What Makes Them Tick?
Employee Motives and Firm Innovation

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ABSTRACT

With few exceptions, empirical innovation research has focused on firm-level pecuniary incentives. Innovation at the firm-level, however, should also depend heavily on the level and quality of individual effort in response to individuals' pecuniary as well as non-pecuniary incentives. In this paper, we examine the impact of individual-level motives and incentives upon innovative effort and performance. Based on research in economics and social psychology, we first develop a basic model of the impact of extrinsic, intrinsic, and social incentives on individuals' innovative effort and performance. Using a survey-based data set (SESTAT 2003), we then present descriptive data on the motives salient to personnel in industrial R&D and test predictions derived from our model. In doing so, we control for a wide range of other variables at the individual, firm, and industry level that have been considered in prior innovation research. We find that individuals engaged in industrial R&D have strong extrinsic, intrinsic, and social motives and that there are systematic differences in these motives across types of individuals and work settings. Motives have significant effects upon innovative effort and performance. These effects vary significantly, however, depending on the particular kind of motive (e.g., intellectual challenge vs. pay). We also find that intrinsic and extrinsic motives affect innovative performance even when controlling for effort, suggesting that motives affect not only the quantity of effort individuals exert, but also the innovative productivity of that effort. Overall, intrinsic motives (in particular, intellectual challenge) appear to be at least as beneficial for innovation as extrinsic motives (e.g., pay). Our results suggest important implications for management and public policy, as well as interesting avenues for future research on innovative activity and performance in organizations.

1 Introduction

Dating from the 1950's and early 1960's, economists such as Jacob Schmookler (1962), Zvi Griliches (1957), Richard Nelson (1959) and Kenneth Arrow (1962) have argued that the rate and direction of technological change could be understood as the outcome of firms' rational, profit-driven investment in innovation. In making the case for the primacy of profit as a driving force behind technical change, economists sensibly focused scholars' attention on firms and their profit incentive since firms are indeed responsible for both a good deal of innovation, and particularly its commercialization. In doing so, they subordinated consideration of the impact of individuals and their motives on technical advance.

The pecuniary and nonpecuniary motives of individuals may, however, have important effects on industrial innovation. Schumpeter's (1934; 1943) writings, for example, suggest a critical role of individuals' pecuniary as well as nonpecuniary incentives for entrepreneurship and innovative activity. Case studies have also illustrated the power of nonpecuniary individual-level incentives for innovation and have shown that these incentives may even dominate competing firm-level incentives (e.g., Katz, 1993; Kidder, 1981). Recent explanations of the "paradox" of open source software development, namely that programmers develop software code despite the apparent absence of financial gain, have also highlighted the role of individual, and especially nonpecuniary, incentives associated with software innovation (Hertel, Niedner, & Herrmann, 2003; Lakhani & von Hippel, 2003; Lerner & Tirole, 2005).[1] Finally, the sociology and economics of science has long featured the importance of individual-level motives such as intellectual challenge, curiosity and peer recognition, and, more recently, even pecuniary rewards, in affecting the advance of science (Dasgupta & David, 1994; Merton, 1973; Stephan, 1996; Stephan & Levin, 1992; Zuckerman, 1988). Although these literatures suggest an important role of individual-level incentives for innovation, there is a dearth of empirical research on the importance of individual incentives for industrial innovation.

In this paper we examine the motives of individuals employed in industrial R&D and study the impact of those motives on individuals' innovative effort and performance. Drawing from social science broadly, we consider the role of individual-level motives in industrial

[1]While some scholars suggest extrinsic benefits in the form of higher expected future earnings stimulate these efforts (Lerner & Tirole, 2005), other scholars emphasize nonpecuniary benefits such as intrinsic pleasure, ego gratification and peer recognition (Hertel et al., 2003; Lakhani & von Hippel, 2003; Lerner & Tirole, 2005). There is, however, no consensus as to the relative importance of the impact of these different types of benefits and associated motives.

innovation by developing and testing a simple model of the impact of both pecuniary and nonpecuniary motives on innovation. In our empirical analysis, we first present descriptive data on the motives of over 11,000 scientists and engineers employed in for-profit firm R&D in a wide range of industries. Guided by our model, we then examine the relationship between employee motives and, respectively, innovative effort and performance. To prefigure our key result, we find that individual-level motives, and especially nonpecuniary motives, significantly impact innovative processes and outcomes.

2 Incentives and the economics of innovation

2.1 Why study individuals' incentives?

A key reason to go beyond firm-level incentives to consider the motives of R&D employees to enrich our understanding of the drivers of innovation is that firms' R&D personnel exercise substantial autonomy--arguably more than other types of employees. This autonomy is generally desirable from the firm's perspective since there is typically uncertainty about how to tackle technical challenges and R&D employees are often more expert than management in their particular fields - and almost always more expert about any particular problem at hand. In addition, effort and performance in R&D are hard to observe and measure, further diminishing the effectiveness of conventional control systems (Hauser, 1998; Ouchi, 1979). Thus, R&D labs are settings where there is significant delegation of authority to individual employees (cf. Foss & Laursen, 2005; Prendergast, 2002). As a consequence, the innovative performance of a firm may be affected by the motives of its R&D personnel, especially if those motives are misaligned with the firm's interests, but also if those motives complement the goals of the firm, in which case superior innovative performance should be achievable by the firm at lower cost (cf. Stern, 2004; Teece, 2003).

Although the impact of individual motives on industrial innovation has been little studied empirically - with Stern (2004), Zenger (1994) and Gambardella et al. (2006) the exceptions - economic theorists have considered implications of individual incentives for firm performance. Typically assuming that employees' incentives are pecuniary, that individuals prefer leisure over work, that individuals' incentives are contractible, and that there is information asymmetry between the employee and the employer, economic theorists have considered how firms should structure contracts with individual employees (i.e., agents) to align their behavior as much as possible with the interests of the firm (i.e., the principal) (Gibbons, 1998; Prendergast, 1999). Of late, economic theorists have begun to entertain the implications of agents' nonpecuniary, intrinsic motives for institutional design and performance, highlighting the different impacts of nonpecuniary and pecuniary motives (e.g., (Akerlof & Kranton, 2005; Besley & Ghatak, 2005; Murdock, 2002). However, with few exceptions, the existing empirical work tends to focus on pecuniary incentives alone (for a review, see Jenkins, Mitra, Gupta, & Shaw, 1998; see also Lazear, 2000; Leonard, 1990; Lerner & Wulf, 2006) and has yet to subscribe to a broader notion of individuals' motives and incentives. Such a broader view may be particularly important for industrial R&D since survey data highlight at least the prevalence - if not the effects - of nonpecuniary motives among R&D personnel. The General Social Survey (GSS) of the University of Chicago's National Opinion Research Center, for example, shows that for scientific and engineering professionals, the nonpecuniary motives of the desire for challenge at work and need for achievement score more highly than pecuniary motives, and such motives loom significantly larger for scientific and engineering professionals within firms than for production workers (Cohen & Sauermann, 2007; GSS, 2001).

2.2 Employee incentives and innovation

2.2.1 Definitions

We start from the premise that an individual's motivation to perform a given activity depends upon the expected benefits from engaging in that activity as well as the individual's *preferences* for these benefits.[2] We refer to these preferences for contingent work benefits as *motives*. Contingent benefits for which a particular individual has a positive preference can potentially motivate actions and are called *incentives*.[3] We will follow social psychologists' classification of benefits and motives as either extrinsic or intrinsic (e.g., Amabile, 1996; Gagne & Deci, 2005; Ryan & Deci, 2000; Sauermann, 2005). To these two classes, we add a third class, social benefits. Social benefits, per the definition below, overlap with intrinsic and especially extrinsic benefits; indeed, one might argue that most of those extrinsic benefits that are nonpecuniary are largely social.[4] We distinguish them from the other two classes for

[2] For simplicity, we do not consider factors that are negatively valued by individuals (e.g., punishments). One could easily extend our discussion to include such factors.

[3] Our definitions are very similar to those used by the Merriam-Webster dictionary, which defines a *motive* as "something (as a need or desire) that causes a person to act" and an *incentive* as "an external influence (as an expected reward) inciting to action." (Definition accessed online on 8/21/2006).

[4] A similar distinction across extrinsic, intrinsic and social benefits has been made in the sociology of science by Stephan and Levin (1992), who emphasize the importance to scientists of "gold" (extrinsic benefits), "puzzles" (intrinsic benefits) and "ribbons" (social benefits).

the pragmatic reason that they are often not as readily managed as extrinsic, pecuniary benefits and that they are, in contrast to pecuniary benefits, tied to a specific social context (Sauermann, 2007). We characterize each of these three classes of benefits in turn.

Extrinsic benefits are provided by some environmental entity such as a market or actor such as an employer, a superior, a judging body, or a customer, typically conditional upon an evaluation of the task outcome. These benefits do not result directly from engaging in the task, but are indirect task outcomes. Extrinsic benefits are those often considered by economists, and within this class of benefits, economists typically focus on those which are pecuniary. Examples of extrinsic benefits from R&D include monetary or other tangible rewards such as pay raises, royalty income from patents, research funding, or a paid vacation.

Intrinsic benefits originate within the individual or the activity itself - not the environment - and are often a function of the interaction between characteristics of the activity (e.g., challenge of the task) and of the individual (e.g., interest in the task).[5] Some intrinsic benefits, such as task enjoyment and intellectual challenge, are realized directly from the process of engaging in certain activities and are thus effort-contingent (Amabile, 1996; Stephan, 1996). Others, such as a feeling of achievement, mastery or self-competence, result directly from task performance and task outcomes.

Social benefits encompass intangible benefits that originate from social relations and associated perceptions that stand outside the task itself. Some of these social benefits are provided informally by others (e.g., social approval, peer recognition) or more formally through institutionalized "award" systems. Social benefits may rely upon explicit recognition by one's peers or others who stand outside of one's organization, as illustrated by the importance that academics often attach to the number of citations that their publications command. Other social benefits are self-administered. For example, individuals may derive pleasure from contributing to the well-being of individuals with whom they have a social relationship (Fehr & Falk, 2002; Fehr & Fischbacher, 2002). Such social incentives may be particularly important in teams or organizations to the extent that members develop a high degree of cohesion and mutual commitment (Alvesson, 2000; Kidder, 1981; O'Reilly, 1989; Ouchi, 1979). Indeed, Hamilton et al. (2003) suggest that some of the apparent productivity benefits observed for teams in a production environment may be due to nonpecuniary

[5] This implies that many intrinsic benefits, unlike extrinsic and social benefits, do not exist independently from a "reference" individual, and a given work attribute may provide an intrinsic benefit in the eyes of one employee but not of another. For example, a particular research question may appear highly interesting to one researcher (and that researcher will derive intrinsic benefits from working on that question), while it appears boring to

rewards associated with team membership. To the extent that individuals internalize social benefits, they come to resemble intrinsic benefits in that their realization does not then depend on any external agents or institutions. Such internalized social benefits also resemble the norms highlighted recently by Akerlof and Kranton (2005). This implies that social benefits can stem from outside as well as from within the individual (e.g., peer recognition vs. satisfaction from having contributed to the team) and thus can be both extrinsic and intrinsic in nature. The important point, however, is that social benefits are closely tied to a particular social context, which can have important implications for managers' ability to shape and manage them.

This typology of benefits, distinguishing across extrinsic, intrinsic, and social benefits, is clearly too broad given that each of these still encompass a heterogeneous set of benefits with potentially unique roles in the innovation process. In addition, most activities may result in several different types of benefits, often making it difficult to single out a particular motive as the sole driver. For example, consider scientific competition. It may be driven by extrinsic benefits associated with career advancement or financial rewards, social benefits in the form of peer recognition, or intrinsic benefits in the form of feelings of superiority and domination. The broad distinction across extrinsic, intrinsic, and social benefits is nevertheless useful to underscore that different motives can apply to R&D employees, and these different motives, in turn, can originate from distinct sources.

2.2.2 Influence of motives and incentives on innovative effort and performance

Assuming that R&D employees have some discretion over how much they actually work, all three classes of motives can stimulate individuals to expend more innovative effort. One might reasonably assume that the effect of these different motives and associated contingent benefits on effort is additive. In this case, one type of incentive may substitute for another, which implies, for example, that firms should be able to pay more intrinsically or socially motivated R&D employees less by allowing them to satisfy these nonpecuniary motives.[6] Indeed, such an inference is suggested by Stern's (2004) finding that new biology Ph.D.'s taking jobs in pharmaceutical R&D labs were willing to accept, on average, 25%

another. Our understanding of the factors driving individual differences in general levels of curiosity as well as which particular problems individuals find interesting is quite limited (Loewenstein, 1994).

[6]Teece (2003) notes that management may well consider the exploitation of "culture", at least partly encompassing nonpecuniary incentives, as management "control on the cheap." He states: "If individuals can be motivated and directed without pecuniary incentives and the exercise of authority, tremendous resource savings can ensue and the innovation processes can avoid the burdens of bureaucracy." (p. 148)

lower salaries if prospective employers allowed them to pursue more academic-like science, publish and participate in the scientific community. Complicating, however, the presumption of simple additivity, experimental work in social psychology suggests an interaction of extrinsic rewards and intrinsic motives; that extrinsic rewards may under certain conditions "crowd-out" intrinsic motivation (Amabile, 1996; Deci, Koestner, & Ryan, 1999; Frey & Jegen, 2001; Wiersma, 1992). Such an interaction would imply, for example, that the net effect of providing an extrinsic reward to an intrinsically motivated individual could be a reduction in effort. Although the psychological mechanisms behind the crowding-out effect remain unclear, and there is only limited evidence of crowding-out in organizational settings (Frey & Jegen, 2001), this effect may be particularly relevant to R&D where intrinsic motives are prominent. [7]

In addition to conditioning the level of effort, the psychology literature concerned with the impact of incentives and motivation on cognition implies that motives and incentives may affect the *quality* or nature of innovative effort as well. More generally, there is substantial experimental research in psychology on the effect of incentives - especially manipulable pecuniary incentives - on different cognitive functions. A review by Camerer and Hogarth (1999) suggests, for example, that pecuniary incentives in laboratory settings have been found to improve some features of individuals' cognition, including memory, recall and simple problem-solving functions. The authors also note, however, that pecuniary incentives in particular can have different effects, depending upon the nature of the task at hand, and the capabilities of the individual. A key implication of this literature for our purpose is that the quality of mental effort may be responsive to both motives and the expectations of some contingent reward from a mental task. Thus, if we think of the level of innovative effort in terms of the time an individual spends on a task, then stronger motives or incentives can conceivably affect the nature and quality of that effort, and, in turn, individual innovative performance.

Amabile and colleagues focus on the impact of the nature of motivation on creativity in particular. In early work, they argue that intrinsic motivation in particular may stimulate creativity by supporting riskier and more exploratory thinking. They further suggest, however, that extrinsic rewards may even undercut creativity by focusing individuals'

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[7] Different explanations concerning the psychological mechanisms underlying crowding-out have been offered. Some authors suggest that salient contingent rewards reduce perceived self-determination and autonomy, which in turn are important facilitating factors for intrinsic motivation. Others suggest that the presence of extrinsic rewards may be construed as a signal that the task will be devoid of intrinsic or social benefits ("Why would

attention on more expedient, and consequently more incremental approaches to solving problems (Amabile, 1996; Amabile, 1993; Hennessey & Amabile, 1998).[8] Thus, the productivity of *creative effort* may differ depending on the degree to which intrinsic or extrinsic motives and incentives dominate. In later work, building on Deci and Ryan (1985) and others, Amabile (1996) extends the model by suggesting that some types of extrinsic rewards can complement intrinsic motivation by providing feedback (e.g., idea validation), as well as resources that enable individuals to pursue their initiatives.

Whether Amabile's argument implies that the R&D efforts of those who are more extrinsically motivated will be less productive is, however, unclear because much of what constitutes industrial R&D is actually straightforward and incremental, demanding little novelty (cf. Fox, 1983; Rosenberg & Steinmueller, 1988).[9] Thus, one might interpret Amabile's argument to suggest that dominant intrinsic motives and rewards increase the quality of innovative effort especially for those R&D tasks that are more demanding of novel approaches and solutions. At the same time, for those R&D tasks that require expedience and little creativity, dominance of extrinsic motivation may increase innovative performance (cf. Amabile, 1993). Thus, extrinsic rewards may, for example, enhance performance in more downstream R&D tasks that are more straightforward and routinized, such as clinical trials in pharmaceutical research.[10]

In addition to preferences for contingent benefits (motives) impacting the quality of innovative effort, other types of individual traits or preferences bearing on the work environment may have similar effects. For example, preferences for independence or job security may not only bear on the kinds of jobs individuals prefer, but, in an R&D setting, the kinds of projects they select, with consequences for performance. For example, those who value job security may be more risk-averse, and thus may pursue less risky, proven

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they pay me for a fun job?"), reducing the amount of nonpecuniary benefits actually perceived (Benabou & Tirole, 2003; Deci et al., 1999).

[8] Manso (2006) develops an agency-type model that produces similar results. More specifically, he shows that short-term pecuniary incentives motivate agents to "exploit", while long-term pecuniary incentives may motivate agents to "explore" and innovate, even if exploration leads to inferior short-term performance.

[9] Moreover, not all creativity researchers see a special role for intrinsic motivation. Some argue that creative products are the result of very ordinary problem-solving processes and do not even require any special creative thinking processes such as "divergent thinking" for which intrinsic motivation might be particularly effective (Weisberg, 2006).

[10] Social psychology research also suggests that the effect of motives and benefits upon the quality of effort may be nonmonotonic. Research on the "choking" effect suggests that very high level of motives (i.e., you care a lot about some benefit) or benefits may cause individuals, preoccupied by the reward rather than the task, to become distracted (deflecting attention from otherwise relevant cues and information), or to become self-conscious at the cost of disrupting potentially beneficial automatic cognitive processes (Baumeister, 1984; Lewis & Linder, 1997).

approaches to solving problems, diminishing the likelihood of significant advance that may require more exploratory approaches (cf. Amabile & Conti, 1999; Dunbar, 1995; Greve, 2003). While our model does not feature such general preferences, our data allow us to examine the role of a small number of such in the empirical analysis below.

Overall, the work of social psychologists suggests that motives and incentives may not only affect the level of effort that individuals expend on innovation, but also the quality of that effort. Moreover, such effects on both the level and the quality of effort may vary, depending on the particular types of individuals' motives and incentives and the nature of the task. Finally, this work also suggests that different types of motives and incentives may not operate independently but may interact, with possibly offsetting effects.

3 Model

Drawing on the prior discussion, we develop a simple model to reflect the impact on innovative effort and performance of individuals' preferences for the benefits from innovative work (what we define as their motives) and the associated expected benefits. The premise of our model is that an individual expends effort, E, to derive utility, U, from that effort, and that utility is a function of some set of extrinsic, intrinsic and social benefits. Accordingly, we assume that U is a function of the individual's intensity of preference (or motive), I, for, respectively, extrinsic (B^e), intrinsic (B^i), and social (B^s) benefits, and the level of effort, such that:

$$U = U^e + U^i + U^s - E^2/2, \qquad (1)$$

where $U^e = I^eB^e$, $U^i = I^iB^i$, and $U^s = I^sB^s$. Thus, we are assuming a simple additive utility function where the benefits are weighted according to their importance to the individual, **I**, a vector the elements of which are I^e, I^i and I^s. We also assume, for simplicity, that the marginal utility from extrinsic, intrinsic, and social benefits, respectively, is constant, while overall utility is diminishing in effort.

We will assume that realized extrinsic benefits, B^e, have a fixed component, W, and a variable component that depends only upon the quantity of innovative output produced, Q. In contrast, we assume that intrinsic benefits as well as social benefits are contingent upon output as well as effort, E. For example, while a feeling of achievement and peer recognition are typically contingent upon performance, task enjoyment and the social benefits derived from stimulating collaboration with others are primarily effort-contingent. Thus, the realized levels of extrinsic, intrinsic, and social benefits can be expressed as:

$$B^e = W + \gamma^e Q \quad (2)$$
$$B^i = \alpha^i E + \gamma^i Q \quad (3)$$
$$B^s = \alpha^s E + \gamma^s Q \quad (4)$$

where γ^e, α^i, γ^i, α^s, $\gamma^s \geq 0$. The coefficients α^i and α^s, defined to be elements of the vector, $\boldsymbol{\alpha}$, denote the impact of effort on intrinsic and social benefits, respectively, and γ^e, γ^i and γ^s, defined to be elements of the vector, $\boldsymbol{\gamma}$, denote the impact of output on extrinsic, intrinsic and social benefits, respectively. These effects are at least partly a function of managerial policy, although managerial influence may be more direct for some types of benefits than for others. For example, management can directly control contingent extrinsic benefits associated with innovative output such as bonuses, pay raises, promotions, etc. For intrinsic benefits, however, that influence may be achieved more indirectly in the provision of facilitating conditions, through, for example, task assignments (e.g., providing more challenging projects). For the current analysis, we assume the α's and γ's to be exogenous; that is, we do not consider the manager's optimization problem. Substituting equations (2) through (4) into equation (1) yields:

$$U = I^e(W + \gamma^e Q) + I^i \alpha^i E + I^i \gamma^i Q + I^s \alpha^s E + I^s \gamma^s Q - E^2/2 \quad (5)$$

Note that our utility function differs from that typically assumed in agency theory in that, while effort has the conventionally assumed negative impact on utility, it may also have an offsetting positive effect via intrinsic and social benefits that are effort-contingent. The simple additive form of our model reflects the assumption that different types of motives and incentives do not interact (we will consider such interactions later).

To address the influence of contingent intrinsic and extrinsic benefits and individuals' preferences for these benefits on innovative performance, we assume for simplicity a constant marginal productivity of effort; that a researcher's innovative output, Q, is a multiplicative function of effort, E, and the researcher's productivity, P:

$$Q = PE \quad (6)$$

Extending prior work on innovative performance that has considered its industry or firm level determinants (cf. Cohen, 1995), we now also consider individual-level determinants. Accordingly, we assume innovative productivity, P, to be a function of vectors of industry characteristics, $\mathbf{A}^1$ (e.g., technological opportunity), firm characteristics, $\mathbf{A}^2$ (e.g., firm size, resources, etc.), and individual characteristics, $\mathbf{A}^3$ (e.g., ability) such that:

$$P=P(\mathbf{A}^1, \mathbf{A}^2, \mathbf{A}^3, \boldsymbol{\alpha}, \boldsymbol{\gamma}, \mathbf{I}) \qquad (7)$$

Following our attention to the impact of motives and the performance-contingency of benefits on individuals' innovative performance, inclusion of $\boldsymbol{\alpha}$, $\boldsymbol{\gamma}$, and $\mathbf{I}$ as arguments of P in equation (7) also allows extrinsic, intrinsic and social motives and incentives to affect researcher productivity. Thus, our model allows both motives (elements of $\mathbf{I}$), and the degree to which benefits are contingent on effort or performance (i.e., the elements of $\boldsymbol{\alpha}$ and $\boldsymbol{\gamma}$) to affect productivity. The discussion above, however, suggests that impact may be quite complex, and differ depending on the nature of rewards and the task.

We will now assume that the individual has unbiased expectations of her own productivity and of the links between effort, performance, and contingent benefits. In equilibrium, the individual chooses a level of utility-maximizing effort, E*, taking into account expected benefits from effort itself as well as the effects of her effort upon innovative output, and, in turn, output-contingent benefits. Substituting PE for Q, we can rewrite (5) and solve for E*:

$$dU/dE = I^e\gamma^eP + I^i\alpha^i + I^i\gamma^iP + I^s\alpha^s + I^s\gamma^sP - E = 0 \qquad (8)$$

$$E^* = I^e\gamma^eP + I^i\alpha^i + I^i\gamma^iP + I^s\alpha^s + I^s\gamma^sP \qquad (9)$$

We represent possible negative effects of extrinsic rewards on (effort-contingent) intrinsic benefits ("motivation crowding-out") by modifying (3) to include an interaction between α^i and γ^e, as well as a parameter ρ to indicate the strength of crowding-out:

$$B^i = \alpha^iE - \rho\alpha^i\gamma^eE + \gamma^iQ, \qquad (3a)$$

where $1/\gamma^e \geq \rho \geq 0$. This formulation reflects the idea that the negative impact of extrinsic rewards on intrinsic benefits is stronger in settings where the potential for intrinsic benefits is large, as well as the idea that crowding-out is due to the contingent nature of extrinsic benefits such as pay (i.e., γ^e) rather than pay levels per se (i.e., W). To consider the possibility of crowding-out, (5) can be rewritten as:

$$U=I^e(W+\gamma^eQ) + I^i(\alpha^iE - \rho\alpha^i\gamma^eE + \gamma^iQ) + I^s\alpha^sE + I^s\gamma^sQ - E^2/2 \qquad (5a)$$

Maximizing (5a) and solving for equilibrium effort yields an expression that allows for crowding-out due to the offering of extrinsic benefits:

$$E^* = I^e\gamma^eP + I^i\alpha^i + I^i\gamma^iP - I^i\rho\alpha^i\gamma^e + I^s\alpha^s + I^s\gamma^sP \qquad (9a)$$

Equations 9 and 9a yield several hypotheses about the determinants of individuals' innovative effort. First, effort is positively related to the importance an individual assigns to extrinsic, intrinsic, and social benefits (I^e, I^i, I^s, respectively). Second, higher productivity, P, increases effort because the marginal payoff to effort is higher. Third, zero productivity does not imply zero effort. Due to the effort-contingent nature of intrinsic and social benefits, individuals who value these benefits will expend effort even if they expect not to realize any innovative output. Thus, the model allows for individuals who are willing to work at least some amount just for the utility derived from the work itself. Fourth, stronger links between effort and intrinsic and social rewards as well as between performance and intrinsic and social rewards (i.e., α's and γ's) will increase effort. Fifth, equation (9a) suggests that stronger (more high-powered) contingent extrinsic benefits (larger γ^e) will negatively moderate the positive effect of I^i to the extent that crowding-out takes place ($\rho>0$). As a result, a stronger link between performance and extrinsic reward has an ambiguous effect on effort.[11]

Having considered our predictions regarding the determinants of effort, our model also suggests predictions with regard to the determinants of innovative performance. Specifically, equation 6 in combination with equation 7 predicts not only a positive effect of effort, but also, controlling for effort, positive effects of intrinsic motives and incentives, and

[11] Taking the derivative of (9a) with respect to γ^e gives $dE^*/d\gamma^e= I^eP- I^i\rho\alpha^i$. This shows that its net effect upon effort depends on the importance of intrinsic and extrinsic benefits (I^e and I^i), productivity, the strength of crowding-out, as well as the degree to which intrinsic benefits derive from effort. Thus, even if crowding-out occurs, the net effect of stronger extrinsic incentives may well be positive, especially if individuals value extrinsic benefits highly, if ability (and thus potential output) is high, if tasks provide few intrinsic benefits to begin with, or if the individual does not care about such benefits. Thus, studies finding positive effects of performance-pay on effort and performance can be entirely consistent with the idea of crowding-out, especially if tasks provide low levels of intrinsic benefits (e.g., windshield installation in Lazear (2000)).

possibly a positive effect of extrinsic and social motives and incentives, per the discussion of Amabile's research above. Obviously, as discussed below, equation 6 also predicts that it is an interaction between the determinants of innovative productivity and effort that drives innovative output. In the following, we examine the impact of individuals' motives on innovative effort and performance. While our model structures our empirical analyses, data limitations prevent us from conducting a comprehensive test of the model predictions. Thus, we rely upon our model principally as a source of qualitative insights.

4 Data

For our empirical analysis, we use restricted-use data from the 2003 Scientists and Engineers Statistical Data System (SESTAT). The SESTAT database is maintained by the NSF (National Science Foundation, 2003) and is composed of three component surveys: the Survey of Doctorate Recipients (SDR), the National Survey of College Graduates (NSCG), and the National Survey of Recent College Graduates (NSRCG). The sample population includes individuals who have a science, engineering or related degree or who worked in a science, engineering or related occupation at the time the data were collected. Most data were collected via a mailed questionnaire; a smaller number of surveys were administered by computer-aided telephone interviews, in-person interviews, and via the internet. Response rates for the three component surveys ranged from 60-80%.[12]

We focus on a sample of 11,041 SESTAT respondents who possess Bachelors, Masters, or Ph.D. degrees, and are employees of private for-profit firms, which are primarily active in one of the industry groups listed in Table 1. As Table 1 shows, a majority of our sample respondents - 6,057, or 54.9% - work in the manufacturing sector, though a sizable minority - 4,391 or 39.8% - work in services, with 1,507 of these working in R&D services. We only include respondents whose primary work classification is basic research, applied research, development, design, or computer applications; the distribution of respondents across these work types is also shown in Table 1. A notable feature of the distribution across work classifications is that 3,658, or 33.1% of the respondents, work in computer applications. Also, only 386, or 3.5% of the sample, work in basic research, a proportion which is comparable to the share of R&D firms spend on basic research more generally.

[12] For more information on the sampling frame, survey administration, etc., please visit http://sestat.nsf.gov/ and http://www.nsf.gov/statistics/survey.cfm. The complete survey instruments are available at http://nsf.gov/statistics/question.cfm.

We were able to obtain two important additional control variables, firm identities and the school awarding the respondent's Ph.D. (employed below as a proxy measure for ability), for that subset of our respondents who have Ph.D.'s (n=2811), and we use this subsample ("limited sample") to conduct a series of robustness checks. A comparison between the full sample and the limited sample is provided in table 2. Apart from the fact that the limited sample is comprised entirely of Ph.D.'s, the key difference between the two samples is that the limited sample has relatively fewer respondents in design and computer applications.

Insert Tables 1 and 2 about here

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5 Measures

Unless otherwise indicated, all measures are constructed from respondents' survey questionnaires and are included in the SESTAT database. Note that missing data on non-critical items was imputed by the NSF. As we show below, the SESTAT data provide some unique measures reflecting extrinsic, intrinsic and social motives, as well as measures of our two key dependent variables, innovative effort and performance. The dataset also, however, poses a number of challenges discussed below.

Dependent Variables

Quantity of effort: Respondents reported the number of hours they work in a typical work week (continuous measure). We use this measure as a proxy for the quantity of effort dedicated to innovation (HRSWORKED).[13]

Innovative Performance: Each respondent reports the number of U.S. patent applications in which he or she was named as an inventor over the last 5 years prior to the survey (USPAPP). Due to this 5-year window, patent counts of individuals who have been in the labor force for less than 5 years are not directly comparable to patent counts for individuals with 5 or more years of experience. Accordingly, we have to adjust for such differences in "exposure time" in our econometric analysis (see discussion of estimation issues below). Moreover, patent output is only an imperfect measure of innovative performance. First, not all inventions are patented. We therefore, as discussed below, include several industry- and firm-level variables to control for the likelihood of whether a given

[13] Note that this measure reflects total hours worked on R&D as well as on other activities, introducing a possible source of measurement error. The SESTAT data also, however, allow us to control for the other, non-R&D activities in which individuals engage (see below).

invention is patented (Cohen, Nelson, & Walsh, 2000). Another widely recognized limitation of this measure is that there is enormous variability in the technical importance as well as economic value of patented innovations that should be considered when assessing innovative performance.[14] To assess the robustness of our results in light of this limitation, we also employ the self-reported number of granted patents that have been licensed or resulted in a commercialized product (USPCOM) as an alternative performance measure because commercialized and licensed patents would tend to reflect more valuable inventions. This measure, however, suffers from the limitation of a longer and likely more variable lag between the measure and the actual innovative activity taking place. A third performance measure we use to explore robustness of our results is the self-reported number of patents granted within the prior five years (USPGRT).

Independent Variables

Preferences for work benefits (motives): Respondents were asked to rate the importance of six work benefits in response to the following question: "When thinking about a job, how important is each of the following factors to you . . ." Respondents rated the importance of each benefit on a 4-point scale anchored by 1 (very important) and 4 (not important at all); for ease of interpretability, we reverse coded these items such that higher scores indicate higher importance. The six work benefits and their associated preference measures (motives) are:

- Salary (IMP_SAL)
- Benefits (IMP_BEN) [15]
- Opportunities for advancement (IMP_ADV)
- Intellectual challenge (IMP_CHAL)
- Level of responsibility (IMP_RESP)
- Contribution to society (IMP_SOC).

Preferences for job characteristics: Respondents were also asked to rate the importance of two factors, job security and independence, which do not constitute contingent work benefits but are better conceived as more general job characteristics. As discussed in our review of the psychology literature, preferences for such factors may also have important impacts on innovative outcomes. Although we did not include preferences for general job characteristics in our formal model, we will include these measures into our regressions on an

[14] Since they do not identify respondents, the SESTAT data do not allow us to match individuals' patents to patent citations, use of which is one way to control for the importance of inventions.

[15] Note that the survey instrument uses the term "benefits" in a more narrow sense (i.e., fringe benefits) than we use it throughout this paper.

exploratory basis.[16] Measurement and coding of these preferences are the same as for the preferences for work benefits discussed above. The two job characteristics are the degree of independence (IMP_IND) and job security (IMP_SEC).

One concern is that self-reported preferences for job benefits and job characteristics such as such as salary, intellectual challenge, and contribution to society may be affected by social desirability bias (SDB). Such bias may occur if individuals try to present themselves in a positive light by giving "desirable" answers (Moorman & Podsakoff, 1992). Typically, one would expect this bias to lead to overstated preferences for socially desirable attributes (e.g., challenging work, contribution to society) and understated preferences for socially less desirable attributes (e.g., pay, security) (Rynes, Gerhart, & Minette, 2004)[17]. Such a bias is unproblematic for our econometric analysis if it similarly affects all individuals or if it is unrelated to any of our other featured variables.

<u>Determinants of R&D productivity:</u>

Industry-level determinants

- Industry classification: Dummies for 28 industries (2- to 4-digit NAICS classification) (IND_NAICS). Industry dummies are included to control for differences in technological opportunity and other industry-level conditions affecting R&D productivity. They should also control for cross-industry differences in patent propensities.

Firm-level determinants

- Employer firm size: Respondents were asked to estimate the size of their employer in terms of the number of employees in all locations combined, represented by a set of dummy variables as follows: EMSIZE1: 10 or fewer employees; EMSIZE2: 11-24; EMSIZE3: 25-99; EMSIZE4: 100-499; EMSIZE5: 500-999; EMSIZE6: 1000-4999; EMSIZE7: 5000-24999; EMSIZE8: 25000+ employees. We include employer size to control for organizational resources (e.g., R&D spending).

[16] One might think of general job characteristics such as independence and job security as benefits that, while not contingent upon effort or performance, are contingent upon employment in a particular firm. In a companion paper, we also consider individuals' choices between different types of employers. In that paper, we consequently treat independence and job security as contingent benefits and preferences for these benefits as motives (Sauermann & Cohen, 2007).

[17] Over 60% of our cases were collected by mail, 28% via computer-assisted telephone interviews, 9% via the internet, and 2% in personal interviews. We checked whether the responses in personal modes (telephone and personal interview) differed from those in impersonal modes (mail, www). We found no significant correlation between survey mode and IMP_SAL; correlations of survey mode with most other preference measures are significant but small, except for somewhat larger correlations with IMP_ADV (r=0.09) and IMP_SOC (r=0.10).

- Startup status: Dummy = 1 if firm was founded within the last five years (NEWBUS).
- Firm identifiers: Employer names are available for our limited sample[18]. We then created a set of 86 dummy variables to control for firm fixed effects for each firm that had at least 5 individuals in our limited sample (EMPLIDCT5)[19].

Individual-level determinants

- Primary work type: Respondents indicated on which of a list of work activities they spend the most hours during a typical work week (WAPRI, see Table 1).
- Number of non-R&D work activities: Respondents indicated which of a list of 9 non-R&D work activities occupied more than 10% of their time[20]. We summed the number of these activities (WORK_NONRD).
- Highest degree: Dummy coding for Bachelors, Masters, and Ph.D. (DEGREE).
- Field of highest degree: Dummy coding for 16 fields[21] (HD_FIELD).
- Ability: For our limited sample, we were able to obtain the names of the Ph.D.-granting institution. We matched these institution names and the Ph.D. field to the National Research Council's evaluation of Ph.D. program quality (Goldberger, Flattau, & Maher, 1995). The particular quality measure we use is a survey rating of "program effectiveness in educating research scholars and scientists" (ABILITY). The scale ranges from 0 ("not effective") to 5 ("extremely effective"). While this measure formally captures the quality of an individuals' graduate education, it is also likely to reflect innate ability to the extent that high-ability individuals self-select or are selected into high-quality Ph.D. programs.[22]
- Tenure in principal job, in years (JOBTENURE) and job tenure squared (JOBTENURE_SQ); serve as measures of job-specific skills and knowledge.

Since survey mode was not random (telephone interviews and personal interviews were used primarily to obtain data from nonrespondents to the paper survey), it is not clear to what extent these correlations reflect SDB.

[18] Since the employer names were obtained in verbatim form, we manually recoded the data to eliminate differences in employer names due to misspellings, the use of abbreviations, etc. In ambiguous cases, we used additional information such as employer location and employer size to determine whether two respondents had the same or different employers.

[19] We conducted our analyses using sets of dummy variables reflecting varying levels of resolution (e.g., one dummy for each firm with 10 or more individuals (EMPLIDCT10), etc.). Smaller sets of dummies had significantly lower explanatory power than EMPLIDCT5, especially in the performance regressions. Regressions using larger sets of dummies (e.g., EMPLIDCT3) sometimes failed to converge due to the large number of degrees of freedom required. Considering the limited effects of EMPLIDCT5 (see below), it is very unlikely that a higher degree of resolution would change our qualitative findings.

[20] These activities included accounting, employee relations, management, production, professional services, sales/marketing, quality management, teaching, other.

[21] These fields include: biology, health/medical sciences, food sciences, chemistry, physics, earth sciences, computer science, materials science, metallurgical engineering, aerospace/astronautical engineering, computer engineering, electrical engineering, mechanical engineering, other engineering, mathematics, other fields.

[22] The field definitions used in SESTAT and the fields ranked by the NRC do not match perfectly. When the SESTAT field definitions were broader, we averaged the NRC ratings of relevant programs, using the number of Ph.D.'s in each program at a given institution as weights (cf. Stephan, Sumell, Adams, & Black, 2005).

- Time since obtaining highest degree, in years (HDTENURE) and HDTENURE_SQ; serve as measures of field-specific skills and knowledge. In addition, this measure could also capture cohort effects (Stephan, 1996).
- Relevance of training: Extent to which the current work is related to the field of the highest degree, 3-point scale (JOBDEGREE); serves as measure of relevance of the skills and knowledge acquired during academic training.

Additional Control Variables:

- Sensitive research: Two dummy variables indicating whether the individual's work was supported by a contract with / a grant from the U.S. department of defense (GOVT_DOD) or the NASA (GOVT_NASA). We expect that findings resulting from such work are less likely to be disclosed in patent applications (negative effect on patent propensity).
- Managerial status: natural log of the number of people the respondent supervises directly (LN_SUPDIR).
- Gender dummy (MALE).
- Race dummies: Dummies for Asian, Black, other (White is omitted category) (RACE).
- Citizenship status: Dummy coded 1 for U.S. citizens (USCITIZEN).
- Marital status dummy (MARRIED). Coded 1 for individuals who are married or living in a marriage-like relationship. Married individuals presumably have more family obligations than individuals who are not married. This variable serves as a proxy for time constraints in our effort regressions.
- Children under the age of 12. Count of children under the age of 12 living in the same household as the respondent (CHILDREN011). This variable serves as a proxy for time constraints in our effort regressions.

6 Description

In this section, we briefly describe the distribution and structure of individuals' motives and preferences for job characteristics, and we provide summary statistics for other key variables.

6.1 Motives and preferences for job characteristics

Table 3 provides summary statistics for the preference measures, ordered from highest to lowest average importance reported for each preference. Note that the means for all preference measures are above three, indicating a high to very high importance of all factors.

According to these data, respondents rated intellectual challenge as the most important work benefit. The second and third most important benefits are (fringe) benefits and salary, followed by opportunities for advancement, responsibility, and contribution to society. With respect to job characteristics, both job security and independence receive relatively high importance ratings.

Insert Table 3 about here

An interesting question is whether the motives and preferences for job characteristics vary, perhaps due to self-selection, across type of work (e.g., basic research vs. development), type of field, or degree. To examine such differences, we regressed the eight preference measures on three sets of dummy variables: primary type of work (basic research is the omitted category), type of degree (Bachelors is the omitted category), and field of highest degree (engineering fields is the omitted category)[23]. The results of these regressions (estimated using ordered probit with robust standard errors) are shown in Table 4. All regressions are highly significant, suggesting that there are significant differences in individuals' preferences across degrees, fields, and types of work. Ph.D.'s report a significantly lower importance of extrinsic benefits (salary and fringe benefits) than Bachelors, while reporting higher importance of certain intrinsic and social benefits (challenge and contribution to society). Ph.D.'s also report a higher importance of independence and a lower importance of job security than Bachelors.

Comparisons of individuals' preference across primary types of work show significant differences with respect to some factors but not others. We find no differences with respect to preferences for salary, and only small differences with respect to preferences for fringe benefits. Individuals primarily engaged in design and computer applications report significantly lower importance of intellectual challenge, responsibility, and independence than individuals in basic research. Finally, the importance of advancement, contribution to society and job security is significantly lower for individuals in applied research, development, design, and computer applications.[24]

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[23] Please refer to the measurement section for a list of all fields. For this analysis, we formed three aggregate classes of fields: engineering (omitted), science, and other fields.

[24] In interpreting these results, we have to consider the potential for social desirability bias. For example, Ph.D.'s could think that they are expected to care more than non-Ph.D.'s about intellectual challenge and contribution to society, and their higher importance ratings could reflect an attempt to conform to these expectations.

Finally, we examined the covariance of the preferences for work benefits and job characteristics. An exploratory factor analysis (common factor analysis, oblique rotation with oblimin(0) criterion) revealed two factors, as shown in Table 5. The motives of intellectual challenge, advancement, responsibility and contribution to society as well as the preference for independence load on one factor. The motives of salary and fringe benefits as well as the preference for job security load on a second factor. It is interesting to note that the preference for opportunities for advancement does not load on the same factor as salary and fringe benefits, indicating that the preference for opportunities for advancement may not strictly - or even primarily - reflect a pecuniary motive. Overall, the results of this factor analysis suggest that individuals' preferences are correlated in systematic ways. While some individuals emphasize extrinsic benefits such as salary and (fringe) benefits as well as job security, others emphasize a mix of intrinsic and social benefits as well as independence. However, the correlation between the two extracted factors is positive (r=0.23), suggesting that intrinsic and extrinsic motives are not two opposite ends of a "motivation continuum" but two motivational orientations that can occur within the same individual (see also Amabile, Hill, Hennessey, & Tighe, 1994).[25]

Insert Tables 4 and 5 about here

6.2 Other selected variables

Table 6 presents summary statistics for our measures of performance, quantity of effort, and selected independent variables, and table 7 presents the correlations. As table 6 shows, the average number of U.S. patent applications in our sample is 1.2. However, the distribution is highly skewed with only 24% of cases reporting any applications. As expected, the average number of commercialized patents, 0.26, is significantly lower than that of patent applications. The average level of effort is 45.5 hours per week. Finally, 45% of the individuals in our sample have a Bachelors as their highest degree, 24% have a Masters and 31% have a Ph.D.

[25] In some disciplines, it is common to use factor-based scores derived from a factor analysis as new variables in subsequent regression analyses. However, this method is appropriate only if the component measures are assumed to capture the same underlying latent construct (Pedhazur & Schmelkin, 1991). We do not make such an assumption. In fact, our subsequent analyses using the individual preference measures shows that even

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Insert Tables 6 and 7 about here

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7 Specifications

In our econometric analysis, we estimate a series of effort and performance regressions. In the following, we present our benchmark specifications and briefly discuss how they differ from the specifications suggested by our theoretical model, largely due to data limitations.

In the effort regressions, we start with an additive model regressing effort ($HRSWORKED_i$ **)** on vectors of measures of: 1.) preferences for work benefits (**I**); 2.) variables affecting individuals' average productivity (**P**); 3.) additional control variables (**V**), including fixed effects for industries and academic fields, and the two measures of preferences for job characteristics (independence and job security) noted above:

$$HRSWORKED_{\mathbf{i}} = \beta_0 + \beta_1 \mathbf{I}^{\mathbf{e}}_{\mathbf{i}} + \beta_2 \mathbf{I}^{\mathbf{i}}_{\mathbf{i}} + \beta_3 \mathbf{I}^{\mathbf{s}}_{\mathbf{i}} + \beta_4 \mathbf{P}_i + \beta_5 \mathbf{V}_{\mathbf{i}} + \upsilon_{i,} \qquad (10)$$

where υ_i is an error term. Contrasting this specification with equation 9 in our theoretical model[26] suggests several important differences that affect the interpretation of our results. First, we do not have measures for the links between effort and performance, on the one hand, and benefits, on the other. These links are represented by the α's and γ's in our theoretical model. While some of these links may be observable (e.g., the slope of a pay-for-performance function), others are not (e.g., the increase in intellectual challenge associated with a task assignment). This implies that estimated coefficients of the I's (i.e., motives) reflect a compound effect of the I's and unobserved α's and γ's. Our qualitative predictions for the effects of the I's, however, should still hold as long as the I's and associated α's and γ's are either uncorrelated or positively correlated. The latter can be expected in light of research suggesting that individuals self-select into organizations offering benefits that "fit" their preferences (Cable & Edwards, 2004; Holland, 1997; Sauermann, 2005), suggesting a positive relationship between the B's and I's, and, in turn, the I's and the α's and γ's.

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preferences that load on the same factor may have very different impacts on the dependent variables. Such differences would be obscured by the use of factor-based scores.

[26] Equation (9) is: $E^* = I^e\gamma^e P + I^i\alpha^i + I^i\gamma^i P + I^s\alpha^s + I^s\gamma^s P$.

Second, our theoretical model predicts an interaction between the determinants of R&D productivity, **P,** and our **I** vector. Although we estimated such multiplicative models by interacting the I's and determinants of P, the interactive terms were never significant when the main effects were included. Thus, we focus on the main effects alone, as reflected in (10).

In our performance regressions, building on Amabile's and the work of other psychologists, our benchmark specification entertains the possibility that individuals' motives and preferences for job characteristics may contribute to innovative productivity controlling for effort. Accordingly, our specification includes our measures of preferences, employee effort, and factors that condition innovative productivity (the arguments of the vector **P)**:

$$USPAPP_{\mathbf{i}} = \beta_0 + \beta_1 HRSWORKED_{\mathbf{i}} + \beta_2 \mathbf{I}^{\mathbf{i}}_{\mathbf{i}} + \beta_3 \mathbf{I}^{\mathbf{e}}_{\mathbf{i}} + \beta_4 I^{s}_{\mathbf{i}} + \beta_5 \mathbf{P}_{\mathbf{i}} + \upsilon_{2i} \qquad (11)$$

For the full sample, we focus our discussion on additive specifications of the performance regressions, since interaction terms including effort and various elements of **P** turned out to be insignificant once the main effects were included. Consistent with our model, however, the interaction between effort and ability is significant in the limited sample where a better measure of ability (quality of graduate education) is available.

8 Estimation issues

8.1 Innovative effort measure

Our sample includes only individuals who are full-time employees, defined as working an average of at least 35 hours per week. Since OLS can produce inconsistent results for truncated dependent variables, one technique we use is truncated regression. Second, a large number of respondents (38%) reported HRSWORKED of 40 hours per week, while only very few individuals report less than 40 hours. It is conceivable that some of the individuals reporting 40 hours actually work less, but report 40 hours since this is the officially required work time in many organizations. In this case, 40 hours could be considered the lower limit of a censored distribution. To address this possibility, we feature our estimation of the effort specification using a tobit regression model, with a lower limit of 40 hours. Finally, many responses are clustered at "round" values such as 40 and 50 hours. To address this issue, we divided the HRSWORKED measure into categories, each spanning 10 hours. Using the resulting measure HRSCAT10 as our new dependent variable, we also estimated an effort regression using ordered probit with robust standard errors.

8.2 Innovative performance measure

Our second featured dependent variable, the number of U.S. patent applications filed over the prior five years, is a discrete measure of innovative performance and has a skewed distribution. Only 24% of our respondents have one or more patent applications, while roughly 76% did not report any patent applications in the five years prior to the survey. In addition, zero patent counts could be produced by different underlying processes. One possibility is that an individual's unobserved performance is not sufficient to yield any patents even though the individual is at risk of patenting. Another possibility is that certain individuals are not at risk of patenting, perhaps because patenting is seen by their employers as undesirable due to the information that a patent discloses (Cohen et al., 2000). A family of count models that accounts for both skewed count outcomes and different processes generating zero counts are zero-inflated negative binomial (ZINB) models (Cameron & Trivedi, 1998). ZINB models have been increasingly used in the literature to examine determinants of patenting and publishing behaviors (e.g., Stephan, Shiferaw, Sumell, & Black, 2005). Estimating a ZINB model amounts to simultaneously estimating two regression models; one is a logit predicting membership in the "always-0" group, and the other one is a negative binomial model for those cases that are not in the "always-0" group. The two regressions can have different independent variables, reflecting the two different underlying processes. In our ZINB models, we excluded several individual-level variables, such as our preference measures, JOBTENURE, HDTENURE, and LN_SUPDIR from the logit part, emphasizing the role of firm characteristics (firm size, startup status, industry) and individuals' type of work, field of highest degree, and type of degree in affecting the likelihood of an individual being at risk of patenting. In addition, the logit component includes two dummy variables indicating whether the individual's research was funded by a contract with or grant from the Department of Defense or the NASA. In discussing the results of ZINB models, we focus primarily on the negative binomial estimation, since patents are by assumption not a valid measure of innovative performance in the logit component.

We also had to address the fact that our performance measures are patent counts over a five-year span, but some individuals have a labor market experience of less than five years. We account for this fact by explicitly considering exposure time (ranging from zero to five years) in the performance regressions.[27]

[27] The adjustment for different exposure times was made by including ln(exposure time) in the model and constraining its coefficient to zero. A more detailed discussion of this method is provided in Long and Freese (2005).

8.3 Endogeneity

The nature of our data warrants careful consideration of endogeneity. First, as described in the measurement section, our performance measures (e.g., USPAPP) capture performance over a 5-year span, while our key independent variables reflect constructs at the time of the survey. Can we assume that the measured values of the featured independent variables (i.e., motives) are are not systematically affected by the performance over the prior five years? The assumption of exogeneity of preferences is routinely made by economists. Perhaps more convincingly, social psychologists typically consider preferences for work attributes to be "trait-like", i.e., relatively stable over time. Several measurement instruments have been developed for such preferences, and they are routinely used in empirical work with the implicit assumption of stability (e.g., Amabile et al., 1994; Cable & Edwards, 2004).[28] However, it is conceivable that individuals' reported preferences change in response to realized benefits. For example, individuals may rationalize the receipt of little financial reward from their innovative efforts by reporting that such rewards matter little to them (cf. Festinger, 1957). To investigate this possibility, we examined the correlation between the importance of salary (IMP_SAL), the satisfaction with salary,[29] and actual (logarithmized) salary levels LN_SALARY.[30] IMP_SAL and LN_SALARY are not significantly correlated ($r=-0.01$, n.s.), while the correlation between satisfaction with salary (SAT_SAL) and LN_SALARY is positive and highly significant ($r=0.19$, $p<0.001$). These correlations suggest that, while satisfaction with a particular benefit may depend on the level of this benefit, the rated importance of the benefit is likely to be largely exogenous.[31] For the purpose of our analysis, we will assume that individuals' preferences are exogenous.

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[28] Studies explicitly investigating the stability of preferences for job characteristics are rare. Genetic research appears promising in this area; in a small-sample twin study, Keller et al. (1992) found that about 40% of measured variance in work values (their term for preferences for job characteristics) was due to genetic factors.

[29] Our respondents also reported their satisfaction with the eight work benefits and job characteristics in their current job. While satisfaction will generally be a positive function of realized benefits, it is a complex psychological construct, which is still not well understood (Cable & Edwards, 2004; Judge, Thoresen, Bono, & Patton, 2001). We thus do not use satisfaction scores as measures of either actual levels of benefits (i.e., B^e, B^i, B^s) or the contingent nature of certain benefits (α's and γ's) in our econometric analysis.

[30] Respondents reported their basic annual salary in the SESTAT surveys. We do not feature this variable in our econometric analysis because (non-contingent) basic salary is not predicted to have an effect on innovative effort or performance (see our model). In addition, actual salary levels may be a function of past effort and performance (e.g., via annual raises) and could thus be endogenous. Unfortunately, we do not have appropriate instruments for salary to examine these relationships in more detail. However, we conduct robustness checks using this variable.

[31] This statement may be invalid if realized benefits are extremely low. For example, the importance of salary may increase if salary is so low that the respondent has to worry about paying her bills. An examination of the satisfaction scores indicates that our respondents rated the satisfaction with all 8 benefits/job characteristics above the midpoint (i.e., somewhat or very satisfied), suggesting that effect should not be a problem in our sample.

Another potential source of endogeneity in our performance regressions is if innovative effort is endogenous with respect to realized performance. According to our model, effort is exogenous with respect to *realized* performance. Effort is, however, endogenous to *expected* performance to the extent respondents believe future performance is associated with expected (performance-contingent) benefits. While our performance measures capture realized performance, we may still expect endogeneity in our regressions if individuals' expectations with respect to benefits and performance are influenced by their observation of their past performance. Despite the plausibility of this possibility, our statistical tests using CHILDREN011 and MARRIED as instruments cannot reject the null hypothesis of exogeneity of HRSWORKED in any of our performance regressions.[32]

9 Results

9.1 Effort

Table 8 reports the results of our effort regressions, featuring the tobit estimates in models 1 and 2. Column 1 shows the results of a regression of HRSWORKED on the productivity and other control variables. In model 2, we add our measures of respondents' preferences for work benefits (i.e., motives) and other job characteristics, notably independence and security. Five of the preference measures have significant effects on effort. Our measure of the desire for intellectual challenge (IMP_CHAL) has the strongest positive effect - at least double that of the others, followed by the importance of responsibility. These positive coefficients are consistent with our model, which predicts that stronger preferences for benefits increase utility from effort and, in turn, optimal effort.[33] What is notable about these results is the dominance of an intrinsic motive - desire for intellectual challenge.

In addition to these positive effects, we observe a small and fragile negative effect of the importance of contribution to society. More importantly, we also observe a significant negative coefficient for the importance of salary. This negative coefficient is unexpected. A corollary analysis suggests that this result is primarily due to a relatively small number of respondents - less than 1% of our sample - who expend more than average effort, yet rate

[32] We tested for potential endogeneity by including the residual from an OLS first-stage effort regression (including instruments) into different specifications of second-stage performance regressions (Wooldridge, 2001). We estimated performance regressions using poisson, negative binomial, and zero-inflated negative binomial models and the first-stage residual was never significant (Chi2(1)=1.69, p=0.19 for the NBREG case).

[33] As discussed above, to the extent that preferences for these work benefits (i.e., the **I** vector in our model) are correlated with the unobserved degree to which effort and performance yield those benefits (i.e., the $\boldsymbol{\alpha}$ and $\boldsymbol{\gamma}$

their preference for salary very low. Thus, there may be some segment of R&D employees who both eschew financial gain yet are very dedicated to their work, much like Kidder's (1981) "Hardy Boys" at Data General who worked very long hours to develop a new generation of minicomputer while claiming that they "don't work for the money." We should, however, not make too much of this result because it is observed only for non-Ph.D.'s. As discussed below, when we estimate the model using the subsample limited to Ph.D.'s, the sign of the coefficient becomes positive (see columns 5 through 8).[34] While our model did not predict negative effects of motives on effort, our finding of such effects merits further research.

As noted above, although preferences for job characteristics (independence, job security) are not included in our formal model, we included them into our regression models. In model 2, we find that the importance of independence has a positive effect on effort while the importance of job security has no significant effect.

Estimating model 2 using truncated regression and ordered probit suggests that the effects of the importance of challenge, responsibility, and salary are robust. However, the effects of the preference for contribution to society and independence appear to be fragile.

As discussed above, we were able to obtain two additional sets of measures for a subsample of our data ("limited sample", exclusively Ph.D.'s). First, we constructed a measure of ability based on the ratings of the quality of the respondent's graduate department. Second, we obtained firm identifiers to control for firm fixed effects. In models 5-8, we examine the robustness of our results to the inclusion of these two sets of measures. Model 5 is equivalent to model 2, but uses only the limited sample. Compared to model 2, the coefficient of the importance of challenge increases and the negative coefficient on the importance of job security becomes significant, while the coefficients of the importance of salary, responsibility, and independence become insignificant. These results suggest differences in the impacts of preferences upon effort across individuals with different degrees.[35] In model 6, we add the ability measure into the regression. As predicted by our

vectors), the estimated coefficients may reflect not only the impact of the motives or preferences (notably desire for challenge, responsibility and independence), but also partially reflect the α's and γ's.

[34] While our model does not predict an effect of basic (non-contingent) salary on individuals' effort, we estimated regressions including this measure as a robustness check. Its inclusion results in slight changes in the coefficients of the measures of some motives and preferences, but the qualitative results remain unchanged. Salary itself has a strong positive impact upon innovative effort. However, we are cautious in interpreting this result since we do not have adequate instruments to address potential simultaneity between effort and salary.

[35] A detailed analysis of such differences using interactions shows three significant effects: For individuals with a master's degree, the preference for contribution to society has a stronger positive effect than for individuals

formal model, individuals with higher ability work more (e.g., because the marginal payoff to effort increases). The coefficients of the preference measures do not change significantly. In model 7, we include one dummy variable for each firm that has 5 or more individuals in our sample. While these dummy variables are jointly significant, their inclusion has little impact on the coefficients of our key independent variables.[36] Model 8 is equivalent to model 7 but is estimated using truncated regression; the qualitative results are unchanged.

Overall, the results of these auxiliary analyses using the limited sample suggest that the lack of firm identifiers and a better measure of ability in our full sample should not significantly affect the estimated effects of individuals' motives and preferences for job characteristics on innovative effort.

Results for the control variables also provide some notable results. For example, we find that, controlling for the time since the respondent's highest degree (HDTENURE), which has a positive and significant coefficient, time at a given job (JOBTENURE) in a firm has a negative and significant coefficient, though with a negative quadratic. Ph.D.'s also appear to spend more time on the job than respondents with either Masters or Bachelors degrees. Finally, our firm size measures suggest that respondents who work in the very smallest (1-10 employees), and the very largest firms (our omitted category of over 25,000 employees) tend to work the hardest, though, controlling for size, respondents who work in new businesses (NEWBUS) work harder still. We examine differences in motives and effort across firm types in more detail in a companion paper (Sauermann & Cohen, 2007).

To summarize our results for our featured variables, motives matter, and the strongest, most robust result is that individuals who desire intellectual challenge expend more effort.

Insert Table 8 about here

9.2 Innovative Performance

9.2.1 Full Sample

Our model predicts a positive effect of the quantity of effort upon innovative performance. In addition, reflecting the insights drawn from psychology noted above, we will

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with a bachelor's degree. For Ph.D.'s, the effect on effort of the importance of salary is more positive, and the importance of job security is more negative than for individuals with a bachelor's degree.

[36] We also estimated a random-effects model, with the same qualitative results.

consider whether preferences for job benefits (i.e., motives) as well as preferences for other job characteristics - notably independence and security - affect the productivity of innovative effort and thus have an effect on performance even controlling for the quantity of effort. We examine these relationships in a series of regressions reported in Table 9. Models 1 through 3 are zero-inflated negative binomial regressions. As discussed above, the ZINB model is superior to the negative binomial regression model when the dependent count variable is characterized by excess zeroes. However, we also estimated our regressions using the negative binomial regression model (models 4 – 6).

Model 1 includes our control variables and our measure of effort (HRSWORKED). HRSWORKED is positive and highly significant. According to this model, a one-standard deviation (6.6 hours) higher level of effort translates into a 12.4% higher expected count of U.S. patent applications.[37]

Next, we estimated a model including HRSWORKED as well as the eight preference measures (model 2). Focusing on the NBREG portion of the zero-inflated negative binomial model (column 2a), four of the eight measures have significant effects. Among the measures of motives, the importance of salary and the importance of intellectual challenge have a significant positive effect. Although the coefficient of the importance of challenge seems considerably larger than that of the importance of salary, the difference is not statistically significant (Chi2(1)=2.42, p=0.12). Concretely, a one-SD higher score on the challenge measure implies an 18.6% higher expected patent count, while a one-SD higher score on the preference for salary leads to a 10.4 % higher expected patent count.[38]

The estimates obtained using negative binomial regression differ slightly from those of the zero-inflated negative binomial models (models 4-6). While the positive effect of effort remains strong and significant, the estimated effect of the importance of salary is insignificant, and the effect of the importance of independence is reduced. The effect of the preference for intellectual challenge, however, is even stronger than in the ZINB models.

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[37] It is conceivable that effort has a nonlinear effect on innovative performance: while effort increases performance at lower and medium levels of effort, extremely high working hours could hurt performance (e.g., employees are overworked, stressed out, etc.). We did not find evidence for such a nonlinear effect.

[38] In column 2b, we report the coefficients of the logit component of the zero-inflated negative binomial model. Note that the logit regression predicts membership in the "never patenting" group, i.e., negative coefficients indicate a higher likelihood of patenting. As expected, Masters and Ph.D.'s are more likely to patent than are Bachelors (omitted category) and individuals in applied research and in development are more likely to be patenters than individuals in basic research (omitted category). Individuals who receive funding from the Department of Defense are less likely to disclose their work in patents.

What could explain the relatively large effects of individuals' motives on performance, controlling for effort? Psychological research suggests that motives and incentives may actually affect the nature of mental effort. For example, incentives, including extrinsic ones, may actually increase attention and affect cognitive functions such as recall (e.g., Camerer & Hogarth, 1999). Amabile and her colleagues suggests that intrinsic motivation, and even certain kinds of supporting extrinsic motivation, may elicit the kind of more exploratory thinking that fosters creativity. In her earlier work, Amabile suggested that, while intrinsic motivation was key to creativity, extrinsic motivation might undermine it. Although, as noted above, we only have measures of motives, not of the different rewards that might be available (i.e., the α's and γ's), Amabile's early conjecture suggests that one might observe a stronger positive effect on performance for our key measure of intrinsic motivation, IMP_CHAL, among those respondents involved in basic and applied research versus those involved in development. The rationale is that if development work is more straightforward, requiring less novelty and creativity than might be demanded in more upstream research, then IMP_CHAL would have less of an effect on the productivity of respondents involved in development. Moreover, if, relative to intrinsic motivation, extrinsic motivation elicits more instrumental, less exploratory ways of thinking, as Amabile suggested, then respondents working in development who are more extrinsically motivated may be more productive. Column 7 in table 9 estimates our model for the sample of respondents engaged in basic or applied research, and column reports 8 the estimates for those engaged in development. What we find is that our key extrinsic motive, the importance of salary (IMP_SAL), *and* our key intrinsic motive, IMP_CHAL, both have significant, positive impacts on productivity for the respondents engaged in basic or applied research, but neither has a significant effect for the respondents engaged in development. Indeed, none of our measures of motives have a significant coefficient among the respondents working in development. Our interpretation of these results is that motives generally - whether intrinsic or extrinsic - can have a performance impact in the types of R&D work which are less routinized, focused more on problem solving sorts of activities where employees have more latitude about the approaches they follow. Assuming development work is more routinized and controlled, performance may depend less on the quality or nature of mental effort, largely because more of the work to be done is more straightforward.

Another result of interest in these two regressions is the notable insignificance of HRSWORKED for the basic/applied research subsample. Though not anticipated and perhaps something we should not read too much into, the result may reflect the notion that, for research tasks demanding more problem solving and creativity, it is not the time expended beyond the forty hour lower threshold that has an effect as much as the quality of the mental effort.[39]

Interestingly, the two measures of preferences for job characteristics also have significant effects on performance. The importance of independence has a significant positive effect, while the importance of job security has a negative, very robust, effect. The latter is quite large; in column 2 of Table 9, a one standard-deviation increase in this measure is predicted to reduce patent output by 11.5 %.

We can only speculate about the mechanisms through which preferences for independence and job security affect innovative productivity. While independence is presumably a non-contingent job characteristic (not a contingent intrinsic benefit in the sense of our model), the social psychology literature suggests a strong connection between independence and intrinsic benefits in the sense that independence may enhance the intrinsic benefits individuals can derive from their work (Deci & Ryan, 1985). The observed effect of the preference for independence may thus be closely related to that observed for intellectual challenge. It is also conceivable that individuals who desire more independence in their work will make more use of any available independence to try new things or to explore new ways of doing things, potentially leading to higher innovative productivity. In contrast to the preference for independence, the preference for job security has a significant negative impact on patent output. As discussed earlier, one possible interpretation is that individuals for whom job security is important may be more risk averse and gravitate to projects and approaches that are more incremental and thus subject to less uncertainty, though offering less innovative potential and therefore less likely to be patentable (cf. Dunbar, 1995).

Among the control variables, there are several results of interest in table 9. While time since highest degree appears to have no significant effect on performance, tenure in the job has a positive, significant effect, suggesting a benefit of firm-specific experience for innovative performance. Also, unsurprisingly, Ph.D.'s are more likely to do work leading to patents than those holding lesser degrees.

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[39] Extending Amabile's (1996) discussion, we also estimated a regressions testing whether the relative importance of intrinsic and extrinsic benefits has a significant effect, in addition to the main effects of preferences for intrinsic and extrinsic benefits. Using the procedure suggested by Kronmal (1993), we included the inverse of the denominator and added this inverse together with the numerator and the interaction between numerator and the inverse of the denominator into the regression equation (Models 3 and 6). The interaction term reflecting the importance of salary relative to the importance of challenge is insignificant, suggesting that there is no independent effect of the relative strength of extrinsic and intrinsic motives.

Insert Table 9 about here

9.2.2 Robustness

Ability and firm effects in the limited sample of Ph.D. respondents

Our limited sample of Ph.D. respondents, for which we have better measures of individuals' ability and firm identifiers, allows us to examine the robustness of our results to two potentially problematic issues. First, the relationship we observe between certain motives and performance may have ability as a common cause. Individuals with an extensive training in top-academic institutions, for example, could have "academic" values that emphasize nonpecuniary motives (Zuckerman, 1988), as well as better training, the latter allowing them to be more productive. In that case, the observed relationship between motives and performance would be spurious. To rule this out, we add an important measure of ability and training.

Second, our analysis thus far could have failed to control sufficiently for firm characteristics, and there are any number of reasons to expect the impact of motives to be at least partly conditioned by firm effects. Among others, it is conceivable that certain firms command higher levels of resources and also attract individuals with particular sets of motives. Alternatively, firms may have different policies linking performance, for example, to financial rewards, implying an impact of firm effects if there is indeed a correlation between the preference for a given type of benefits and the degree to which that benefit is contingent upon performance within a firm.[40]

Table 10 reports the results of a set of regressions using the limited sample. Due to the smaller sample size, zero-inflated negative binomial models did not reliably converge. Thus, we report results from negative binomial regressions. In models 1 – 3, standard errors are adjusted for correlation within firms (Huber-White variance estimates), for models 4 and 5 (which include firm fixed effects), standard errors are White's robust standard errors.

Model 1 is equivalent to model 5 in table 9 for the full sample. Comparing the two regressions, we observe that the importance of salary and the importance of independence

[40] Also, firms may differ in their propensity to patent, i.e., in the likelihood that a given invention is actually patented. While it is not clear that the latter effect would systematically affect our estimates of the impact of motives on performance, controlling for such effects is certainly desirable.

appear to have a somewhat stronger positive effect in this limited sample, while the importance of job security and intellectual challenge have a somewhat smaller effect.[41] In model 2, we add our measure of ability (quality of graduate department). This measures has a significant and economically meaningful positive effect (a one-SD higher ability score translates into an 8.3% higher expected patent count), but its addition to the model has virtually no effect on the preference measures. Since our formal model predicts a positive interaction between effort and ability, we add this interaction term in model 3. The interaction term is significant at the 5% level, suggesting that the productivity of innovative effort increases with the ability of the individual. In models 4 and 5, we add a dummy variable for every firm that has 5 or more individuals in our sample. The firm effects are jointly significant and their inclusion also changes the coefficients of some preference measures. More specifically, the coefficients of importance of salary, importance of challenge, and importance of independence are somewhat reduced, although only the reduction in the coefficient of the importance of salary is marginally significant (Chi2(1)=2.98, p=0.08). Model 5 includes both our ability measure and the set of firm dummies. The main effects of effort and ability are insignificant, but the interaction term is highly significant.

Overall, our analyses using the limited sample show, first, that ability and effort affect performance interactively, as suggested by our formal model. Second, the effects of individuals' motives and preferences for job characteristics are largely independent of ability, ruling out an important alternative explanation for our results. Third, the significant impacts of individuals' motives and preferences for job characteristics persist even with controls for firm fixed effects. At the same time, however, the coefficients of some preference measures change once we control for firm effects, suggesting that firms may differ with respect to the motives and preferences of their employees, which in turn could impact their relative innovative performance. We examine this interplay between individual and firm-level effects in more detail in related work (Sauermann & Cohen, 2007).

Insert Table 10 about here

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[41] Regressions examining these differences using interaction terms show that the effect of the preference for contribution to society is significantly smaller for Ph.D.'s than for Bachelors (negative interaction), while the effects of the importance of independence and job security are significantly larger (positive interaction).

Other robustness tests employing the full sample

We conducted additional analyses to probe the robustness of our results. First, there are a small number of cases in our sample with a very high number of reported U.S. patent applications. While these cases might be truly exceptional performers, it could also be that a very high count of USPAPP reflects measurement error (e.g., individuals reported lifetime patents) or cases where individuals are named on patents without having directly contributed to the invention. Given the small mean of USPAPP in our sample, such cases could severely impact our estimation results. To assess any such effect, we dropped all respondents reporting more than 20 U.S. patent applications in a 5-year span (77 cases, 0.7% of the full sample). The results are reported in table 10, col. 6. The effect of HRSWORKED is unchanged compared to the reference model (model 2a in table 9). However, the effect of the importance of salary becomes insignificant. The effect of the preference for challenge remains large and highly significant.[42] In model 7, we estimate a negative binomial model involving only those cases that have at least one patent application (N=2640). In other words, this regression examines the impact of effort and individuals' preferences for a certain group of individuals: those who were productive enough to have at least one patent application *and* who were not precluded from patenting by institutional factors (e.g., who are not in the "never patent" group predicted by the logit part of the ZINB model). Compared to the reference model (model 5 in table 9), the effect of effort is reduced. The effect of the importance of salary as well as independence increases. The effect of the importance of challenge is reduced but remains highly significant. The effect of the importance of job security becomes insignificant.

Finally, in addition to using U.S. patent applications, we also estimated performance regressions using alternative measures of innovative performance (Table 11). The most important alternative measure is the number of patents granted over a 5-year span that were licensed or commercialized (USPCOM). The virtue of this measure is that it provides a rough sense of the number of economically important inventions that were patented, thus providing a crude quality threshold for our performance measure, as opposed to the number of patent applications or patents granted, the majority of which are not economically

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[42] In order to assess the validity of extremely high counts of patent applications in our data, we compared the distribution of USPAPP to data from the NBER patent data file. More specifically, we counted the number of granted patents per unique inventor for the time period 1992-1997. Roughly 0.23% of the inventors in the NBER file had patent counts of 50 or higher. In our data, roughly 0.18% of the cases had USPAPP counts of 50 or higher. While the two patent measures are not directly comparable for various reasons, this comparison suggests that very high patent USPAPP counts are likely to be valid. Accordingly, we include these cases in our full sample.

important. As noted above, the reason that we do not, however, feature this measure is, first, strategic considerations other than value may condition the firm's decision to commercialize the invention. Second, the commercialization introduces a substantial and highly variable time lag between the R&D activity and the observed outcome. Notwithstanding these latter concerns, a number of our results are robust. First, as presented in Table 11, our measure of effort, HRSWORKED, continues to have a positive, significant coefficient. The qualitative results for our featured independent variables also remain robust. Preference for intellectual challenge importantly affects performance. Preference for salary also remains positive and significant, but only in the ZINB regressions. Finally, the effect of the preference for job security remains negative and significant.[43]

Insert Table 11 about here

Our results on the determinants of innovative performance highlight several robust effects of preferences for contingent benefits (i.e., motives), as well as preferences for security and independence, controlling for effort. The effect of the desire for intellectual challenge was robust across all specifications and samples, except when the model was applied only to respondents working in development. We also found a positive effect of the preference for salary, though less robust than the effect of intellectual challenge and typically lower in magnitude. Another very robust and intriguing result was that the greater the desire for job security, the lower the respondent's innovative productivity, and, less robustly, we find the greater the desire for independence, the greater the respondent's innovative productivity. In our sample limited to Ph.D. respondents, we also observed that the effects of the motives and preferences for security and independence were robust to the inclusion of an additional measure of ability as well as firm effects.

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[43] Another alternative performance measure includes granted patents over a 5-year span (USPGRT). Table 11 shows that, while effort has strong and significant impacts on U.S. patent applications the effect on granted patents is insignificant. Second, the importance of salary has slightly positive impacts on the patent measures. Third, the impact of a preference for intellectual challenge is strong and significant for all patent measures. Fourth, the impact of a preference for independence is strong and positive for patent applications and granted patents. An interesting interpretation of the weaker effect for commercialized patents is that a high need for independence may help in producing creative and innovative inventions, but it may not help (or even hurt) in producing inventions that have (short-term) economic value for the employer. Fifth, a high importance of job security has a negative impact on all three patent measures.

10 Discussion

In this paper, we examine the impact of the motives and incentives of R&D employees on innovative effort and performance. As we know, the goals of firms and their employees may differ. Also, intrinsic incentives loom large for R&D employees; information asymmetry between R&D employees and management is especially acute; and the evaluation of R&D outcomes can be very difficult. This all implies that the motives of R&D employees, and the way in which those motives are managed, can play an important role in affecting innovative processes and performance.

In the first part of this paper, we discussed the nature of individuals' motives and incentives, drawing heavily on research in social psychology and economics. We then presented a simple model that captures various ways in which extrinsic, intrinsic, and social motives and incentives condition individuals' innovative effort, productivity, and output. We examined some of the relationships suggested by this model using NSF survey data on the science and engineering workforce. While the data did not allow a full test of the model, we have gained several insights. We have learned, for example, that R&D employees in industry are characterized by a range of intrinsic and extrinsic motives in their work, and that prominent among these are the desire for intellectually challenging work as well as that for income. We also learned that these motives differ considerably across R&D employees, even after controlling for their fields, their training, and the type of tasks in which they engage. Moreover, these differences appear to matter. A preference for challenging work and responsibility appears to elicit more effort in R&D, and, controlling for effort, preferences for challenge as well as - to a lesser extent - the preference for salary are associated with superior performance. In addition, preferences for job characteristics appear to matter as well: the importance of independence has a positive impact on productivity, while the importance of job security has a negative impact. These results are robust across different estimation methods, and the inclusion of controls for firm effects, and individual ability and experience.

Policy and managerial implications of our findings are several. For managers, the findings highlight the importance of intrinsic motivation for innovative performance.[44] Accordingly, management should explicitly consider the returns to the provision of such benefits and the associated enabling conditions, while of course recognizing the associated costs and challenges. Intrinsic and social incentives can provide leverage where pecuniary incentives tend to less effective, such as when the link between effort and performance is highly uncertain or when agents' behaviors and performance are hard to observe by principals, conditions which are often characteristic of R&D (cf. Alchian & Demsetz, 1972; Ouchi, 1979; Prendergast, 1999). Under these conditions, intrinsic and social incentives may be more effective motivators, because they are either contingent on task engagement (some intrinsic benefits) or because they do not require that management be able to observe performance to the extent required for pecuniary incentives (Alvesson, 2000; Osterloh & Frey, 2000; Ouchi, 1979; Prendergast, 2002). Moreover, individuals engaged in innovation appear to have particularly strong preferences for intrinsic and social benefits, potentially providing such benefits very high motivating "power".

But management also needs to recognize that intrinsic and social motives can detract from organizational goals. For example, there are cases where individuals pursued research projects out of their own interest, even against explicit policies of management. While such projects have sometimes yielded high returns for the employing organization (Bartlett & Mohammed, 1995; Katz, 1993; Kidder, 1981), they will often run against the interests of the employer and may have negative impacts on firm performance. Social motives may also conflict with organizational interests. The professional norms of open science and the desire for peer recognition, for example, may motivate an industrial scientist to disseminate publicly important research findings while the employer would benefit from secrecy.

These examples raise the more general point that organizations often cannot control intrinsic and social incentives directly. Intrinsic benefits are typically provided indirectly, through *facilitating or enabling conditions* such as task assignments or the provision of greater autonomy that affect the likelihood of the realization of such benefits (Deci & Ryan, 1985; Hackman & Oldham, 1976). Similarly, social benefits are not always under the control of the organization, notably if the individuals are strongly embedded in a social context external to the organization such as a profession (Alvesson, 2000; Gouldner, 1957, 1958), though employers can allow their employees to interact more intensively with their professional communities (Henderson & Cockburn, 1994; Stern, 2004).

For government, our results suggest that policies that encourage educational institutions to strengthen and reinforce intrinsic motivation, including love of challenge, curiosity, etc., may offer social dividends. Our results also suggest that policies that change the incentives of individuals engaged in innovation should be evaluated in light of the complex ways in which such changes in incentives may affect not only the rate and direction

[44] Intrinsic and social factors may also play an important role in the attraction and retention of highly qualified

of research effort, but its productivity as well. One such policy was the Bayh-Dole Amendment and related legislation that allowed universities and other institutions receiving public research support to retain patent rights from sponsored research, spawning a rapid acceleration in academic patenting. Although there has been much concern expressed over the growing commercial incentives of academics since the advent of Bayh-Dole, we know little about how stable their motives are, nor how changing the nature of the rewards to academic research might change academics' research activity or productivity.

Finally, for policymakers - as well as managers - our analysis should not be construed as suggesting that there is some ideal R&D employee distinguished by some level, for example, of desire for challenge or income. We suspect that superior innovative performance for firms and even academic institutions is best achieved through a mix of individuals with different motives, who are exposed to a range of incentives and broader research and professional environments that will vary across the demands of different tasks.

Our analysis is subject to a number of important qualifications. First, our measures of individuals' preferences are single-item measures, while social psychologists typically prefer to use multiple items and to explicitly assess the reliability of the resulting measures. Second, to advance our research agenda, we need more complete data on a broader range of motives. On the basis of interviews, we believe, for example, that the social motive of loyalty to project teams may importantly affect effort (cf. Dunbar, 1995; Kidder, 1981), and that the intrinsic motive of wanting to have an impact importantly drives engineers. We also need better measures on the extent to which various extrinsic, intrinsic, and social work benefits are available in different innovative settings and on the extent to which they are contingent upon innovative effort and performance. Finally, notwithstanding the large body of research assuming stability of employees' motives (cf. Amabile et al., 1994; Cable & Edwards, 2004), we must entertain the possibility that R&D employees' motives may themselves be influenced by previously realized benefits, implying endogeneity. To the degree that this is true, one should view our results as more descriptive.

Despite these limitations, our empirical results suggest that individuals' motives and incentives - pecuniary as well as nonpecuniary - may be important drivers of innovative activity and performance, and that future research could fruitfully examine their effects.

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individuals (cf. Henderson, 1994; Sauermann & Cohen, 2007; Stern, 2004).

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APPENDIX

Table 1: Sample Composition (Number of Cases in each Cell)

Industry (IND_NAICS)	Primary work activity (WAPRI) Basic Research	Applied Research	Develop-ment	Design	Computer Applications	Total
21x Mining,Oil,Gas	≤5	57	49	33	36	180
22x Utilities	9	37	31	107	91	275
23x Construction	≤5	17	15	74	28	138
311-312 Manufacturing:Food,Bev,Tobacco	8	51	47	26	30	162
313-316 Manufacturing:Textiles	≤5	7	16	≤5	14	41
3211,337 Manufacturing:Wood,Furniture	≤5	≤5	10	16	13	45
322-323 Manufacturing:Paper,Printing	≤5	23	32	20	34	109
324 Manufacturing:Petroleum	≤5	21	10	22	20	74
325 Manufacturing:Chemicals ex Pharma	21	206	213	76	55	571
3254 Pharma	50	239	152	27	72	540
326 Manufacturing:Plastics,Rubber	≤5	19	33	27	16	97
327 Manufacturing:NonmetalMinerals	≤5	7	23	21	11	62
331 Manufacturing:PrimaryMetal	≤5	7	17	26	16	67
332 Manufacturing:FabricatedMetal	≤5	10	50	60	19	142
333 Manufacturing:Machinery	≤5	43	106	159	101	414
3341 Manufacturing:Computers	8	51	144	67	156	426
3342-3343 Manufacturing:Communications,Audio, Video	≤5	41	89	79	107	321
3344 Manufacturing:Semiconductors,Electronics	11	90	327	190	263	881
3345 Manufacturing:Instruments	≤5	39	96	103	106	349
335 Manufacturing:HouseholdAppliances,Lighting	≤5	24	60	42	43	174
3361-3363 Manufacturing:Auto	8	54	129	140	81	412
3364 Manufacturing:Aircraft,Aerospace	9	94	210	284	203	800
3365-3369 Manufacturing:TransportationEquipment	≤5	≤5	17	25	18	66
3391 Manufacturing:MedicalEquipment	6	50	91	50	34	231
3399 Manufacturing:Misc.	≤5	≤5	23	21	23	73
517 Telecom Services	16	54	83	103	282	538
5415 Computer Systems Design	38	145	307	206	1,650	2,346
5417 Scientific R&D Services	163	812	312	84	136	1,507
Total	386	2,213	2,692	2,092	3,658	11,041

Source: Based on NSF (2003): SESTAT restricted-use data file.
Note: Counts <5 suppressed due to NSF confidentiality restrictions.

Table 2: Comparison of Full and Limited Sample

Primary work activity (WAPRI)	Full Sample Frequency	Percent	Limited Sample Frequency	Percent
Basic Research	386	3.50	117	4.16
Applied Research	2,213	20.04	1,096	38.99
Development	2,692	24.38	934	33.23
Design	2,092	18.95	261	9.28
Computer Apps./Programming	3,658	33.13	403	14.34
Total	11,041	100.00	2,811	100.00
DEGREE				
Bachelor	4,989	45.19	0	0.00
Master	2,672	24.20	0	0.00
PhD	3,380	30.61	2,811	100.00
Total	11,041	100.00	2,811	100.00

Source: Based on NSF (2003): SESTAT restricted-use data file

Table 3: Importance of Organizational Benefits and Job Characteristics, 4-Point Scale

Preference measure	N	Mean	S.D.
Importance intellectual challenge	11041	3.64	0.53
Importance (fringe) benefits	11041	3.58	0.55
Importance salary	11041	3.56	0.53
Importance opportunities for advancement	11041	3.35	0.65
Importance level of responsibility	11041	3.28	0.63
Importance contribution to society	11041	3.11	0.73
Importance job security	11041	3.52	0.59
Importance independence	11041	3.48	0.59

Source: Based on NSF (2003): SESTAT restricted-use data file

Table 4: Differences in Preference Ratings (ordered probit, robust SE)

	1	2	3	4	5	6	7	8
	IMP_SAL	**IMP_BEN**	**IMP_CHAL**	**IMP_ADV**	**IMP_RESP**	**IMP_SOC**	**IMP_IND**	**IMP_SEC**
Applied Research	0.042	-0.022	-0.012	-0.160*	-0.085	-0.130*	0.025	-0.152*
	[0.068]	[0.071]	[0.075]	[0.063]	[0.065]	[0.066]	[0.066]	[0.069]
Development	0.036	-0.114	-0.144	-0.178**	-0.098	-0.245**	-0.064	-0.182**
	[0.067]	[0.071]	[0.074]	[0.062]	[0.064]	[0.065]	[0.065]	[0.068]
Design	-0.011	-0.113	-0.244**	-0.374**	-0.230**	-0.344**	-0.174**	-0.208**
	[0.070]	[0.073]	[0.076]	[0.064]	[0.066]	[0.067]	[0.067]	[0.070]
Computer Apps./Programming	0.037	-0.182**	-0.264**	-0.352**	-0.318**	-0.404**	-0.176**	-0.241**
	[0.066]	[0.070]	[0.073]	[0.061]	[0.063]	[0.064]	[0.064]	[0.067]
Master	-0.031	-0.118**	0.081**	0.05	0.082**	0.120**	0.021	-0.141**
	[0.030]	[0.030]	[0.030]	[0.028]	[0.028]	[0.027]	[0.028]	[0.029]
PhD	-0.311**	-0.408**	0.232**	-0.012	0.056	0.244**	0.093**	-0.361**
	[0.030]	[0.031]	[0.032]	[0.029]	[0.029]	[0.028]	[0.030]	[0.030]
Field: Science	0.014	0.057*	0.027	-0.048	-0.043	0.054*	0.055*	0.04
	[0.027]	[0.027]	[0.028]	[0.026]	[0.026]	[0.025]	[0.026]	[0.027]
Field: Other	0.055	0.116**	-0.024	-0.079*	-0.009	0.008	0.125**	0.03
	[0.037]	[0.037]	[0.036]	[0.033]	[0.033]	[0.033]	[0.035]	[0.035]
Observations	11041	11041	11041	11041	11041	11041	11041	11041
Chi-square	147.253	209.662	195.433	97.424	113.087	317.059	99.29	164.425
df	8	8	8	8	8	8	8	8

Robust standard errors in brackets
* significant at 5%; ** significant at 1%

Source: Based on NSF (2003): SESTAT restricted-use data file

Table 5: Factor Loadings of Preference Measures

Preference measure	Factor 1	Factor 2	Uniqueness
Importance responsibility	**0.69**	0.02	0.51
Importance challenge	**0.62**	-0.08	0.64
Importance contribution to society	**0.51**	-0.01	0.75
Importance opportunities advancement	**0.49**	0.21	0.67
Importance benefits	0.01	**0.68**	0.54
Importance salary	-0.04	**0.62**	0.63
Importance independence	**0.57**	-0.04	0.68
Importance job security	0.04	**0.51**	0.73

Source: Based on NSF (2003): SESTAT restricted-use data file

Table 6: Summary Statistics for Selected Variables

	Variable	Type	Obs	Mean	Std. Dev.	Min	Max
Dependent variables	uspapp	count	11,041	1.19	4.49	0	96
	uspgrt	count	11,041	0.60	2.88	0	96
	uspcom	count	11,041	0.26	1.76	0	96
	hrsworked	continuous	11,041	45.40	6.64	30	96
Firm level indep. variables	emsize1	dummy	11,041	0.03	0.17	0	1
	emsize2	dummy	11,041	0.03	0.18	0	1
	emsize3	dummy	11,041	0.09	0.28	0	1
	emsize4	dummy	11,041	0.11	0.31	0	1
	emsize5	dummy	11,041	0.05	0.22	0	1
	emsize6	dummy	11,041	0.14	0.34	0	1
	emsize7	dummy	11,041	0.17	0.38	0	1
	emsize8	dummy	11,041	0.38	0.48	0	1
	newbus	dummy	11,041	0.08	0.28	0	1
	emplidct10	51 dummies	2,811				
	emplidct5	86 dummies	2,811				
Individual level indep. variables	wapri basic	dummy	11,041	0.03	0.18	0	1
	wapri applied	dummy	11,041	0.20	0.40	0	1
	wapri devlop	dummy	11,041	0.24	0.43	0	1
	wapri design	dummy	11,041	0.19	0.39	0	1
	wapri comp.	dummy	11,041	0.33	0.47	0	1
	wa_nonrd	count	11,041	1.54	1.47	0	8
	jobdegree	Likert 1-3	11,041	2.53	0.66	1	3
	hd_bachelor	dummy	11,041	0.45	0.50	0	1
	hd_master	dummy	11,041	0.24	0.43	0	1
	hd_phd	dummy	11,041	0.31	0.46	0	1
	male	dummy	11,041	0.80	0.40	0	1
	married	dummy	11,041	0.75	0.43	0	1
	children011	count	11,041	0.66	0.97	0	9
	jobtenure	continuous	11,041	6.75	7.29	supp.*	46
	hdtenure	continuous	11,041	13.27	9.55	1	49
	ln_supdir	continuous	11,041	0.55	0.81	supp.*	5.53
	govt_nasa	dummy	11,041	0.03	0.16	0	1
	govt_dod	dummy	11,041	0.12	0.33	0	1
	uscitizen	dummy	11,041	0.85	0.36	0	1
	asian	dummy	11,041	0.24	0.43	0	1
	black	dummy	11,041	0.05	0.21	0	1
	white	dummy	11,041	0.71	0.45	0	1
	race_other	dummy	11,041	0.06	0.24	0	1
	e93_score	continuous	2,811	3.42	0.77	0.42	4.75

Source: Based on NSF (2003): SESTAT restricted-use data file
Note: *suppressed due to NSF confidentiality restrictions.

Table 7: Correlations

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	uspapp	1														
2	uspgrt	0.7958*	1													
3	uspcom	0.5951*	0.7832*	1												
4	hrsworked	0.1040*	0.0713*	0.0515*	1											
5	imp_sal	-0.0207	-0.0310*	-0.0129	-0.0446*	1										
6	imp_ben	-0.0379*	-0.0396*	-0.023	-0.0345*	0.5003*	1									
7	imp_chal	0.0680*	0.0487*	0.0320*	0.1162*	-0.0008	0.0593*	1								
8	imp_adv	0.0187	-0.0086	-0.0076	0.0452*	0.2027*	0.2015*	0.3330*	1							
9	imp_resp	0.0281*	0.0116	0.0103	0.1047*	0.1045*	0.1096*	0.4336*	0.4504*	1						
10	imp_soc	0.0283*	0.0105	-0.002	0.0461*	-0.0152	0.0973*	0.3164*	0.2656*	0.3544*	1					
11	imp_ind	0.0490*	0.0398*	0.0229	0.0813*	0.0351*	0.0866*	0.3763*	0.2273*	0.4390*	0.3069*	1				
12	imp_sec	-0.0551*	-0.0387*	-0.0344*	-0.0538*	0.2894*	0.4210*	0.0337*	0.2070*	0.1030*	0.1133*	0.0586*	1			
13	emsize1	-0.0013	0.0003	-0.001	0.0393*	-0.0381*	-0.0812*	0.0163	-0.0131	0.0075	-0.0009	0.0299*	-0.0730*	1		
14	emsize8	0.0353*	0.0275*	0.0059	0.0021	0.0105	0.0495*	-0.0005	-0.0077	-0.0046	0.0082	-0.0077	0.0418*	-0.1393*	1	
15	newbus	0.0146	-0.0085	-0.0043	0.0786*	-0.0320*	-0.0641*	0.0206	0.0330*	0.0146	0.0027	0.0063	-0.0918*	0.2438*	-0.1928*	1
16	wapri: basic	0.01	0.0089	-0.0127	-0.011	-0.008	0.0119	0.0270*	0.0404*	0.0296*	0.0497*	0.0191	0.0261*	0.0114	-0.0320*	0.0073
17	wapri: applied	0.1483*	0.1067*	0.0419*	0.0616*	-0.0308*	-0.0047	0.0842*	0.0389*	0.0461*	0.0993*	0.0642*	-0.0185	0.0068	0.0196	0.0148
18	wapri: develop	0.0611*	0.0591*	0.0655*	0.0576*	-0.011	-0.0213	0.0245	0.0434*	0.0482*	0.0326*	0.0189	-0.012	-0.0166	0.0124	0.0103
19	wapri: design	-0.0441*	-0.0276*	-0.0116	-0.0089	0.0017	0.019	-0.0421*	-0.0400*	-0.0153	-0.0475*	-0.0402*	0.0111	-0.0360*	0.0027	-0.0629*
20	wapri: comp.	-0.1491*	-0.1251*	-0.0808*	-0.0933*	0.0379*	0.0029	-0.0693*	-0.0552*	-0.0820*	-0.0941*	-0.0459*	0.0073	0.0348*	-0.0177	0.0276*
21	wa_nonrd	0.0162	0.0273*	0.0262*	0.2222*	0.0221	0.0349*	0.0505*	0.1117*	0.1390*	0.0765*	0.0686*	0.0135	0.0465*	-0.0600*	0.0131
22	jobdegree	0.0336*	0.0208	0.0206	0.0347*	0.0314*	0.0316*	0.0568*	0.0682*	0.0717*	0.0687*	0.0336*	0.0404*	0.0158	0.0049	-0.0115
23	hd_bachelor	-0.1709*	-0.1346*	-0.0754*	-0.0865*	0.0746*	0.1001*	-0.0862*	-0.0271*	-0.0485*	-0.1135*	-0.0442*	0.0982*	-0.0073	-0.0493*	-0.0466*
24	hd_master	-0.0773*	-0.0596*	-0.0257*	-0.0343*	0.0345*	0.0149	-0.0108	0.0118	0.0141	-0.0027	-0.0109	-0.0001	-0.0122	0.0310*	0.0008
25	hd_phd	0.2563*	0.2007*	0.1053*	0.1252*	-0.1126*	-0.1219*	0.1032*	0.0184	0.0392*	0.1251*	0.0578*	-0.1059*	0.0193	0.0244	0.0496*
26	male	0.0648*	0.0604*	0.0439*	0.0678*	-0.0137	-0.0507*	-0.0225	-0.0498*	-0.0402*	-0.0853*	-0.0466*	-0.0584*	0.0341*	-0.0362*	0.0232
27	married	0.0449*	0.0433*	0.0277*	0.0158	0.0196	0.0467*	-0.0370*	-0.0445*	-0.0125	0.016	-0.0209	0.0258*	-0.0177	-0.0036	-0.0318*
28	children011	0.0324*	0.0268*	0.0219	0.0047	0.0416*	0.0505*	-0.018	0.0256*	0.0021	0.0154	-0.0181	0.0253*	-0.0043	-0.0178	0.0161
29	jobtenure	0.0471*	0.0781*	0.0582*	-0.0257*	-0.0319*	0.0392*	-0.0505*	-0.1666*	-0.0597*	-0.0117	0.0227	0.0307*	-0.0464*	0.1616*	-0.1956*
30	hdtenure	0.0206	0.0654*	0.0464*	0.0279*	-0.0536*	-0.0119	-0.0582*	-0.2775*	-0.0950*	-0.0238	0.0158	-0.0391*	0.0173	0.0079	-0.0703*
31	ln_supdir	0.1144*	0.0990*	0.0766*	0.2502*	-0.0153	-0.0016	0.0743*	0.0695*	0.1154*	0.0763*	0.0513*	-0.0368*	0.0154	-0.0198	0.006
32	ability	0.0593*	0.0297	-0.0085	0.0748*	-0.0520*	-0.045	0.0313	-0.0387	-0.0443	-0.0585*	-0.0295	-0.0749*	-0.0502*	-0.014	0.0175

		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
16	wapri: basic	1															
17	wapri: applied	-0.0953*	1														
18	wapri: develop	-0.1081*	-0.2843*	1													
19	wapri: design	-0.0920*	-0.2421*	-0.2745*	1												
20	wapri: comp.	-0.1340*	-0.3524*	-0.3997*	-0.3403*	1											
21	wa_nonrd	-0.007	0.0389*	0.0630*	0.0382*	-0.1196*	1										
22	jobdegree	0.0256*	0.0825*	0.0540*	0.0286*	-0.1532*	0.0108	1									
23	hd_bachelor	-0.0192	-0.2177*	-0.1066*	0.1401*	0.1733*	0.0581*	-0.0124	1								
24	hd_master	-0.0166	-0.0964*	-0.0057	0.0123	0.0834*	-0.0132	0.0738*	-0.5130*	1							
25	hd_phd	0.0362*	0.3247*	0.1203*	-0.1627*	-0.2646*	-0.0505*	-0.0552*	-0.6031*	-0.3753*	1						
26	male	-0.0487*	-0.0532*	0.0340*	0.0667*	-0.0222	0.0064	0.0268*	-0.0077	-0.0301*	0.0363*	1					
27	married	-0.0353*	0.0161	0.02	-0.0012	-0.0172	0.022	0.0215	-0.1091*	0.0333*	0.0869*	0.1254*	1				
28	children011	-0.0097	-0.0194	0.0131	-0.0099	0.0166	0.024	0.0155	-0.0329*	-0.0024	0.0378*	0.0640*	0.3393*	1			
29	jobtenure	-0.0102	0.019	0.0137	0.0604*	-0.0749*	-0.0108	0.0226	0.0288*	-0.004	-0.0274*	0.0782*	0.1057*	-0.0761*	1		
30	hdtenure	-0.0273*	-0.0217	-0.0039	0.0525*	-0.0111	0.0131	-0.1049*	0.0859*	-0.0710*	-0.0267*	0.1290*	0.1946*	-0.1291*	0.5077*	1	
31	ln_supdir	-0.0041	0.0821*	0.0559*	0.0094	-0.1271*	0.3957*	0.0500*	-0.0961*	-0.0354*	0.1366*	0.0726*	0.0841*	0.0640*	0.0756*	0.0842*	1
32	ability	0.0147	0.0429	0.0048	-0.021	-0.0572*	-0.0204	-0.0448	.	.	.	-0.0198	-0.0652*	0.0007	0.0327	0.0374	-0.0121

* significant at 1%

Source: Based on NSF (2003): SESTAT restricted-use data file

Table 8: Effort Regressions

	Full Sample				Limited Sample			
	tobit40	tobit40	truncreg35	oprobit	tobit40	tobit40	tobit40	truncreg35
	1	2	3	4	5	6	7	8
	hrsworked	**hrsworked**	**hrsworked**	**hrscat10**	**hrsworked**	**hrsworked**	**hrsworked**	**hrsworked**
Imp. Salary		-0.519*	-0.440*	-0.074**	0.379	0.392	0.570	0.497
		[0.205]	[0.185]	[0.026]	[0.394]	[0.393]	[0.393]	[0.378]
Imp. Benefits		-0.183	-0.136	-0.017	-0.142	-0.131	-0.133	-0.197
		[0.208]	[0.184]	[0.027]	[0.382]	[0.382]	[0.381]	[0.348]
Imp. Challenge		1.298**	0.948**	0.141**	1.749**	1.666**	1.721**	1.540**
		[0.210]	[0.179]	[0.027]	[0.434]	[0.434]	[0.432]	[0.358]
Imp. Advancement		-0.029	-0.003	0.001	-0.066	-0.066	-0.101	0.000
		[0.174]	[0.151]	[0.022]	[0.328]	[0.327]	[0.326]	[0.307]
Imp. Responsibility		0.652**	0.618**	0.088**	0.517	0.548	0.469	0.470
		[0.186]	[0.158]	[0.023]	[0.354]	[0.354]	[0.353]	[0.328]
Imp. Contr. Society		-0.305*	-0.142	-0.021	0.025	0.066	0.061	0.079
		[0.144]	[0.125]	[0.019]	[0.297]	[0.297]	[0.295]	[0.254]
Imp. Independence		0.411*	0.359*	0.019	0.197	0.229	0.251	0.183
		[0.182]	[0.156]	[0.023]	[0.355]	[0.354]	[0.355]	[0.327]
Imp. Job Security		-0.295	-0.260	-0.006	-0.730*	-0.671*	-0.752*	-0.682*
		[0.175]	[0.158]	[0.022]	[0.324]	[0.324]	[0.322]	[0.304]
Ability						0.855**	0.785**	0.649**
						[0.239]	[0.239]	[0.219]
Employer ID's (86)							included	included
IND_NAICS (27)				----------included----------				
EMSIZE: 1-10	-0.733	-0.987	-0.424	-0.075	-0.260	-0.006	1.542	1.631
	[0.581]	[0.581]	[0.547]	[0.079]	[1.087]	[1.087]	[1.198]	[1.202]
EMSIZE: 11-24	-2.062**	-2.191**	-1.684**	-0.217**	-1.419	-1.433	0.125	0.405
	[0.567]	[0.565]	[0.498]	[0.073]	[1.072]	[1.070]	[1.179]	[1.051]
EMSIZE: 25-99	-0.794*	-0.927*	-0.636	-0.077	0.003	-0.018	1.537	1.389
	[0.377]	[0.375]	[0.339]	[0.048]	[0.698]	[0.697]	[0.878]	[0.834]
EMSIZE: 100-499	-0.526	-0.547	-0.596*	-0.110**	-0.770	-0.766	0.782	0.487
	[0.332]	[0.330]	[0.294]	[0.042]	[0.672]	[0.670]	[0.851]	[0.764]
EMSIZE: 500-999	-0.932*	-0.922*	-0.934**	-0.136*	-0.680	-0.589	1.338	1.020
	[0.437]	[0.435]	[0.362]	[0.055]	[0.903]	[0.902]	[1.052]	[1.033]
EMSIZE: 1000-4999	-0.742*	-0.754*	-0.734**	-0.108**	-1.017	-1.077	0.348	0.137
	[0.302]	[0.301]	[0.258]	[0.038]	[0.582]	[0.581]	[0.760]	[0.673]
EMSIZE: 5000-24999	-0.512	-0.483	-0.457*	-0.088*	-0.654	-0.639	0.163	0.206
	[0.275]	[0.274]	[0.229]	[0.034]	[0.537]	[0.535]	[0.669]	[0.576]
New Business	2.569**	2.538**	1.975**	0.266**	3.078**	3.020**	3.077**	2.418**
	[0.375]	[0.373]	[0.333]	[0.048]	[0.681]	[0.680]	[0.679]	[0.653]
HD_FIELD (15)				----------included----------				
WAPRI: applied research	0.829	0.819	0.475	0.064	-1.338	-1.336	-1.702	-1.720
	[0.549]	[0.546]	[0.472]	[0.071]	[0.916]	[0.914]	[0.914]	[0.883]
WAPRI: development	0.964	1.001	0.488	0.045	-1.288	-1.249	-1.562	-1.696
	[0.553]	[0.550]	[0.474]	[0.071]	[0.952]	[0.950]	[0.953]	[0.910]
WAPRI: design	0.971	1.076	0.481	0.037	-1.380	-1.282	-1.657	-2.015
	[0.574]	[0.571]	[0.488]	[0.074]	[1.099]	[1.097]	[1.097]	[1.078]
WAPRI: computer apps.	-0.188	-0.044	-0.270	-0.047	-2.701*	-2.575*	-2.668*	-2.467*
	[0.561]	[0.559]	[0.482]	[0.073]	[1.083]	[1.080]	[1.081]	[1.123]
WA_NONRD	1.101**	1.062**	0.888**	0.122**	1.168**	1.174**	1.120**	0.952**
	[0.070]	[0.070]	[0.063]	[0.009]	[0.150]	[0.150]	[0.149]	[0.128]
DEGREE: masters	0.859**	0.748**	0.528*	0.074*				
	[0.245]	[0.244]	[0.208]	[0.031]				
DEGREE: phd	2.699**	2.390**	2.038**	0.284**				
	[0.274]	[0.276]	[0.243]	[0.035]				
HDTENURE	0.153**	0.162**	0.143**	0.020**	0.272**	0.268**	0.272**	0.244**
	[0.036]	[0.036]	[0.031]	[0.005]	[0.080]	[0.080]	[0.080]	[0.076]
HDTENURE_SQ	-0.003**	-0.004**	-0.003**	-0.000**	-0.006**	-0.006**	-0.006**	-0.005**
	[0.001]	[0.001]	[0.001]	[0.000]	[0.002]	[0.002]	[0.002]	[0.002]
JOBTENURE	-0.104*	-0.100*	-0.117**	-0.019**	-0.207*	-0.210*	-0.240**	-0.236**
	[0.041]	[0.040]	[0.034]	[0.005]	[0.084]	[0.084]	[0.084]	[0.080]
JOBTENURE_SQ	0.002	0.002	0.002*	0.000**	0.005	0.005	0.006*	0.007*
	[0.001]	[0.001]	[0.001]	[0.000]	[0.003]	[0.003]	[0.003]	[0.003]
JOBDEGREE	0.569**	0.523**	0.457**	0.058**	0.385	0.442	0.351	0.281
	[0.158]	[0.157]	[0.136]	[0.020]	[0.308]	[0.308]	[0.308]	[0.279]
LN_SUPDIR	1.929**	1.850**	1.619**	0.206**	2.104**	2.125**	2.147**	1.974**
	[0.126]	[0.126]	[0.114]	[0.016]	[0.250]	[0.250]	[0.249]	[0.208]
MALE	1.183**	1.216**	0.964**	0.161**	0.881	0.943	1.065*	0.770
	[0.249]	[0.249]	[0.220]	[0.033]	[0.507]	[0.506]	[0.505]	[0.484]
MARRIED	-0.121	-0.008	-0.084	-0.012	-0.223	-0.108	-0.097	-0.192
	[0.241]	[0.241]	[0.211]	[0.030]	[0.492]	[0.492]	[0.494]	[0.450]
CHILDREN011	-1.345**	-1.273**	-1.089**	-0.182**	-3.011**	-3.064**	-3.180**	-2.979**
	[0.261]	[0.260]	[0.244]	[0.037]	[0.551]	[0.550]	[0.554]	[0.532]
MALE X CHILDREN011	1.373**	1.331**	1.088**	0.182**	2.648**	2.675**	2.796**	2.667**
	[0.276]	[0.275]	[0.257]	[0.038]	[0.580]	[0.579]	[0.582]	[0.569]
USCITIZEN	1.141**	1.234**	0.770**	0.071	0.000	-0.081	0.041	-0.087
	[0.301]	[0.300]	[0.276]	[0.038]	[0.552]	[0.552]	[0.549]	[0.530]
RACE (3)				----------included----------				
Constant	37.852**	33.985**	37.509**		35.174**	31.913**	30.509**	33.595**
	[1.176]	[1.596]	[1.438]		[2.972]	[3.105]	[3.238]	[2.630]
Observations	11041	11041	11023	11041	2811	2811	2811	2811

Robust standard errors in brackets
* significant at 5%; ** significant at 1%

Source: Based on NSF (2003): SESTAT restricted-use data file

Table 9: Performance Regressions

				Full Sample				Basic/Appl.	Development
	ZINB	ZINB	ZINB(logit)	ZINB	NBREG	NBREG	NBREG	NBREG	NBREG
	1	2a	2b	3	4	5	6	7	8
	uspapp	**uspapp**		**uspapp**	**uspapp**	**uspapp**	**uspapp**	**uspapp**	**uspapp**
Hours Worked	0.018**	0.015**		0.016**	0.021**	0.018**	0.018**	0.009	0.023**
	[0.005]	[0.005]		[0.005]	[0.005]	[0.005]	[0.005]	[0.006]	[0.007]
Imp. Salary		0.186**		0.184**		0.112	0.109	0.301**	0.033
		[0.064]		[0.064]		[0.070]	[0.070]	[0.097]	[0.092]
Imp. Benefits		-0.043		-0.043		-0.02	-0.018	-0.087	-0.051
		[0.070]		[0.070]		[0.073]	[0.073]	[0.100]	[0.091]
Imp. Challenge		0.323**				0.382**		0.466**	0.19
		[0.065]				[0.068]		[0.100]	[0.108]
Imp. Advancement		-0.047		-0.029		-0.051	-0.031	0.113	-0.047
		[0.053]		[0.053]		[0.056]	[0.056]	[0.079]	[0.089]
Imp. Responsibility		-0.078		-0.07		-0.084	-0.073	-0.177*	-0.044
		[0.055]		[0.055]		[0.057]	[0.057]	[0.082]	[0.092]
Imp. Contribution Society		-0.033		-0.022		0.018	0.03	-0.032	-0.05
		[0.046]		[0.047]		[0.049]	[0.050]	[0.062]	[0.076]
Imp. Independence		0.181**		0.207**		0.116*	0.149**	0.129	0.230**
		[0.053]		[0.053]		[0.057]	[0.057]	[0.075]	[0.088]
Imp. Job Security		-0.205**		-0.209**		-0.265**	-0.271**	-0.343**	-0.183*
		[0.060]		[0.059]		[0.059]	[0.059]	[0.086]	[0.084]
Imp. Chall_inv.				-2.156**			-2.500**		
				[0.662]			[0.712]		
Imp. Salary X Imp. Chall_inv.				0.035			-0.079		
				[0.720]			[0.847]		
IND_NAICS (27)	---included---								
EMSIZE: 1-10	0.226	0.218	0.926*	0.241	-0.154	-0.201	-0.192	-0.472	-0.152
	[0.282]	[0.284]	[0.383]	[0.286]	[0.202]	[0.203]	[0.203]	[0.308]	[0.334]
EMSIZE: 11-24	-0.125	-0.104	0.614	-0.1	-0.449*	-0.423*	-0.428*	-0.653*	0.092
	[0.251]	[0.239]	[0.356]	[0.239]	[0.203]	[0.202]	[0.202]	[0.292]	[0.291]
EMSIZE: 25-99	-0.067	-0.101	0.739**	-0.096	-0.414**	-0.453**	-0.452**	-0.660**	-0.305
	[0.160]	[0.154]	[0.254]	[0.154]	[0.128]	[0.124]	[0.124]	[0.166]	[0.197]
EMSIZE: 100-499	-0.251	-0.204	0.627*	-0.203	-0.562**	-0.521**	-0.525**	-0.388*	-0.440*
	[0.185]	[0.183]	[0.253]	[0.181]	[0.124]	[0.129]	[0.127]	[0.167]	[0.188]
EMSIZE: 500-999	-0.202	-0.254	0.409	-0.255	-0.387**	-0.397**	-0.401**	-0.794**	-0.169
	[0.178]	[0.180]	[0.334]	[0.181]	[0.144]	[0.139]	[0.139]	[0.239]	[0.211]
EMSIZE: 1000-4999	-0.285**	-0.257*	0.007	-0.263*	-0.271**	-0.242**	-0.247**	-0.305*	-0.199
	[0.107]	[0.107]	[0.219]	[0.108]	[0.093]	[0.092]	[0.093]	[0.143]	[0.139]
EMSIZE: 5000-24999	-0.196	-0.189	0.135	-0.188	-0.192	-0.174	-0.175	-0.531**	-0.279*
	[0.108]	[0.104]	[0.187]	[0.104]	[0.109]	[0.105]	[0.105]	[0.114]	[0.122]
New Business	0.026	-0.028	-0.778**	-0.045	0.339**	0.289*	0.283*	0.022	0.482**
	[0.163]	[0.155]	[0.301]	[0.154]	[0.127]	[0.124]	[0.124]	[0.163]	[0.176]
HD_FIELD (15)	---included---								
WAPRI: applied research	-0.048	-0.071	-0.884**	-0.071	0.318*	0.303*	0.300*	0.203	
	[0.151]	[0.143]	[0.301]	[0.143]	[0.140]	[0.134]	[0.134]	[0.122]	
WAPRI: development	-0.315*	-0.299*	-0.825**	-0.308*	0.096	0.108	0.098		
	[0.158]	[0.153]	[0.318]	[0.152]	[0.141]	[0.136]	[0.136]		
WAPRI: design	-0.377*	-0.346	[0.183]	-0.358	-0.24	-0.224	-0.239		
	[0.191]	[0.187]	[0.314]	[0.186]	[0.162]	[0.156]	[0.156]		
WAPRI: computer apps.	-1.065**	-1.077**	0.295	-1.068**	-1.208**	-1.183**	-1.189**		
	[0.225]	[0.218]	[0.337]	[0.219]	[0.162]	[0.155]	[0.155]		
WA_NONRD	-0.028	-0.018	0.048	-0.019	-0.063*	-0.055*	-0.057*	-0.068	-0.008
	[0.029]	[0.029]	[0.042]	[0.029]	[0.024]	[0.024]	[0.024]	[0.036]	[0.034]
DEGREE: Masters	0.252*	0.211	-0.456**	0.215	0.502**	0.470**	0.475**	0.498**	0.457**
	[0.128]	[0.128]	[0.157]	[0.128]	[0.098]	[0.096]	[0.096]	[0.163]	[0.138]
DEGREE: PhD	0.849**	0.795**	-2.013**	0.798**	1.629**	1.569**	1.578**	1.439**	1.598**
	[0.120]	[0.118]	[0.228]	[0.117]	[0.086]	[0.084]	[0.084]	[0.137]	[0.127]
HDTENURE	-0.021	-0.022		-0.022	-0.018	-0.018	-0.018	-0.003	-0.025
	[0.013]	[0.013]		[0.013]	[0.014]	[0.013]	[0.013]	[0.019]	[0.019]
HDTENURE_SQ	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000
	[0.000]	[0.000]		[0.000]	[0.000]	[0.000]	[0.000]	[0.001]	[0.001]
JOBTENURE	0.028*	0.031*		0.031*	0.026*	0.028*	0.028*	0.037*	0.059**
	[0.013]	[0.012]		[0.012]	[0.013]	[0.013]	[0.013]	[0.019]	[0.020]
JOBTENURE_SQ	-0.001	-0.001		-0.001	0.000	0.000	0.000	-0.001	-0.002*
	[0.000]	[0.000]		[0.000]	[0.000]	[0.000]	[0.000]	[0.001]	[0.001]
JOBDEGREE	0.117*	0.120*		0.123*	0.191**	0.193**	0.198**	-0.061	0.160*
	[0.059]	[0.057]		[0.057]	[0.059]	[0.057]	[0.057]	[0.084]	[0.080]
LN_SUPDIR	0.259**	0.273**		0.270**	0.267**	0.279**	0.275**	0.368**	0.179**
	[0.041]	[0.040]		[0.040]	[0.042]	[0.041]	[0.042]	[0.062]	[0.059]
MALE	0.580**	0.575**		0.578**	0.644**	0.635**	0.639**	0.380**	0.571**
	[0.088]	[0.086]		[0.085]	[0.087]	[0.085]	[0.085]	[0.113]	[0.133]
USCITIZEN	0.122	0.135		0.134	0.099	0.125	0.122	-0.126	-0.05
	[0.085]	[0.083]		[0.083]	[0.092]	[0.090]	[0.090]	[0.131]	[0.129]
RACE (3)	included	included		---------------------------------------included---------------------------------------					
GOVT_DOD			0.798**		-0.384**	-0.397**	-0.398**	-0.29	-0.07
			[0.224]		[0.122]	[0.120]	[0.120]	[0.230]	[0.193]
GOVT_NASA			0.519		-0.441*	-0.452*	-0.448*	-0.542	-0.201
			[0.358]		[0.195]	[0.195]	[0.193]	[0.363]	[0.318]
Constant	-3.287**	-4.411**		-2.821**	-5.653**	-6.413**	-4.575**	-6.160**	-5.743**
	[0.544]	[0.575]		[0.640]	[0.421]	[0.517]	[0.599]	[0.724]	[0.897]
Observations	11041	11041		11041	11041	11041	11041	2599	2692
Chi-square	474.779	544.528		539.588	2547.493	2787.656	2753.149	964.149	626.032
df	69	77		78	71	79	80	76	75

Robust standard errors in brackets
* significant at 5%; ** significant at 1%

Source: Based on NSF (2003): SESTAT restricted-use data file

Table 10: Performance Regressions: Robustness Checks

	Limited Sample					uspapp<21	uspapp>0
	NBREG	NBREG	NBREG	NBREG	NBREG	ZINB	NBREG
	1	2	3	4	5	6	7
	uspapp	**uspapp**	**uspapp**	**uspapp**	**uspapp**	**uspapp**	**uspapp**
Hours Worked	0.013**	0.012*	0.010*	0.010*	0.007	0.015**	0.009*
	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]	[0.004]	[0.004]
Imp. Salary	0.262**	0.265**	0.262**	0.205**	0.206**	0.084	0.142**
	[0.073]	[0.073]	[0.072]	[0.078]	[0.078]	[0.050]	[0.052]
Imp. Benefits	-0.058	-0.063	-0.064	-0.029	-0.033	-0.02	-0.01
	[0.083]	[0.082]	[0.082]	[0.081]	[0.081]	[0.048]	[0.056]
Imp. Challenge	0.277**	0.271**	0.273**	0.240**	0.235**	0.297**	0.155**
	[0.089]	[0.089]	[0.088]	[0.080]	[0.079]	[0.056]	[0.053]
Imp. Advancement	0.013	0.016	0.019	0.035	0.043	-0.041	0.004
	[0.065]	[0.065]	[0.064]	[0.064]	[0.064]	[0.041]	[0.045]
Imp. Responsibility	-0.124	-0.116	-0.124	-0.119	-0.122	-0.093*	-0.051
	[0.068]	[0.067]	[0.067]	[0.064]	[0.064]	[0.044]	[0.048]
Imp. Contribution Society	-0.125*	-0.123*	-0.118*	-0.09	-0.086	-0.051	-0.045
	[0.060]	[0.061]	[0.059]	[0.056]	[0.055]	[0.036]	[0.040]
Imp. Independence	0.316**	0.318**	0.316**	0.285**	0.286**	0.116*	0.162**
	[0.065]	[0.066]	[0.066]	[0.065]	[0.065]	[0.046]	[0.045]
Imp. Job Security	-0.186*	-0.174*	-0.168*	-0.220**	-0.203**	-0.113**	-0.093
	[0.080]	[0.079]	[0.078]	[0.075]	[0.073]	[0.042]	[0.054]
Ability		0.103*	0.106*		0.088		
		[0.046]	[0.045]		[0.046]		
Hours X Ability			0.014*		0.015**		
			[0.006]		[0.006]		
EMPLIDCT5				included	included		
IND_NAICS (27)				included			
EMSIZE: 1-10	0.261	0.307	0.292	0.49	0.508	-0.07	0.089
	[0.343]	[0.344]	[0.336]	[0.326]	[0.320]	[0.224]	[0.198]
EMSIZE: 11-24	-0.09	-0.095	-0.086	0.154	0.162	-0.265	-0.088
	[0.283]	[0.278]	[0.276]	[0.281]	[0.276]	[0.179]	[0.202]
EMSIZE: 25-99	-0.142	-0.146	-0.152	0.098	0.081	-0.278*	-0.103
	[0.156]	[0.156]	[0.157]	[0.170]	[0.170]	[0.114]	[0.105]
EMSIZE: 100-499	-0.185	-0.182	-0.18	0.013	0.014	-0.468**	-0.158
	[0.169]	[0.171]	[0.171]	[0.180]	[0.180]	[0.117]	[0.117]
EMSIZE: 500-999	-0.441	-0.432	-0.426	-0.082	-0.078	-0.228	-0.17
	[0.239]	[0.239]	[0.242]	[0.199]	[0.199]	[0.143]	[0.135]
EMSIZE: 1000-4999	-0.149	-0.163	-0.152	0.033	0.028	-0.220**	-0.146*
	[0.120]	[0.120]	[0.121]	[0.132]	[0.133]	[0.085]	[0.074]
EMSIZE: 5000-24999	-0.181	-0.191	-0.192*	-0.021	-0.033	-0.176*	-0.126
	[0.099]	[0.098]	[0.098]	[0.115]	[0.115]	[0.076]	[0.072]
New Business	0.118	0.107	0.106	0.112	0.105	0.166	0.017
	[0.162]	[0.161]	[0.159]	[0.159]	[0.157]	[0.120]	[0.104]
HD_FIELD (15)				included			
WAPRI: applied research	0.029	0.033	0.03	-0.041	-0.049	-0.095	0.037
	[0.171]	[0.172]	[0.172]	[0.159]	[0.158]	[0.120]	[0.111]
WAPRI: development	-0.223	-0.202	-0.208	-0.337*	-0.337*	-0.195	-0.146
	[0.181]	[0.181]	[0.181]	[0.170]	[0.170]	[0.132]	[0.114]
WAPRI: design	-0.418*	-0.4	-0.398	-0.460*	-0.448*	-0.423**	-0.153
	[0.212]	[0.213]	[0.213]	[0.204]	[0.202]	[0.149]	[0.135]
WAPRI: computer apps.	-1.337**	-1.318**	-1.328**	-1.382**	-1.386**	-0.832**	-0.563**
	[0.233]	[0.232]	[0.232]	[0.200]	[0.200]	[0.168]	[0.137]
WA_NONRD	-0.007	-0.011	-0.009	0.005	0.004	-0.03	0.011
	[0.037]	[0.036]	[0.036]	[0.034]	[0.034]	[0.022]	[0.021]
DEGREE: Masters						0.163	0.129
						[0.094]	[0.081]
DEGREE: PhD						0.548**	0.460**
						[0.088]	[0.068]
HDTENURE	-0.015	-0.016	-0.015	0.003	0.004	-0.021*	-0.041**
	[0.017]	[0.017]	[0.017]	[0.016]	[0.017]	[0.010]	[0.011]
HDTENURE_SQ	0	0	0	0	0	0.000	0.001**
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
JOBTENURE	-0.002	-0.003	-0.003	-0.003	-0.003	0.021*	0.013
	[0.016]	[0.016]	[0.016]	[0.015]	[0.016]	[0.010]	[0.011]
JOBTENURE_SQ	0.001	0.001	0.001	0.001	0.001	0.000	0.000
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.000]	[0.000]
JOBDEGREE	-0.021	-0.015	-0.014	0.003	0.008	0.116*	-0.009
	[0.062]	[0.062]	[0.062]	[0.063]	[0.063]	[0.045]	[0.047]
LN_SUPDIR	0.265**	0.268**	0.274**	0.282**	0.291**	0.227**	0.120**
	[0.059]	[0.059]	[0.059]	[0.049]	[0.049]	[0.035]	[0.034]
MALE	0.367**	0.375**	0.372**	0.406**	0.407**	0.440**	0.254**
	[0.102]	[0.103]	[0.104]	[0.101]	[0.102]	[0.074]	[0.074]
USCITIZEN	0.138	0.131	0.12	0.07	0.048	0.018	0.119
	[0.102]	[0.101]	[0.102]	[0.105]	[0.105]	[0.073]	[0.074]
RACE (3)				included			
GOVT_DOD	-0.251	-0.246	-0.246	-0.033	-0.034		-0.125
	[0.215]	[0.213]	[0.213]	[0.193]	[0.191]		[0.111]
GOVT_NASA	-0.636**	-0.622**	-0.627**	-0.878**	-0.871**		-0.15
	[0.243]	[0.239]	[0.238]	[0.260]	[0.260]		[0.172]
Constant	-3.963**	-4.344**	-4.275**	-3.409**	-3.614**	-3.221**	-2.245**
	[0.601]	[0.624]	[0.626]	[0.624]	[0.640]	[0.481]	[0.454]
Observations	2811	2811	2811	2811	2811	10964	2640
Chi-square	1949.85	1833.938	2006.37	3454.243	3620.323	478.516	534.105
df	76	77	78	162	164	77	79

Robust standard errors in brackets
* significant at 5%; ** significant at 1%

Source: Based on NSF (2003): SESTAT restricted-use data file

Table 11: Alternative Performance Measures (full sample, robust SE)

	ZINB	NBREG	ZINB	NBREG	ZINB	NBREG
	1	2	3	4	5	6
	uspapp	**uspapp**	**uspcom**	**uspcom**	**uspgrt**	**uspgrt**
Hours Worked	0.015**	0.018**	0.016**	0.017**	0.008	0.011*
	[0.005]	[0.005]	[0.006]	[0.006]	[0.005]	[0.005]
Imp. Salary	0.186**	0.112	0.188*	0.118	0.084	0.063
	[0.064]	[0.070]	[0.088]	[0.085]	[0.073]	[0.069]
Imp. Benefits	-0.043	-0.02	-0.017	0.024	0.004	0.014
	[0.070]	[0.073]	[0.089]	[0.088]	[0.071]	[0.068]
Imp. Challenge	0.323**	0.382**	0.390**	0.417**	0.318**	0.352**
	[0.065]	[0.068]	[0.105]	[0.103]	[0.078]	[0.079]
Imp. Advancement	-0.047	-0.051	-0.183*	-0.197*	-0.137*	-0.166**
	[0.053]	[0.056]	[0.077]	[0.077]	[0.060]	[0.061]
Imp. Responsibility	-0.078	-0.084	-0.038	-0.044	-0.113	-0.125
	[0.055]	[0.057]	[0.083]	[0.082]	[0.068]	[0.065]
Imp. Contribution Society	-0.033	0.018	-0.055	-0.033	-0.058	-0.025
	[0.046]	[0.049]	[0.073]	[0.071]	[0.055]	[0.055]
Imp. Independence	0.181**	0.116*	0.164	0.157	0.231**	0.205**
	[0.053]	[0.057]	[0.084]	[0.085]	[0.065]	[0.066]
Imp. Job Security	-0.205**	-0.265**	-0.284**	-0.292**	-0.203**	-0.241**
	[0.060]	[0.059]	[0.081]	[0.081]	[0.065]	[0.063]
IND_NAICS (27)	included					
EMSIZE (7)	included					
New Business	-0.028	0.289*	-0.181	0.003	-0.35	0.075
	[0.155]	[0.124]	[0.187]	[0.170]	[0.204]	[0.134]
HD_FIELD (15)	included					
WAPRI: applied research	-0.071	0.303*	0.329	0.648**	-0.285	0.136
	[0.143]	[0.134]	[0.291]	[0.249]	[0.191]	[0.159]
WAPRI: development	-0.299*	0.108	0.605*	0.765**	-0.448*	-0.004
	[0.153]	[0.136]	[0.295]	[0.250]	[0.221]	[0.163]
WAPRI: design	-0.346	-0.224	0.259	0.211	-0.464	-0.391*
	[0.187]	[0.156]	[0.317]	[0.261]	[0.289]	[0.176]
WAPRI: computer apps.	-1.077**	-1.183**	-0.379	-0.597*	-1.277**	-1.402**
	[0.218]	[0.155]	[0.344]	[0.273]	[0.383]	[0.187]
WA_NONRD	-0.018	-0.055*	0.003	0.013	0.002	-0.01
	[0.029]	[0.024]	[0.042]	[0.031]	[0.038]	[0.026]
DEGREE: Masters	0.211	0.470**	0.424**	0.403**	0.398*	0.524**
	[0.128]	[0.096]	[0.164]	[0.133]	[0.171]	[0.107]
DEGREE: PhD	0.795**	1.569**	0.986**	1.284**	1.017**	1.602**
	[0.118]	[0.084]	[0.136]	[0.127]	[0.164]	[0.101]
HDTENURE	-0.022	-0.018	0.104**	0.098**	0.080**	0.076**
	[0.013]	[0.013]	[0.020]	[0.020]	[0.016]	[0.016]
HDTENURE_SQ	0	0	-0.002**	-0.002**	-0.002**	-0.002**
	[0.000]	[0.000]	[0.001]	[0.001]	[0.000]	[0.000]
JOBTENURE	0.031*	0.028*	0.051*	0.059**	0.047**	0.048**
	[0.012]	[0.013]	[0.020]	[0.019]	[0.015]	[0.015]
JOBTENURE_SQ	-0.001	0	-0.001	-0.001*	-0.001	-0.001*
	[0.000]	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]
JOBDEGREE	0.120*	0.193**	0.193*	0.192*	0.1	0.163**
	[0.057]	[0.057]	[0.078]	[0.077]	[0.070]	[0.062]
LN_SUPDIR	0.273**	0.279**	0.352**	0.352**	0.298**	0.312**
	[0.040]	[0.041]	[0.059]	[0.057]	[0.047]	[0.046]
MALE	0.575**	0.635**	0.641**	0.693**	0.705**	0.753**
	[0.086]	[0.085]	[0.138]	[0.129]	[0.102]	[0.096]
USCITIZEN	0.135	0.125	0.03	0.032	0.096	0.055
	[0.083]	[0.090]	[0.142]	[0.142]	[0.100]	[0.110]
RACE (3)	included					
GOVT_DOD		-0.397**		-0.819**		-0.465**
		[0.120]		[0.157]		[0.145]
GOVT_NASA		-0.452*		-0.159		-0.136
		[0.195]		[0.316]		[0.228]
Constant	-4.411**	-6.413**	-9.668**	-10.285**	-5.701**	-7.583**
	[0.575]	[0.517]	[0.865]	[0.794]	[0.697]	[0.594]
Observations	11041	11041	11041	11041	11041	11041
Chi-square	544.528	2787.656	730.548	1101.737	599.439	2056.896
df	77	79	77	79	77	79
pseudoR2		0.111		0.123		0.133
alphaest		3.954		6.555		4.416

Standard errors in brackets
* significant at 5%; ** significant at 1%

Source: Based on NSF (2003): SESTAT restricted-use data file