KAUFFMAN
The Foundation of Entrepreneurship

KAUFFMAN DISSERTATION EXECUTIVE SUMMARY

Part of the Ewing Marion Kauffman Foundation's Emerging Scholars initiative, the Kauffman Dissertation Fellowship Program recognizes exceptional doctoral students and their universities. The annual program awards up to fifteen Dissertation Fellowship grants of $20,000 each to Ph.D., D.B.A., or other doctoral students at accredited U.S. universities to support dissertations in the area of entrepreneurship.

Since its establishment in 2002, this program has helped to launch world-class scholars into the exciting and emerging field of entrepreneurship research, thus laying a foundation for future scientific advancement. The findings generated by this effort will be translated into knowledge with immediate application for policymakers, educators, service providers, and entrepreneurs as well as high-quality academic research.

Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP Kauffman Dissertation Fellowship Program KDFP

www.kauffman.org/kdfp

Individual Incentives as Drivers of Innovative Processes and Performance

Henry Sauermann
Duke University, Fuqua School of Business

May, 2008

Abstract

Drawing on research in economics and social psychology and using survey data from over 10,000 scientists and engineers (SESTAT 2003), I examine the relationships between individuals' pecuniary and nonpecuniary motives and incentives, innovative effort, and innovative performance in firms. I find that individuals' motives, in particular intrinsic motives such as intellectual challenge, are important drivers of innovative outcomes. I also investigate differences in motives, effort and performance between startups and established firms. While extrinsic motives differ across firm types, intrinsic motives are surprisingly similar. The existing differences in motives explain only a limited amount of the observed significant effort and performance differences in startups versus established firms.

This research was funded in part by the Ewing Marion Kauffman Foundation. The contents of this publication are solely the responsibility of the author.
The use of NSF data does not imply NSF endorsement of the research methods or conclusions contained in this report.

Executive Summary

> *"…most seemed to view the prospect of stock as a mere sweetener, and most agreed with Ken Holberger, who declared, 'I don't work for money.' "*
>
> Tracy Kidder (1981): The soul of a new machine

Firms, both small and large, are major sources of innovation; it is thus imperative to gain a better understanding of the drivers of innovative efforts and performance of firms. Scholars in the fields of the economics of innovation as well as strategy have pursued various fruitful avenues in explaining the levels and direction of innovative effort of firms and in identifying the firm-level factors that drive superior innovative performance. Innovation at the firm level, however, should also depend heavily on the level and nature of the efforts of the individual employees that are ultimately responsible for innovative activities within firms.

While firm-level profit incentives have received great attention in the innovation and strategy literatures, the motives and incentives of individuals engaged in firm innovation have largely been ignored. At the same time, qualitative evidence as well as research in other fields suggest that individuals' incentives may have important impacts upon innovation. Moreover, the motives and incentives of individuals span a wide range of factor such as intellectual challenge, peer recognition, fame, making the world a better place, and money. However, even though the argument that individuals' incentives matter is intuitively appealing, the concrete pecuniary and non-pecuniary motives and incentives that drive individuals engaged in firm innovation, as well as the relationships between these motives and incentives and innovative outcomes are poorly understood. To address this gap, I employ an interdisciplinary approach to study the nature of scientists' and engineers' pecuniary as well as nonpecuniary motives as well as the impacts these motives have on innovative activities and performance in firms.

I define individual-level *incentives* as expected pecuniary or non-pecuniary benefits that are contingent upon individuals' employment, effort or performance. Examples include contingent pay, intellectual challenge, and peer recognition. Individual-level *motives* are defined as individuals' preferences over these benefits (e.g., how important are pay and peer recognition to the individual). Using these definitions, I theoretically and empirically examine the following research questions:

1. What are the motives of individuals engaged in firm innovation?
2. How do individuals' motives and incentives affect their innovative effort and performance?
3. How do individuals' motives and incentives differ between entrepreneurial and established firms, and are any such differences associated with differences in innovative effort and performance across firm types?

My empirical analysis builds on the National Science Foundation's SESTAT 2003 data, which contain survey responses from over 10,000 scientists and engineers employed in U.S. firms. Among others, the data contain measures of individuals' extrinsic, intrinsic, and social motives, effort, and innovative performance.

Conceptual Background

Work can provide individuals with a wide range of different benefits, including pay, intellectual challenge, peer recognition, etc. Such work benefits can be contingent upon employment in a particular organization (e.g., fixed wage), upon effort (e.g., hourly wage) or upon performance (e.g., performance-based pay). Based on the prior literature in social psychology and organizational behavior, as well as my own interviews with scientists, engineers, and managers, I distinguish work benefits and motives along two key dimensions: extrinsic vs. intrinsic and social vs. nonsocial (Figure 1). I briefly characterize each of these types in the following.

Extrinsic benefits are provided by some external entity such as a market or by some actor such as an employer, a superior, or a customer. These benefits do not result directly from engaging in the task, but are indirect task outcomes. 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., nature of the task) and of the individual (e.g., interest in the task). 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. Others, such as a feeling of achievement, mastery or self-competence, result directly from task outcomes. Since intrinsic benefits are not directly provided

by management, management can only indirectly affect them by providing conditions that enable employees to realize such benefits. Examples of such "enabling conditions" include the provision of autonomy to choose projects of personal interest and the freedom to publish and to engage with the scientific community.

Social benefits are intangible benefits that originate from social relations and associated perceptions. Extrinsic social benefits are provided by others, either informally (e.g., social approval, peer recognition) or more formally through institutionalized "award" systems. Social benefits may be derived from a reference group within a focal organization or from others who stand outside of one's organization, e.g., the larger scientific community. Other social benefits are self-administered. For example, individuals may derive pleasure from contributing to the success of a team.

Nonsocial benefits are benefits that are not tied to a particular social context. For example, to the extent that pay is valued for its purchasing power, it is an extrinsic benefit that is valued regardless of the particular person or group providing that pay. Similarly, intrinsic benefits derived from intellectual challenge or from satisfying curiosity do not require any outside agents and are not contingent on any relationship with the social environment.

Figure 1: Typology of Benefits and Motives

	Extrinsic	**Intrinsic**
Social	e.g., peer recognition	e.g., feeling of contributing to society
Nonsocial	e.g., pay	e.g., intellectual challenge

In chapter Two of my dissertation, I begin by developing a basic formal model that reflects the impact on innovative effort and performance of individuals' expected benefits from innovative work and of their preferences for those benefits. In essence, my model assumes that individuals choose a utility-maximizing level of effort, given certain expectations of effort-contingent and performance-contingent extrinsic and intrinsic benefits. Stronger motives and incentives are predicted to increase the overall levels of innovative effort and performance. I also consider the possibility that individuals' motives and incentives affect not only the quantity of effort, but also the *quality* of that effort. Such "productivity effects" can occur via two general channels.

First, the nature of individuals' motives and incentives may affect cognitive processes such as attention or divergent thinking. For example, social psychologists have suggested that intrinsic motivation is more beneficial for creativity than extrinsic motivation. Second, motives and incentives may affect choices individuals make regarding the allocation of their effort, e.g., choices what projects to work on or whether or not to collaborate with others.

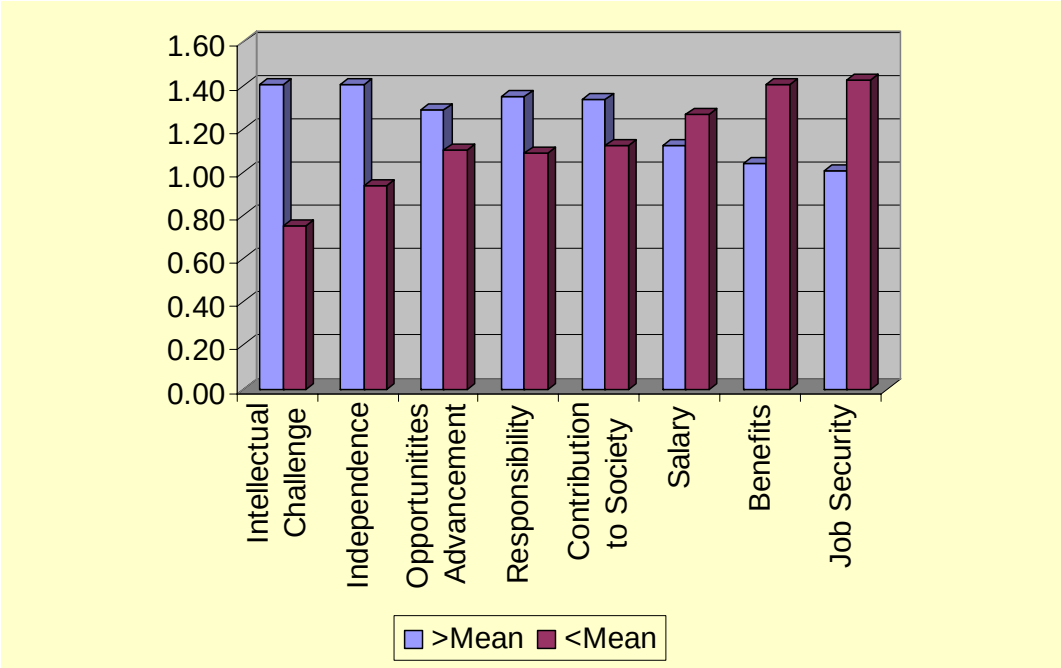
The Structure of Motives and the Basic Relationships between Motives, Effort, and Innovative Performance

The SESTAT (2003) data allow me to examine the nature of individuals' motives and to test key predictions of my formal model. As measures of motives, I use respondents' ratings of the importance of a range of work benefits. The factors rated were salary, fringe benefits, job security, intellectual challenge, independence, opportunities for advancement, responsibility, and contribution to society. Analyzing these ratings, I find that respondents reported a high importance of all eight factors (means between 3 and 4 on a 4-point scale), with the highest ratings for intellectual challenge, followed by fringe benefits, salary, and job security. Examining potential differences in the motives of different groups of individuals, I observe systematic differences by degree (e.g., Ph.D. vs. non-Ph.D.), but only small differences across fields (e.g., science vs. engineering) controlling for degree.

I measure effort using respondents' self-reported number of hours worked in a typical work week. My measure of innovative performance is the number of U.S. patent applications in which the respondent was named as an inventor over the last 5 years. For robustness checks, I also use alternative performance measures such as commercialized patents and publications in professional journals. Among the wide range of control variables are industry dummies, firm characteristics (e.g., firm age, firm size), and individual characteristics (e.g., age, gender, type of R&D, university degree, work experience, ability). A simple comparison of the innovative performance of individuals with high versus low motives of a particular type shows that higher scores on intrinsic motives are generally associated with higher innovative performance, while higher scores on extrinsic motives tend to be associated with somewhat lower innovative performance (Figure 2). As figure 2 shows, individuals with an above-average score on the challenge motives have about twice as many patent applications as individuals with a below-average score on the

challenge motive. However, this simple comparison does not account for various other factors such as industry, field, degree type, or work experience. Accordingly, regression analyses are required to examine the relationships between motives, effort, and performance in more detail.

Figure 2: Average Number of Patent Applications for High vs. Low Scorers on Motives



I estimate a series of regression models to examine the relationship between individuals' various motives and effort. The results suggest that individuals who find intellectual challenge and responsibility very important expend significantly more effort than individuals who find these factors less important. Somewhat surprisingly, individuals who express a high importance of salary work significantly less.

Regressions with patent applications as the dependent variable show a significant impact of effort (hours worked) on performance. More interestingly, however, I also find a significant positive impact of the importance of challenge, independence, salary, and responsibility on performance, controlling for effort. I also find a strong negative impact of the importance of job security. The significant coefficients on the measures of motives suggests that individuals' motives impact innovative performance not only via the level of effort exerted, but also via other channels, e.g., via the *quality* of that effort. Interestingly, these "productivity effects" are very pronounced in basic and applied research, but are much weaker in

development. One possible interpretation of these results is that motives generally - whether intrinsic or extrinsic - can have stronger productivity effects 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.

Additional analyses using the subsample of Ph.D.'s suggest that the key results are robust to the inclusion of firm-fixed effects and of an additional measure of individuals' ability (the quality ranking of the degree-granting department).

Motives, Effort, and Performance in Startups versus Established Firms

Given the finding that individuals' motives appear to significantly impact innovative effort and performance, it is important to examine the implications of such effects for the relative innovative performance of firms and firm types. In the third chapter of this dissertation, I focus on potential differences in individuals' motives and incentives in startups versus established firms, and I examine to what extent any such differences explain differences in innovative effort and performance.

There are several reasons to believe that startups and established firms may offer different benefits and incentives to their employees. Economist Joseph Schumpeter, for example, argued that the incentives driving entrepreneurial innovation were predominantly nonpecuniary, including the desire to accomplish something significant, the satisfaction of intellectual curiosity, and the excitement of challenge and competition, among others. Schumpeter also suggested that large bureaucratic organizations are less able than small firms to provide such incentives and would, therefore, exhibit an inferior innovative performance. More generally, the individual-level incentives available in startups and established firms may differ because of certain structural, i.e., enduring, characteristics that either directly affect individuals' incentives or that constrain management's ability to provide certain incentives. The most important such constraint may be the scarcity of financial resources in many startups, which may limit management's ability to directly provide extrinsic benefits such as job security and pay or to provide working conditions that allow individuals to realize high levels of intrinsic and social benefits. A second such constraint may be complexities associated with organizational size that may limit large firms' ability to observe individuals' performance or to support certain intrinsic benefits such as a sense of independence or feeling of achievement. While it is not clear to what extent such differences in incentives really exist in contemporary

research organizations, we expect that any such differences would lead to a systematic self-selection of individuals in organizational settings that provide the incentives and work conditions they value highly. As a consequence, startups and established firms could be characterized by different sets of motives and incentives of their employees and, consequently, different innovative effort and performance.

After modeling the relationships between firm types, individuals' motives, effort, and innovative performance in a simple formal model, I test key model predictions using the SESTAT 2003 data. For that purpose, I define startups as firms that are younger than 6 years and have no more than 100 employees. Small established firms are firms older than 5 years with no more than 100 employees. Finally, large established firms are firms that are older than 5 years and have more than 500 employees.

I find that individuals' pecuniary motives, such as their desire for pay and job security, are significantly stronger in established firms compared to startups, while their nonpecuniary motives, such as their desire for intellectual challenge and independence, are surprisingly similar. Assuming that employees' motives reflect the availability of actual benefits and incentives, this would suggest that large established firms are better able to provide extrinsic benefits such as salary, fringe benefits, and job security, while not being disadvantaged at providing intrinsic incentives such as intellectually challenging work or independence.

I further find that individuals employed in startups expend significantly more effort than individuals in small and large established firms. Startup employees also have almost twice as many patent applications as individuals in small established firms and about 35% higher patent application counts than individuals in large established firms. While I cannot explain the "effort advantage" of startups, three factors appear to account for their "performance advantage." First, individuals in startups are characterized by lower levels of desire for job security (perhaps reflecting risk-aversion), which is negatively associated with innovative performance. Second, individuals in startups expend more effort, which in turn has positive effects on performance. Third, there may be selection effects in that "potential" startups with a strong technological capability and patent applications are more likely to be born and survive. Auxiliary analyses involving recent job changers in my data also suggest that startups may attract individuals with more existing patent applications, rather than "causing" their employees to produce more applications.

Managerial and Policy Implications

Policy and managerial implications of these findings are several. For managers, the findings highlight the importance of intrinsic motivation for innovative performance. Accordingly, management should explicitly consider the returns to the provision of intrinsic benefits and the required enabling conditions, while of course recognizing the associated costs and challenges. Nonpecuniary incentives can provide leverage where pecuniary incentives tend to be less effective, such as when the link between effort and performance is highly uncertain or when employees' behaviors and performance are hard to observe, conditions which are often characteristic of R&D. Moreover, individuals engaged in innovation appear to have particularly strong preferences for intrinsic and social benefits, potentially providing such benefits with a very high motivating power.

But management also needs to recognize that intrinsic and social incentives 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. Similarly, the professional norms of open science and the desire for peer recognition, for example, may motivate an industrial scientist to disseminate important research findings while the employer would benefit from secrecy.

For government, my results suggest that policies that encourage educational institutions to strengthen and reinforce intrinsic motivation, including love of challenge, curiosity, etc., may offer social dividends. My results also suggest that policies that change select 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 amount of research effort, but its direction and productivity as well.

Finally, for policymakers - as well as managers - my 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. Following my analysis of productivity effects across different types of R&D, I suspect that superior innovative performance of 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.

My results concerning systematic differences in motives across firm types, as well as my finding of higher levels of effort and performance in startup firms are very intriguing. At the same time, they have to be interpreted with caution, since there remains ambiguity with respect to the source of these differences. More specifically, it is not clear to what extent higher levels of effort and performance suggest a true "innovation advantage" of startups over established firms or to what extent they are the result of selection processes at the levels of both the firm and the individual. Only if there are true structural advantages of startups, my results would suggest that technological progress could benefit from a larger role of entrepreneurial firms, possibly stimulated by adequate policy measures. Thus, more research is needed into the nature and sources of differences in innovative processes and performance between startups and established firms. I suggest that such research could benefit from particular attention to micro-level factors such as the motives and incentives of the individuals actually engaged in innovation within firms.