending out resumes to a large number of universities and firms, receiving a smaller number of interviews with those firms, and then receiving one or more job offers before accepting a final offer of employment.[30] I exploit two facts about this process. First, since all graduates must engage in some job search, graduating professionals are a particularly attractive sample from the perspective of selectivity. Second, and more importantly, prior to accepting a specific offer, many professionals receive *multiple job offers*. Each offer is composed of a wage offer and job characteristics (including scientific orientation) which are observed to the employee.[31] By

[29] Indeed, several important studies on the structure of wages exploit job-switching behavior in order to highlight the importance of controlling for individual effects and to contribute a less biased estimate of parameters of direct economic interest (Murphy and Topel, 1987; Abowd, Kramarz, and Margolis, 1999; Entorf and Kramarz, 1998).

[30] While I will describe the institutions of the scientific labor market, the analysis of the process by which professional labor markets operate also largely applies for law students, post-residency physicians, MBAs , and other graduate professional school candidates.

[31] Since a formal job offers confers a legal responsibility on the firm, such offers will not be made unless the firm is

surveying candidates about their multiple job offers, it is therefore possible to estimate the relationship between wages and scientific orientation, even after fully taking into account ability heterogeneity across individuals through the inclusion of person-specific fixed effects. In other words, the multiple job offers methodology allows us to observe different points on the wage-Science curve *for a randomly selected worker at a point in time* ($w_{i,j} = q_i + q_S SCI_j + e_{i,j}$), likely reducing the ability bias endemic to many prior studies.[32]

The multiple job offers methodology of course rests on several important assumptions. First, the methodology assumes that differences in information among offering firms about the quality and preference of candidates is uncorrelated with scientific orientation. If science-oriented firms can judge researcher's abilities more accurately than others, then science-oriented firms may tend to make fewer but more attractive job offers, thus leading to a positive bias for the hedonic coefficient. Second, the method assumes that scientific orientation is uncorrelated with alternative unobserved sources of variation in productivity. If firms' scientific orientation is correlated with unobserved practices which are the structural sources of productivity gains, then the hedonic equation will obviously be subject to omitted variable bias. Third, the method assumes that observed job offers are comparable in terms of the "seriousness" of the offer. As much as possible, the data were gathered just prior to the time the candidate accepted an offer; according to survey respondents, these "final-round" offers reflected their beliefs about the job characteristics they would be accepting if they chose an offer. Finally, the method assumes that candidates who receive multiple job offers are drawn independently from the distribution of candidates. While there is no structural reason to believe that ability should be associated with the number of received offers, it is likely that individuals with more offers are drawn from a more attractive portion of the distribution.[33] While discussions with survey respondents (and examination of the offers of single-offer candidates) suggests that the receipt of multiple job offers

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willing to employ the worker under the proposed package. As well, in equilibrium, firms will not make offers which have a zero probability of acceptance.

[32] In a somewhat similar vein, Royalty (1999) exploits the observation of multiple health insurance options by individual workers in a given firm to directly estimate the preference parameters through the direct application of the discrete choice model.

[33] The resulting selectivity bias is analogous to the phenomena identified by Gibbons and Katz (1992); the observed sample will have higher average ability than the population.

is not obviously correlated with ability in this particular market, we will be careful to discuss this source of selectivity when reviewing our results in the next several sections.

V. Data

The data used to evaluate the hedonic wage equation for life scientists was collected using an author-developed survey administered to life science researchers.[34] The survey records information about the experience, preferences, and decisions of individual candidates on the job market. This section describes the sample selection procedure, and then reviews the survey and the summary statistics for the dataset.

Sample Selection

The sample population was drawn from individuals who, with some probability, were in a position to receive multiple private sector life sciences research job offers. To ensure compatibility across responses, the sample is restricted to PhD biologists (though several candidates also hold an MD). The target population was therefore current researchers who (a) held a PhD in biology, (b) were currently searching for a permanent research position, and (c) expressed interest in receiving offers from non-academic employers. To access this target population, surveys were distributed to the following populations:

- current postdoctoral researchers whose funding was expiring at four American research institutions
- participants in two AAAS-sponsored Biology Job Fairs (held in Cambridge, MA, and Palo Alto, CA), the majority of whom were postdoctoral researchers
- post-PhD biologists with resumes posted to BIOMEDNET (www.biomednet.com)

For each data source, several candidates were interviewed more extensively in order to ensure that each group was comparable with the others (conditional on researcher quality). Overall, data was collected from 107 biologists who received a total of 223 job offers. Non-

[34] Data was gathered between June, 1998, and June, 1999 by mail and telephone interviews (and a small number of e-mail responses). Except for a small number of individual cases, the surveys were administered prior to the time the individual commenced working for the accepted employment offer.

research-oriented job offers (e.g., management consulting, software start-up management, lab management) were excluded as were observations composed of candidates who only received one job offer. Once these jobs are excluded, the sample includes 66 job candidates who received a total of 166 offers; on average, each scientist with multiple job offers received 2.5 offers.

The Survey Instrument

The data are drawn from the information collected on the surveys administered to the populations described above (see Appendix A for a copy of the survey). The goal in developing the survey was to collect information about the relationship between the job market environment and different element of the job offers received by life science researchers.[35] The survey is composed of five sections. The first elicits resume information about the respondent's background and demographics. Part II gather data about the length and outcome of the job search. In Part III, respondents compare job offers according a number of distinct dimensions and provide an *ordinal* ranking of their offers. In other words, if an individual received three offers, she would rank these three offers in terms of an individual dimension, such as "Quality of Internal Research Environment," with the highest quality offer receiving a "1," the next preferred offer a "2" and the lowest-quality research environment rated a "3."[36] Part IV asks more concrete data about each individual offer, denoted hereafter as *cardinal* data (i.e., generally comparable in magnitude and intensity). In addition to questions about measurable characteristics (such as salary or permission to publish in the public scientific literature), a number of questions are asked according to five-point Likert scales (with higher levels on the scale corresponding to higher objective rankings). The final section of the survey gathers information about the characteristics which respondents rank as most important in choosing to accept a research-oriented employment offer.

[35] The final form of the survey resulted from an iterative process. In response to a pre-test of the survey (the results of which are not included in the final sample), the survey was amended using feedback from both researchers with prior experience in field-based survey work and focus group discussions with biologists who served as pre-test subjects. My special thanks to Eric von Hippel for his detailed comments on an early draft of the survey. From the perspective of this paper, the main change in the survey over time were to refine the descriptive wording of the scientific environment and to divide out individual elements of the salary package (SALARY vs. BONUS, etc…).

[36] With a larger sample of job offers, such ordinal data could be used in the context of a multivariate semiparametric rank estimator (Abrevaya and Hausman, 1999), thus substantially weakening the statistical assumptions underlying the procedure.

It is useful to distinguish between the use of the ordinal and cardinal data. Whereas ordinal information provides comparative information about monetary and non-monetary qualities of each job, the cardinal data is composed of data from each candidate where the information about one offer is independent of the information from other offers. Both types of information are subject to limitations. Ordinal data, by its very nature, cannot be used to provide a measure of the intensity of different rankings either within a given job characteristic or across characteristics. On the other hand, cardinal data is subject to various types of measurement error; for example, the use of Likert scales in regression analysis imposes strong assumptions about how different responses differ from each other. However, the empirical approach overcomes these issues in two distinct ways. First, throughout the analysis, fixed individual effects are employed to derive the principal results; by construction, this limits the measurement bias to differences across responses *within individuals*. Second, the analysis evaluates both the ordinal and cardinal data, identifying those conclusions which are robust across data types.

Variables and Summary Statistics

As mentioned earlier, the dataset is composed of 166 job offers from 66 individuals who received multiple job offers. (see Table 1 for all variable names and definitions, Table 2 for means and standard deviations).[37] The first set of variables are ordinal in nature– each individual ranked their jobs in order of their preference according to each dimension. Not surprisingly, the mean of each of these variables slightly less than 2 (recall that while the average number of job offers per respondent is 2.5, the data count each job offer as a separate observation and so individuals with a larger number of offers appear more frequently than those with only two or three offers). The principal dependent regressor that we will use in this context is MONETARY, or the ranking of offers in terms of "overall monetary compensation." The analysis focuses on evaluating the relationship between the MONETARY rank and two elements of the scientific orientation of each organization: first, the overall research quality (RESEARCH QUALITY) and whether

[37] As mentioned earlier, we gathered demographic information but do use it in the current analysis. Briefly, most of the sample is married (71%) male (63%), and the average age is just above 34. The average respondent applied for 15.7 jobs and received their first job offer after 4.3 months.

researchers have discretion in choosing their own projects (FLEXIBILTY).[38] Based on the focus group discussions and interviews, the survey also asked respondents to rank jobs according to several control factors, such as the availability of Research Funding (FUNDING), the impact of the job on career (CAREER), and the degree of fit between specific training (JOBFIT). While this study takes each of these latter factors as a control variable, one could imagine separate investigations of each. For example, the JOBFIT variable might provide information about the degree of idiosyncratic bargaining power that a worker possesses with each employee, allowing more nuanced evaluation of the degree of bargaining power held by the employee. As well, by including CAREER in all regressions, the analysis explicitly distinguishes between participation in Science as a career-advancement strategy and intrinsic preferences for a Science-oriented research environment.

The second set of variables are based on the cardinal data drawn from the Job Offer Record (Part IV of the Survey). The dependent variable is the baseline salary associated with each offer, SALARY. The average SALARY offer is a little more than $60,000 though the standard deviation is quite large. Of course, SALARY only captures one dimension of the monetary compensation package, so we are careful to show that each of our findings is robust to the inclusion of controls which may be associated with other dimensions of earnings in the firm (BONUS and STOCK_DUMMY) and long-term career opportunities (PROMOTION). The STOCK_DUMMY variable (whether the employee received stock options), in particular, may be an important indicator that the current salary is only a small portion of the expected (but risky) lifetime compensation associated with a job offer; while this control is imperfect, robustness to this eliminates a principal alternative explanation for the results.

Several different cardinal variables are used to evaluate the scientific orientation of each organization: (a) whether researchers are allowed to continue to publish discoveries (PERMIT_PUB), (b) how strong the incentives for publication are (INCENT_PUB (rated on a 1-5 scale), and (c) whether researchers are allowed to continue postdoctoral research projects (CONTINUE RESEARCH). Interestingly, while most research positions do permit researchers

[38] The survey includes another element of the scientific orientation (Publication Incentives) but the wording of this question led to a relatively low response rate of usable responses.

to publish (the mean is over .9), there is substantial variance among offers in terms of the incentives to publish and just under 50% of positions allow researchers to continue their prior research agenda. Finally, though not a central feature of Science per se, the analysis includes the availability of access to cutting-edge equipment (EQUIPMENT), a Likert scale variable, which serves as a control variable describing an alternative (and potentially important) aspect of the research environment.[39]

In addition to the control variables for career opportunities, and other aspects of monetary compensation and the research environment, each job offer is coded with a JOBTYPE. Six different jobtypes are included in the analysis: Established Firm, Start-up Firm, Government Lab, Medical Center/Hospital, University Faculty, University Postdoc (see Table 3 for the distribution). Though the plurality of job offers are received from established firms and start-up firms, our main analysis does include jobs from the public and university sectors. The focus groups and interviews suggested that, while public sector and medical center employment is perceived to be quite similar to employment by private firms (the only difference being the formal status of the organization), academic university jobs and postdoctoral positions are only imperfect substitutes and may offer a number of job characteristics which are not captured in a parsimonious statistical design (e.g., collegiality, the option value of moving to the private sector, etc…). As a result, the analysis carefully establishes the degree to which the results are robust to the inclusion of these control variables for the type of employer and also to restricting the sample only to non-academic positions (i.e., excluding university and postdoctoral positions).

Before turning to the empirical results, two final issues arise in terms of the sample. While there are 166 job offers for which an alternative job offer for that candidate is observed (i.e., it is a multiple), many surveys were only completed with either the ordinal or cardinal data but not both. As a result, the final sample in the ordinal analysis includes data on 136 job offers, while the final sample in the cardinal analysis includes data on 123 job offers. In addition, for some of these offers some of the control variables are missing (e.g., the respondent did not report whether stock

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[39] As mentioned earlier, the survey actually includes much more detailed information about each offer, including the source of each job offer (and how applicants found out about the job opportunity, etc…). While such issues are interesting in their own right, they are unrelated to the direct question of the relationship between Science and wages, and so I defer analysis of these variables for later work.

options were received). For any variable which includes missing values, a dummy variable has been included which is equal to one if the variable is missing for that observation and is zero otherwise. With these issues in place, we now turn to the empirical findings.

VI. Empirical Results

This section presents the empirical evidence about the relationship between different measures of monetary compensation and the scientific orientation of organizations. The analysis is divided into two distinct sections. First, the analysis focuses on the ordinal (ranked) data, establishing a negative relationship between individuals' ranking of jobs according to their monetary compensation and their ranking of these jobs according to (a) the quality of the internal research environment and (b) the flexibility of the job in terms of research project selection. This evidence is interpreted to be consistent with the relative salience of the Preference hypothesis. The analysis then turns to the cardinal data. Conditional on the presence of individual fixed effects, offered wages are declining in (a) the permission to publish in the scientific literature, (b) permission to continue postdoctoral research projects, and (c) in the presence of an incentive system based on scientific publication. These findings depend critically on controlling for individual heterogeneity; cross-sectional comparisons result in the (expected) upward bias to the measured compensating differential.

Ordinal Data

The discussion begins in Table 4, where the offers have been cross-tabulated according to two distinct dimensions in each panel (recall that the job ranked highest for a given dimension is assigned a value of one for that characteristic). Tables 4A and 4B present the cross-tabulation between MONETARY and (a) JOBFIT and (b) CAREER. The majority of the rankings are on or just off the diagonal – jobs ranked highly in terms of fit or career advancement also tend to rank highly in terms of monetary compensation. In contrast, Tables 4C and 4D presents MONETARY cross-tabulated with the RESEARCH QUALITY and FLEXIBILITY rankings, respectively. The distribution of these rankings is much more dispersed. For example, out of 53 individuals who reported the ordinal rankings, only 16 (30%) chose to rank the job with highest monetary compensation as highest on FLEXIBILITY. In other words, the majority of jobs ranked most highly in terms of MONETARY were ranked as less than highest in terms of RESEARCH QUALITY or FLEXIBILITY.[40]

Table 5 extend this logic. For each regression in Table 5, the dependent variable is the MONETARY rank of each job. Each regression includes both a full set of individual fixed effects as well as controls for JOBFIT, CAREER, and FUNDING.[41] Beginning with the full sample of observed job offers, (5-1) and (5-3) demonstrate that MONETARY is negatively correlated with RESEARCH QUALITY and FLEXIBILITY, respectively. These results continue to hold even when we exclude all purely academic jobs (university positions and postdoctoral appointments), though the statistical significance on the FLEXIBILITY coefficient becomes marginal (see (5-2) and (5-4)). Finally, in (5-5), the effect of the RESEARCH QUALITY and FLEXIBILITY rankings are both included with both effects remaining statistically significant and of roughly the same magnitude as in the specifications where each was included individually.

These results provides preliminary evidence for the salience of the Preference effect in shaping the relationship between monetary compensation and the scientific orientation of the firm. Research environments which allow workers access to high-quality research colleagues and an ability to choose their own projects (both of these aspects will be instrumentally important for scientists who have a taste for Science) tend to offer less attractive monetary compensation. Of course, the methodology for evaluating the quantitative importance of ordinal data is problematic since one cannot concretely identify the intensity associated with an ordinal ranking.[42] The analysis is therefore extended through the analysis of the cardinal data, to which we now turn.

Cardinal Data

The analysis of the cardinal data proceeds in three stages. First, we begin the analysis by examining the pairwise correlations among the key variables. Second, we examine a baseline

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[40] As well, cross-tabulations between elements of the job itself were examined (available from the author). To the extent that several of these distributions are along the diagonal (e.g., the cross-tabulation of FLEXIBILITY AND CAREER), controlling for this collinearity in the regression will be important.

[41] The results are robust to the inclusion of different control variables (or subsets of the current controls).

[42] If we take the estimates at face value, the results suggests that as the value of RESEARCH QUALITY increases by one, the predicted value of MONETARY declines approximately .3.

regression and compare the results depending on whether fixed researcher effects are included. This allows us to evaluate both the equilibrium relationship between Science and wages as well as providing a glimpse at the bias arising from not controlling for ability effects. Finally, we review the regression evidence for the cardinal data more thoroughly, highlighting the robustness (or not) of each of the results as well as the ability to distinguish between more fine-grained hypotheses.

Similar to the cross-tabulation analysis with the ordinal data, we begin our analysis by examining the pairwise correlations among our key variables (Table 6). These unconditional correlations are cross-sectional and so do not control for scientist quality. It is useful to note that, in this cross-section, SALARY is statistically uncorrelated with the elements of a firm's scientific orientation (PERMIT_PUB, CONTINUE RESEARCH, and INCENT_PUB). However, SALARY is positively correlated with the BONUS associated with the offer, the availability of STOCK OPTIONS, and (more weakly) with PROMOTION opportunities. Based on these pairwise results, we ensure that our regression results are robust to their inclusion throughout.[43] In addition, the individual elements of Science are correlated positively with each other. For example, firms who provide incentives for employees to publish also tend to allow researchers to continue research projects from prior employment (an agenda-continuance effect). As a result, in Tables 7A-7C, we first explore the relationship between SALARY and each of the individual aspects of Science separately; in Table 7D, the elements are combined into a single empirical model.

In Table 7A, we examine the baseline regression of the relationship between the (natural log of) offered SALARY[44] and PERMIT_PUB (whether the employees is permitted to publish results in the public scientific literature). As mentioned earlier, this is, in some sense, the most direct test of the relationship between Science and wages; the permission to publish is the hallmark of Science as an institution. (7a-1) reports the unconditional pairwise correlation between SALARY and PERMITPUB, which is both quantitatively small (.03) and statistically insignificant. In sharp contrast, once we include individual fixed effects (7a-2), the parameter

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[43] Actually, given the high collinearity between STOCK and BONUS we include both of these variables in only some regressions and focus on the more relevant STOCK variable for the remainder.

[44] While the hedonic is in the form of ln(SALARY) throughout, the results are robust to the use SALARY level.

estimate becomes both negative and significant (-.27), both statistically and quantitatively.

These two estimates allow us to directly evaluate the salience of key effects identified in the economic model. First, at the point estimate provided in (7a-2), $\bar{g}(f\ b_S - a_S) = -.27$. In other words, at the mean human capital level in the observed sample, the Preference effect outweighs the impact of the Productivity effect and implies a 27% salary discount for Science-oriented firms. Second, the difference between the cross-sectional results and the fixed effects results provides information about the "size" of the ability bias effect. Once again taking the results from (7a-1) and (7a-2) at face value, the estimates imply (a) that we can reject the non-fixed-effect regressions and (b) that the size of the bias is approximately equal to 30% of observed average wages. Examining the distribution of the researcher fixed effects (Figure 1) illustrates the magnitude of the researcher ability effects more directly. According to Figure 1, the inter-quartile distribution ranges from a nearly 40% wage decline for the 25% scientists (relative to the median scientist) to nearly a 40% wage increase for the scientist at the 75% level. These results are perhaps even more striking when one considers that the sample *conditions* on a population of PhD holders. While the relatively small sample size and the simple specification suggest that these results should be treated with caution, the extremely large estimated magnitudes suggest that there seem to be important differences based on whether jobs incorporate PERMIT_PUB and according to the perceived ability of the researcher by the job market.

These two quite striking results in the baseline model are robust to the inclusion of several different control structures. First, consistent with the correlation patterns from Table 7, we include the PROMOTION, BONUS and STOCK variables; the coefficient on PERMIT_PUB remains negative (7a-3). As well, in (7a-4) and (7a-5), we include dummies for each type of employer type (listed in Table 3); the results suggest that the PERMIT_PUB result does not simply reflect differences between these types. In particular, this suggests that the results are not being driven purely by differences between the following organizational forms: (a) university versus private job offers or (b) established versus start-up firms. Indeed, in (7a-5), we include controls for both employer type and the other observed elements of the offer; the results are negative and of the same magnitude.

Finally, in (7a-6), the sample is restricted to include only non-academic jobs (thus we include offers from established firms, start-up firms, government labs, and medical centers in the analysis). The coefficient remains negative, though the parameter is somewhat smaller than earlier regressions and becomes only marginally significant. In other words, even if one focuses only on non-academic employment offers, the labor market for life scientists reflects a wage discount for those firms who allow their scientists to continue publication in the scientific literature.

Tables 7B and 7C employ a similar set of regressions to establish how wages are impacted by two other elements of the firm's scientific orientation (CONTINUE and INCENT_PUB). We first examine the impact of allowing the research to continue research on projects begun prior to employment. As with PERMIT_PUB, there is a marked difference in the coefficient depending on whether one controls for individual fixed effects (which result in a negative coefficient on CONTINUE). Similarly, this negative result is robust to the inclusion of the PROMOTION and STOCK_DUMMY variables. In contrast to the PERMIT_PUB result, however, this finding seems to be driven, at least in part, by differences among employer types; after one controls additionally for employer type, the coefficient remains negative but marginally loses significance at the 10% level (t=1.58).

In table 7C, we examine the relationship between SALARY and two additional elements of the firm's scientific orientation (INCENT_PUB and EQUIPMENT). With respect to the incentives to publish in the public scientific literature, the results reinforce the earlier findings and are consistent with the presence of a quantitatively significant compensating differential which reduces wages for firms who offer high levels of INCENT_PUB. As before, this result remains significant even when one restricts the sample to non-academic employers. On the other hand, using the full sample, there seems to be a wage premium associated with employment at firms who offer cutting-edge scientific equipment. However, this result is clearly not robust to the exclusion of academic employment offers, suggesting caution when interpreting this finding. As well, in contrast to Tables 7A & 7B, the results for INCENT_PUB and EQUIPMENT do not depend on the inclusion of individual fixed effects; the compensating differential is estimated to be negative even when uses the cross-sectional dimension of the dataset.

Finally, Table 7D presents two combination models which allow us to evaluate the ability to separately distinguish the separate impacts of different elements of the firm's scientific orientation. The evidence when one does not control for human capital differences is extremely ambiguous. While INCENT_PUB is negative and significant, PERMIT_PUB is positive (and nearly significant) while CONTINUE RESEARCH is positive though not significant. When one turns to the fixed effects analysis, however, the analysis consistently reflects a negative association between salary and scientific orientation. While the separate effects for INCENT_PUB and PERMIT_PUB cannot be distinguished (in every attempted regression, one was negative and significant and the other was negative but insignificant), the results suggest a joint impact for these two regressors, and also for CONTINUE and EQUIPMENT.

VII. Discussion and Conclusion

Though the sample size is small, the results strongly point towards the possibility that scientists pay a compensating differential to participate in Science. While the theoretical relationship between Science and wages is ambiguous (depending on the relative salience of the Preference and Productivity effects, and the degree of rent-sharing), the empirical evidence suggests that the balance is tilted in favor of the Preference effect, at least for researchers seeking employment as research biologists. Offers from Science-oriented firms are ranked lower in terms of their monetary compensation and indeed, this is reflected in lowered offered wages. This finding turns out to be robust across different characterizations of participation in Science and across different samples and control structures. However, the results depend critically on controlling for differences among workers in terms of their ability (which was accomplished by the introduction of the multiple job offer methodology). Indeed, cross-sectional analysis which did not include individual effects leads to a substantial upward bias on the parameter describing the empirical relationship between wages and Science.

Three additional issues stand out from this analysis. First, these results have potential implications for the estimates of the benefits from science-oriented practices in the context of prior R&D productivity studies. As discussed in Section II, prior studies have focused almost exclusively on the Productivity effect in interpreting the R&D productivity “boost” associated with science-oriented practices. Such an interpretation ignores two sources of bias: the wage-savings associated with the compensating differential and the unmeasured correlated between the adoption of scientific practices and average researcher ability. While prior researchers have acknowledged the possibility of bias (Henderson and Cockburn, 1994), the results, taken at their face value, suggest that these two effects may explain an important portion (perhaps even a majority) of the overall measured effect (which is equal to approximately a 40% productivity increase according to Henderson and Cockburn (1994)).

Consider the specification which speaks most directly to these prior results, which focused on the "Incentives to Publish in the Scientific Literature" (see Table 7C). Even in the model in which all non-academic offers are excluded, the estimated compensating differential over the full "range" of the Likert scale variable (the same comparison used by Henderson and Cockburn (1994)) is equal to 20%. Taking this as a baseline (which also corresponds to the approximate median estimates across all the specifications for all practices), the estimates imply that a Science-oriented firm will pay workers 20% less, on average; if researcher salaries compose two-thirds of overall R&D expenditures (and if we assume that the cost of participating in Science is a sunk cost unreflected in current R&D budgets), then science-oriented firms can employ nearly 15% more scientists (of equal ability), or approximately 40% of the total measured productivity effect.

In addition, the measured productivity effect is potentially biased by the fact that science-oriented firms employ better researchers who both have higher returns to participation in Science and will be associated with higher R&D productivity (see FN 28). Indeed, while we cannot estimate the magnitude of this bias without a full examination of the relationship between Science and *accepted* job offers, a preliminary analysis suggests that there is a significant correlation (.24) between the estimated fixed effect (drawn from the sample in Figure 1) and the probability of accepting a job with PERMIT_PUB = 1. While this calculation is obviously preliminary, it suggests the possibility that the R&D productivity results do in fact reflect some degree of unmeasured ability bias.

Taken together, the evidence suggests a potentially important role for ability bias and compensating differentials in understanding the productivity results. Of course, it is possible that the results depend on the fact that the sample is drawn from an "extreme" case – biologists with PhDs are perhaps uniquely associated with a "taste" for Science. While the generality of these results to a wide sample of biologists, to other scientific disciplines, and to researchers without their PhD, remains an open area for future research, it should be highlighted that life sciences researchers now compose over one-third of *all* graduating PhDs in the natural sciences (National Science Foundation, 1999).

Beyond the direct application of these results to research on the productivity and labor market consequences of participation in Science, the framework and empirical results may have more general implications for future research on the economics of science and technical change and for public policy analysis. Specifically, while there is broad (though not unanimous) agreement that basic research of some type should be subsidized as the result of the appropriability issues, the exact form of that subsidy is much more contentious (Wright, 1983). While much public policy discussion argues that researchers – even basic researchers – should be evaluated on their ability to long-term commercial consequence of their research proposals (Committee for Economic Development, 1998), others contend that the peer-reviewed scientific research funding and publication system operates according to an internal logic which can be easily undermined by providing high-powered explicit incentives for applied commercial output (David and Dasgupta, 1994; Nelson and Rosenberg, 1994). The plausibility of this latter view is made much more salient in the presence of a distinct "taste" for Science on the part of researchers. Indeed, from an extreme perspective, one could argue that the peer-reviewed funding and publication system is in fact more efficient, even from a purely commercial perspective. If there is a significant compensating differential under such a system, then the total amount of scientific research per dollar of expenditure will be higher under this latter system; as long as the level of spillovers per unit of scientific research are not sufficiently lower under peer review than under the more focused system, then the total spillover into technological innovation may be *increasing in the degree of insulation from commercial incentives*.

Finally, perhaps the key finding of this paper is that a professional ethic – participation in the public scientific community – has real effects on an economic observables (the wage) and may have effects on observed productivity. The relatively large quantitative impact of this is particularly surprising since, as opposed to most on-the-job amenities (such as safety or benefits programs), a "taste" for Science is most likely not universally shared among all workers but is concentrated among workers in research-oriented careers. Moreover, scientists are by no means the only professional community in which *profession-specific* values may influence behavior. For example, if physicians claim to value the health of their patients (as they often do), do physicians *pay* to cure their patients? In particular, do HMOs who offer higher-quality health care (in terms of fewer restrictions on costly procedures and the like) extract a discount on the salary they offer new physicians as a result of their pro-patient reputation? Similarly, lawyers often claim to value justice in the legal system. Is this reflected in lower wages for those firms who participate in pro bono activities or who are more directly involved in courtroom activity or appellate work (as opposed to corporate law)? Perhaps surprisingly, following the seminal study of Friedman and Kuznets (1954), there has been almost no systematic economic analysis of the impact of professional ethics on labor markets (though Weisbrod (1983) is an interesting (though not dispositive) exception). This paper provides something of a foundation to perform these future studies.[45] Similar to the current context, accounting for human capital effects will be paramount in any professional labor market; however, the multiple job offers methodology will also apply in these markets. The average law student receives several job offers during their law school career, and, after residency, many physicians receive multiple offers from different HMOs. Moreover, relative to the number of postdoctoral biologists seeking first-time employment in the private sector, law schools and medical residencies offer potentially much larger cohort populations from which to gather data on multiple job offers. Such studies are left for future research.

[45] For example, Miller (1999) employs the multiple job offers methodology to evaluate the value placed on diversity and mentoring programs by minority MBA candidates. While not a profession-specific intrinsic preference, Miller highlights how the methodology can be extended to evaluate the economic impact of group-specific preferences.

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TABLE 1
VARIABLES & DEFINITIONS

VARIABLE	DEFINITION
JOB MARKET EXPERIENCE	
# OFFERS RECVD	Number of offers received
JOB OFFER ORDINAL COMPARISON RANKINGS (1=highest)	
MONETARY	Ranking of offer in terms of monetary compensation
RESEARCH QUALITY	Ranking of offer in terms of internal research environment
FLEXIBILITY	Ranking of offer in terms of flexibility to choose research projects
FUNDING	Ranking of offer in terms of availability of research funding
CAREER	Ranking of offer in terms of impact on career advancement
JOBFIT	Ranking of offer in terms of how well it 'fits' with prior research experience
JOB OFFER CARDINAL RECORD INFORMATION	
JOB TYPE	1= Established Firm, 2= Startup Firm, 3= Government, 4=Medical School or Medical Center, 5=University, 6=Postdoc
SALARY	Annual starting salary (in US Dollars)
BONUS	Signing bonus and relocation (in US Dollars)
STOCK_DUMMY	Job offer includes stock options = 1, No = 0
PERMIT_PUB	Permission to publish in outside journals = 1, No permission = 0
INCENT_PUB	Likert Scale rating (1-5) of incentives to publish in refereed outside journals
EQUIPMENT	Likert Scale rating (1-5) of access to "cutting-edge" equipment
CONTINUE RESEARCH	Job allows continuation of current research project = 1, No = 0
PROMOTION	Likert Scale rating (1-5) of opportunities for internal promotion

TABLE 2
MEANS & STANDARD DEVIATIONS

	N	MEAN	STANDARD DEVIATION
JOB MARKET EXPERIENCE			
# OFFERS RECVD	166	2.51	1.032
JOB OFFER ORDINAL COMPARISON RANKINGS (1=highest)			
MONETARY	136	1.949	0.984
RESEARCH QUALITY	125	1.888	0.986
FLEXIBILITY	117	1.897	0.977
FUNDING	119	1.916	0.996
CAREER	132	1.947	0.983
JOBFIT	118	1.898	1.008
JOB OFFER CARDINAL RECORD INFORMATION			
Monetary Compensation			
SALARY	123	61958.85	31394.96
BONUS	73	8.19	15.77
STOCK_DUMMY	74	0.37	0.48
Scienentific Orientation Indicators			
PERMIT_PUB	116	0.91	0.28
INCENT_PUB	105	3.88	1.13
EQUIPMENT	113	4.06	0.86
CONTINUE RESEARCH	113	0.46	0.50
PROMOTION	112	3.48	1.29

TABLE 3
DISTRIBUTION OF JOB OFFERS

Job Category	Description	No of Offers
1	Established Firm	40
2	Startup Firm	28
3	Government	6
4	Medical Center	37
5	University	34
6	Postdoc	21
Total		166

TABLE 4
CROSS TABULATIONS: JOB OFFER COMPARISON RANKINGS
(Rank = 1 is highest)

Table 4a: Money and Jobfit

MONETARY (Ranking of monetary compensation)	**JOB FIT** (Ranking of offer in terms of how well it ‘fits’ with prior research experience)					
	1	2	3	4	5	6
1	**20**	**14**	**2**	**2**		
2	**19**	**17**	**5**	**1**		
3	**5**	**5**	**8**			
4		**2**	**1**	**4**		
5						**1**
6					**1**	

Table 4c: Money and Research Environment

MONETARY (Ranking of monetary compensation)	**RESEARCH QUALITY** (Ranking of offer in terms of internal research environment)					
	1	2	3	4	5	6
1	**19**	**20**	**5**	**3**		
2	**26**	**15**	**4**	**1**		
3	**6**	**6**	**8**	**1**		**1**
4	**1**	**2**	**3**	**1**	**1**	
5		**1**				
6	**1**					

Table 4b: Money and Career Advancement

MONETARY (Ranking of monetary compensation)	**CAREER** (Ranking of impact on career advancement)					
	1	2	3	4	5	6
1	**26**	**20**	**3**	**1**		
2	**20**	**25**	**3**	**2**		
3	**4**	**3**	**13**	**1**		**1**
4		**4**	**1**	**3**		**1**
5					**1**	
6				**1**		

Table 4d: Money and Flexibility

MONETARY (Ranking of monetary compensation)	**FLEXIBILITY** (Ranking of offer in terms of flexibility to choose research projects)					
	1	2	3	4	5	6
1	**16**	**19**	**8**	**1**		
2	**25**	**17**	**2**	**1**		
3	**5**	**5**	**8**	**1**		**1**
4	**2**	**1**	**1**	**2**		
5					**1**	
6		**1**				

TABLE 5
REGRESSION: JOB OFFER COMPARISON RANKINGS

	(5-1)	(5-2)	(5-3)	(5-4)	(5-5)
Dependent Variable	**MONETARY**				
Sample	All Job Types	Exclude Academic Job Offers*	All Job Types	Exclude Academic Job Offers*	All Job Types
RESEARCH QUALITY	**-0.34** **(0.12)**	**-0.32** **(0.16)**			**-0.27** **(0.12)**
FLEXIBILITY			**-0.39** **(0.13)**	**-0.27** **(0.19)**	**-0.30** **(0.13)**
JOBFIT	**0.20** **(0.12)**	**0.29** **(0.16)**	**(0.32)** **(0.12)**	**0.35** **(0.17)**	**0.27** **(0.12)**
CAREER	**0.23** **(0.12)**	-0.04 (0.16)	**0.30** **(0.13)**	0.04 (0.18)	**0.33** **(0.13)**
FUNDING	**0.34** **(0.13)**	**0.26** **(0.17)**	0.17 (0.12)	0.18 (0.17)	**0.28** **(0.13)**
Controls					
Individual Dummies	(53)	(42)	(53)	(42)	(53)
Regressions Statistics					
R-squared	0.49	0.53	0.49	0.50	0.52
# of Observations	136	88	136	88	136

Notes: Only persons with multiple job offers are included in the regressions
Standard errors shown in parenthesis
Sig. = significant at 10% level.
* Regressions 5-2 and 5-4 exclude postdoctoral positions and job offers from universities and medical centers.

TABLE 6
CORRELATION OF
JOB OFFER RECORD DATA

	SALARY	PERMIT_PUB	CONTINUE RESEARCH	INCENT_PUB	EQUIPMENT	BONUS	PROMOTION
SALARY	1.0000						
PERMIT_PUB	0.0042	1.0000					
CONTINUE RESEARCH	-0.0881	0.0224	1.0000				
INCENT_PUB	-0.1522	0.2541*	0.2666*	1.0000			
EQUIPMENT	0.0966	-0.0035	-0.0068	0.2633*	1.0000		
BONUS	0.2935*	0.0732	0.1162	0.0941	0.1713	1.0000	
PROMOTION	0.1534	-0.0538	0.1878*	0.0118	0.1089	0.2524*	1.0000

* = significant at 5%

TABLE 7A
HEDONIC WAGE REGRESSION: PERMISSION TO PUBLISH

DEPENDENT VARIABLE = LN(SALARY)

	(7a-1)	(7a-2)	(7a-3)	(7a-4)	(7a-5)	(7a-6)
	Baseline (NO FE)	**Baseline** (w/ FE)	**Include Promotion, Bonus and Stock Options** (w/ FE)	**Include Job Type** (w/ FE)	**Full Model** (w/ FE)	**Full Model excluding Academic Job Offers*** (w/ FE)
PERMIT_PUB	0.03 (0.18)	**-0.27** **(0.11)**	**-0.24** **(0.10)**	**-0.18** **(0.10)**	**-0.18** **(0.10)**	**-0.14** **(0.08)**
CONTROLS						
PROMOTION			**0.06** **(0.02)**		**0.04** **(0.02)**	0.04 (0.03)
BONUS			**0.004** **(0.002)**		**0.003** **(0.002)**	-0.002 (0.004)
STOCK_DUMMY			**0.25** **(0.07)**		**0.19** **(0.08)**	0.09 (0.07)
JOBTYPE CONTROLS				YES	YES	
INDIVDIUAL FIXED EFFECTS	NO	YES (54; Sig.)	YES (54; Sig.)	YES (54; Sig.)	YES (54; Sig.)	YES (43; Sig.)
Regressions Statistics						
R-squared	0.009	0.92	0.95	0.94	0.96	0.97
# of Observations	123	123	123	123	123	84

Notes: Only persons with multiple job offers are included
Standard errors shown in parenthesis
Sig. = significant at 10% level.
* Regression 7a-6 excludes postdoctoral positions and job offers from universities and medical centers.

TABLE 7B
HEDONIC WAGE REGRESSION:
OPPORTUNITY TO CONTINUE Ph.D./POSTDOCTORAL RESEARCH

Dependent Variable	LN(SALARY)			
	(7b-1)	(7b-2)	(7b-3)	(7b-5)
	Baseline (NO FE)	**Baseline** (w/ FE)	**Include Promotion and Stock Options** (w/ FE)	**Full Model** (w/ FE)
CONTINUE RESEARCH	-0.01 (0.10)	**-0.25 (0.07)**	**-0.18 (0.06)**	-0.11 (0.07)
CONTROLS				
PROMOTION			**0.05 (0.02)**	**0.04 (0.02)**
STOCK_DUMMY			**0.25 (0.07)**	**0.17 (0.08)**
JOBTYPE CONTROLS				YES
INDIVDIUAL FIXED EFFECTS	NO	YES (54; Sig.)	YES (54; Sig.)	YES (54; Sig.)
R-squared	0.05	0.92	0.94	0.95
# of Observations	123	123	123	123

Notes: Only persons with multiple job offers are included
Standard errors shown in parenthesis
Sig. = significant at 10% level.

TABLE 7C
HEDONIC WAGE REGRESSION:
EQUIPMENT AND INCENTIVES TO PUBLISH

Dependent Variable	LN(SALARY)			
	(7c-1)	(7c-2)	(7c-3)	(7c-4)
	Baseline (NO FE)	**Baseline** (w/ FE)	**Include Promotion and Stock Options** (w/ FE)	**Full Model Excl. Academic Job Offers*** (w/ FE)
INCENT_PUB	**-0.13** **(0.05)**	**-0.07** **(0.03)**	**-0.06** **(0.03)**	**-0.05** **(0.03)**
EQUIPMENT	0.09 (0.06)	**0.10** **(0.03)**	**0.07** **(0.03)**	-0.005 (0.04)
CONTROLS				
PROMOTION			**0.044** **(0.020)**	0.041 (0.026)
STOCK_DUMMY			**0.23** **(0.07)**	0.04 (0.07)
INDIVDIUAL FIXED EFFECTS	NO	YES (54; Sig.)	YES (54; Sig.)	YES (43; Sig.)
R-squared	0.11	0.94	0.95	0.97
# of Observations	123	123	123	84

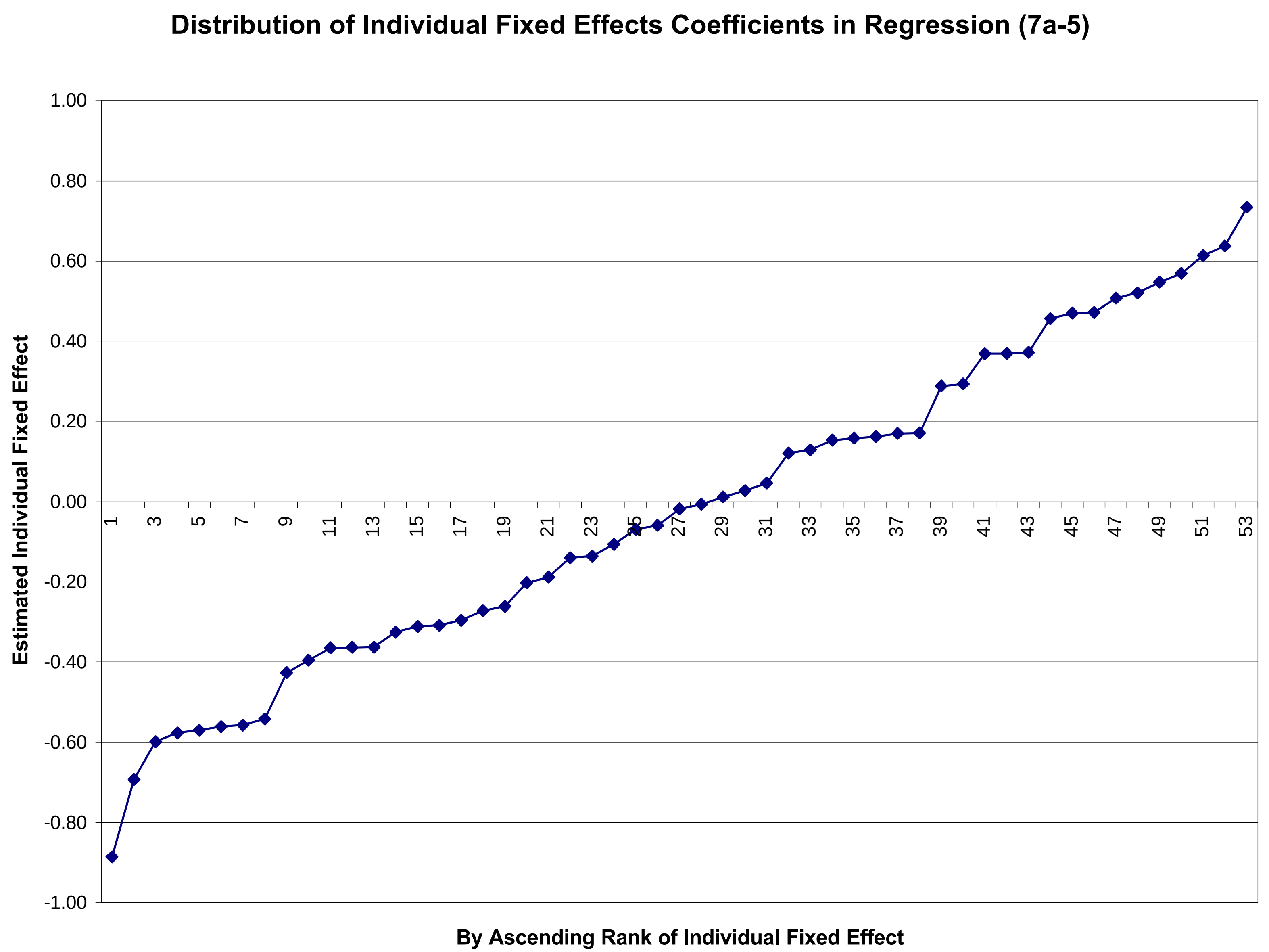
Notes: Only persons with multiple job offers are included
Standard errors shown in parenthesis
Sig. = significant at 10% level.
* Regression 7c-4 excludes postdoctoral positions and job offers from universities and medical centers.

TABLE 7D
HEDONIC WAGE REGRESSION:
COMBINATION MODELS

Dependent Variable	LN(SALARY)	
	(7d-1)	(7d-2)
	Baseline (NO FE)	**Baseline** (w/ FE)
PERMIT_PUB	0.30 (0.19)	-0.06 (0.11)
CONTINUE RESEARCH	0.12 (0.10)	**-0.17** **(0.06)**
INCENT_PUB	**-0.16** **(0.05)**	**-0.05** **(0.03)**
EQUIPMENT	0.09 (0.06)	**0.10** **(0.03)**
CONTROLS		
INDIVDIUAL FIXED EFFECTS	NO	YES (54; Sig.)
R-squared	0.16	0.94
# of Observations	123	123

Notes: Only persons with multiple job offers are included
Standard errors shown in parenthesis
Sig. = significant at 10% level.

FIGURE 1



Number of Individuals = 53

APPENDIX A

The Job Market Survey for Life Science Researchers

Principal Investigator: Professor Scott Stern, MIT Sloan School & NBER
Research Assistants: Kwanghui Lim, Amalia Miller

The goal of this project is to evaluate how organizations recruit life science researchers. We are exploring the components of job offers provided to candidates, and how candidates choose among competing job packages. Our focus is on the tradeoffs between monetary and non-monetary elements of the job package. Among candidates with more than one job offer, we are analyzing differences in packages offered to the same individual and how candidates choose among competing offers.

Enclosed is a survey which we are administering to life sciences researchers. The survey requests information about each job offer that you have received in your current job search and requires at most 25 minutes to complete. If you are not yet on the job market or have not yet received a job offer, please retain this survey until you receive offers. The survey is divided into five parts:

- Background information (a resume can be substituted for this section)
- Job market experience
- Job offer comparisons
- Job Offer Record(s)
- Factors affecting job choice
- Compensation choice and future contact

Please detail each job offer you have received in a Job Offer Record. Four are enclosed; if you have received more than four job offers, please make and complete additional copies of the Job Offer Record.

Each participant will receive a small gift (see Section VI) as well as a copy of the completed analysis. Participation in this study is entirely **voluntary**, and you can decline to answer any questions or decline further participation at any time without prejudice. Responses will be kept both **confidential** and **anonymous** (your name and address will only be used to process your compensation and will be deleted thereafter). Please return this survey and direct inquiries to:

Professor Scott Stern
MIT Sloan School
E52-554
Cambridge, MA 02142
TEL: 617-253-5219
FAX: 617-253-2660
e-mail: sstern@mit.edu

Thank you for your participation!

The Job Market Survey for Life Sciences Researchers

PART I. **BACKGROUND** (You may skip this section by attaching a resume)

Sex: ☐Male ☐Female (please check ✓)

Marital status: ☐Married ☐Unmarried

Age: ______ Nationality: ____________________

Number of children: ______ Race (optional): ____________________

Current employer: ____

Current lab affiliation: ____

Expiration date of current funding: Month: ____ Year: _____

Previous degrees	Institution	Field of Study	Year Granted
BA/BS	________________________	______________________	____________
MA/MS	________________________	______________________	____________
PhD	________________________	______________________	____________
MD	________________________	______________________	____________
Other (_______)	________________________	______________________	____________

PART II. **JOB MARKET EXPERIENCE**

- How many jobs have you formally applied for (by letter, e-mail, or through a formal interview)? ___________ Applications
- When did you start your current job search (by sending out a resume, application, or participating in a formal interview)? Month: _____ Year: _____
- What was the length of time between the start of your job search and the receipt of your first offer? ________ Months

Have you already accepted a job offer? ☐ Yes ☐ No

If yes, which offer did you accept?

Name of Organization: ________________________________

Job title: ________________________________

IV. JOB OFFER RECORD

Please complete one per offer you received

Name of organization: ______________________ Department/Division: __________________

Location (City/State): ___________ /____ Job title: ______________________________

- Did you send a resume or job application letter to this organization? Yes ☐ No ☐
- Did you personally know any member of this organization prior to your job search? ☐ Yes ☐ No
- What aspects of your scientific background will you use in this job?
  ☐ None ☐ Disciplinary principles ☐ Doctoral research ☐ Postdoctoral research
- Will you continue your current research projects at this job? ☐ Yes ☐ No

Please rate this job along the following dimensions:

		LOW				HIGH
Overall impact on career advancement (internal or external)	N/A	1	2	3	4	5
Opportunities for internal promotion	N/A	1	2	3	4	5

A. MONETARY COMPENSATION

Annual (12 month) starting salary: $_______________

Signing bonus + relocation allowance: $_______________

Maximum bonus in 1st year of employment: $_______________ (excluding salary)

Stock option plan (describe): ____

B. RESEARCH ENVIRONMENT

Please rate this job along the following dimensions:

		LOW				HIGH
Quality of internal research environment	N/A	1	2	3	4	5
Flexibility to choose research projects	N/A	1	2	3	4	5
Incentives to present & publish scientific research	N/A	1	2	3	4	5
Availability of “cutting-edge” technologies/equipment	N/A	1	2	3	4	5
Availability of research funding	N/A	1	2	3	4	5
Work on joint research with university researchers	N/A	1	2	3	4	5
Work on joint research with other external researchers	N/A	1	2	3	4	5

Do you have permission to publish scientific results in refereed journals? ☐ Yes ☐ No
Does the company sponsor an in-house seminar series? ☐ Yes ☐ No
Does the company sponsor continuing education? Yes ☐ No ☐

Number of paid research conferences attendances per year ______
What share of your time will be devoted to: Company research _____% Individual research _____% Other _____%
Number of technicians and junior researchers reporting to you ______

C. BENEFITS PACKAGE

Health care insurance ☐ Yes ☐ No
Paid pregnancy leave ☐ Yes ☐ No
On-site day care facilities ☐ Yes ☐ No
Number of days of paid: Vacation _____ Sick ______ Personal ______
No. of people you share an office with: ☐ 0(own office) ☐ 1 ☐ 2 ☐ more than 2

Other benefits (list) ____

____

PART V. FACTORS AFFECTING JOB CHOICE

From the following list of factors, please rank the top *three* in terms of their importance to you in choosing a job.

FACTORS	**Rank the top three factors (1 = Highest, 3 = Lowest)**
Monetary compensation	________
Quality of organization's internal research environment	________
Availability of research funds	________
Flexibility to choose research projects	________
Opportunity to interact with outside researchers	________
Incentives to publicly present and publish scientific research	________
Non-monetary benefits (Health, Daycare, Vacation, etc…)	________
Geographic location	________
Family concerns (e.g., spouse or family location)	________
Other (describe) _______________________	________

Imagine that you received job offers from two organizations. The first has an ideal research environment, while the second has a minimally acceptable research environment. How much more must the second organization pay you in order for you to accept its offer?

$_____________

Why?

____

____

PART VI. COMPENSATION CHOICE AND FUTURE CONTACT

- How would you like to be compensated for this survey? (choose one)
  - ☐ Starbucks' gift certificate ($10)
  - ☐ CDNOW digital gift certificate ($10)
  - ☐ Amazon.com digital gift certificate ($10)

- If you have not yet accepted an offer, can we contact you again? ☐Yes ☐ No
- How?
  - ☐ E-mail: ___________________________________
  - ☐ Phone: ___________________________________

Thank you for your participation in this survey !!!

PART III. JOB OFFER COMPARISON

	Each column lists a dimension of the job offer. Please rank your offers along these dimensions. (1 = Highest, 2=2nd Highest, and so on)							
Name of Organization	Overall monetary compensation	Overall impact on career advancement	Overall benefits package	Quality of internal research environment	Availability of research funding	Flexibility to choose research projects	Incentives to present & publish scientific research	Degree of "fit" between job and prior scientific background
Job Offfer Comparison Example								
Ivy Medical Center	*1*	*2*	*3*	*3*	*3*	*1*	*2*	*2*
Silicon Biotech	*2*	*1*	*2*	*2*	*2*	*3*	*1*	*3*
ViagraPharm Inc.	*3*	*3*	*1*	*1*	*1*	*2*	*3*	*1*
Job Offer Comparison Record								

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