Workplace Diversity and Incentive Contracts: Theory and Evidence

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Abstract

This paper presents a simple theory of the provision of incentives in firms in which the principal optimally chooses both compensation contracts and the composition of the work force. Assuming that individuals display group loyalty, a less diverse (more homogeneous) work force will be more cooperative. Simple comparative statics provide some testable implications relating risk, diversity and incentive pay. I also analyze the case in which workers' characteristics cannot be readily observed ex ante. The theory then predicts that firms are more likely to prevent workers from interacting with each other when workers are expected to have similar characteristics. This shows a surprising effect of diversity in the workplace: more diverse firms will promote more interactions between workers of different types, i.e. they will be less segregated.

I test the main predictions of the model using a cross-sectional sample of corporate boards. I use the proportion of women on boards as a measure of diversity. There are three main empirical findings: (1) a significant negative correlation between firm risk and diversity, (2) a significant positive relationship between performance-based compensation and diversity and (3) a significant positive correlation between the number of board meetings (a measure of interactions among directors) and diversity. The evidence is broadly consistent with the implications of the theory.

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1 Introduction

Firms are social institutions, where workers with possibly different personal characteristics and backgrounds interact with each other. An economically interesting question arises when social interactions in the workplace change workers' responses to the *incentive structure* imposed by firms. This paper analyzes the effects of *group loyalty*, or the tendency to care about the well-being of people who have characteristics that are similar to one's own, on the provision of incentives in firms. I present a model in which a principal can use three different instruments to induce effort from her workers: incentive pay, the composition of the work force (i.e., its degree of diversity) and the amount of social interactions among workers in the workplace. The model predicts certain relationships among these three instruments. I test the main implications of the theory using data on directors of publicly traded corporations. The empirical results provide some preliminary but surprisingly strong support for the theory. The evidence suggests that there are gains to incorporating variables such as diversity and social interactions into formal models of incentives in organizations. This paper is a first step in that direction. I show that introducing the ideas of group loyalty, diversity and social interactions in an otherwise standard principal-agent model generates new implications and suggests different ways of looking at data.

Group loyalty may be a consequence of identification, or the feeling of being part of a group.[1] This paper adopts the assumption that increasing the diversity of the work force reduces its group loyalty. This relationship between similarity and attraction is well documented in the social psychology literature (Byrne, 1969; Lott and Lott, 1965; Zander, 1979). Although groups are usually associated with characteristics such as race and gender, other characteristics may well lead to group loyalty. Therefore, I interpret diversity broadly. I assume that employees can be characterized by their *types*. As in Athey et al. (2000), "(types) can be interpreted as gender, ethnicity, cultural background, personality type, or even skill set (e.g., operations versus marketing skills for managers, theorists versus empiricists for academics)" (p.765).

I develop a simple model in which one principal (firm) needs to employ two agents (a team of workers) to produce one single output. Effort is not observable, therefore the usual moral hazard problems arise.

[1] Simon (1991) suggests that identification with an organization is a way of reducing agency problems. See also Akerlof and Kranton (2000) for an approach that puts identity in the utility function. Akerlof (1983) discusses case studies of social identification and class loyalties. Luttmer (2001) provides evidence of group loyalty in individual support for redistribution. He finds that individuals are more likely to support welfare spending when it is more likely to affect their own racial group. Athey et al. (2000) model discrimination in promotion decisions within firms by assuming that mentoring relationships are more likely to occur between members of the same group. Therefore, a more homogeneous (less diverse) work force leads to more mentoring interactions between entry- and upper-level employees.

The principal can design a compensation contract that links workers' pay to team performance. However, incentive pay is costly due to workers' risk-aversion. The principal can also choose the composition of the team, based on her knowledge of workers' characteristics. The degree of similarity between workers will affect their degree of group loyalty. Therefore, a more homogeneous (less diverse) team is more cooperative and exerts more effort than a less homogeneous (more diverse) one. Thus, the principal prefers homogeneous teams. However, choosing a very homogeneous work force might also be costly. Finding people with very similar characteristics demands time and resources. This cost should increase with the degree of desired similarity, because no two people are exactly alike.[2] The principal's problem is to find the optimal combination of these two instruments.

A natural question that arises in this context is whether work force homogeneity and incentive pay are substitutes or complements. Common intuition suggests that they are substitutes: if incentive pay is very costly, the firm may want to rely more on work force homogeneity as a means of providing incentives, and vice-versa.[3] However, my model shows that homogeneity and incentive pay can sometimes be complements. Work force homogeneity increases the total levels of effort for a given incentive scheme. Therefore, more homogeneity makes workers more sensitive to monetary incentives, which may lead to complementarities between the two instruments.

Although this ambiguity might suggest that the implications of the model are not easily testable, this is not true. The main testable implication is that *incentive pay and work force homogeneity are two different instruments to achieve a common goal*. If they are complements, incentive pay is positively related to homogeneity while risk (the cost of providing incentive pay) should be negatively related to homogeneity. If they are substitutes, incentive pay is negatively related to homogeneity while risk (the cost of providing incentive pay) should be positively related to homogeneity. In other words, *the relationship between risk and homogeneity should have the opposite sign as the relationship between homogeneity and incentive pay.* This a clear-cut empirical prediction, one that the evidence I present in this paper is consistent with.

When I introduce uncertainty about workers' personal characteristics, firms gain a third instrument to induce effort from workers. As long as some workers' characteristics cannot be perfectly observed ex ante, workers will gradually learn about coworkers' characteristics if meeting and talking to each other is required by the nature of their jobs. Firms may want to organize work in ways that promote

[2] Homogeneity costs may be either exogenous, such as search costs or opportunity costs for not hiring workers based on their productive characteristics, or endogenous costs, such as the ones arising from excessive conformity or the increasing likelihood of collusion among workers.

[3] For example, Kanter (1977) argues that this is indeed the case.

or prevent this kind of learning. In short, the amount of interactions among workers in the workplace is also a variable that is at least partially under the principal's control. I show that firms will distort the organization of work in order to facilitate learning when workers are expected to be different from each other. When workers are expected to be similar, firms prefer to restrict social interactions in the workplace in order to prevent learning.

This result shows that policies towards more diversity in firms may have some surprising consequences. If differences in observable and unobservable characteristics are not too negatively correlated, policies (like affirmative action) that require firms to hire a diverse work force in terms of observable characteristics may lead them to promote social interactions in the workplace in order to improve learning about workers' unobservable characteristics. In short, more diverse firms will also be less segregated: employees of different types will interact more than employees of similar types. The intuition behind this result is that, when workers hold negative stereotypes about coworkers, cooperation is initially very low, therefore firms do not have much to lose if negative stereotypes are confirmed ex post, but they do gain a lot if learning reveals that stereotypes were not justified. This implication is also testable: *diversity should be positively related to the amount of interactions among workers in the workplace.*

In the empirical part of this paper, I look at a cross-sectional sample of boards of directors of 1462 publicly traded firms in fiscal year 1998. Boards are good examples of teams and their members are offered the same compensation contracts. Because information on directors is usually available to the public (due to regulations, listing requirements or shareholder activism), measures of diversity can be constructed using demographic information on individual directors. In this paper I use the proportion of women on boards as a measure of diversity, but I also briefly discuss the distinction between inside and outside directors as an alternative measure of diversity.[4]

The empirical evidence provides strong support for the hypothesis that proportions of men and women affect the design of compensation contracts and that firms take that into account when choosing the gender composition of their work force. I cannot empirically reject the two main implications of the model. I find diversity to be negatively related to firm risk and positively related to incentive pay, which confirms the first prediction. Incidently, this evidence also suggests that work force homogeneity and incentive pay are indeed substitutes, in accordance with simple intuition. I also find that directors meet more often in more diverse firms, which confirms the second prediction.

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[4] I chose these measures of diversity mainly because they are relatively easy to collect. I plan to extend the analysis in this paper to include other alternative measures of diversity.

I find that firms facing more variability in their stock returns have fewer women on their boards of directors. This result is surprisingly strong and very robust. The model fits the evidence better than other competing explanations, such as claims that women are less efficient in complex environments, that women are more "stabilizing" or that women are more risk-averse. In my model, a negative relationship between diversity and firm risk implies that incentive pay and work force homogeneity are substitutes. Therefore, after controlling for risk, incentive pay should be positively related to diversity. Consistent with this implication, I find that restricted stock comprises a greater share of director compensation in firms with relatively more women on their boards. This finding is also robust. Together, these two pieces of evidence suggest that incentive pay and work force homogeneity are substitutes.

I use the number of board meetings as a proxy for social interactions among directors in the workplace. Consistent with the theory, I find a positive correlation between the number of board meetings and diversity. Therefore, the main implications of the model survive empirical scrutiny.

To my knowledge, this is the first paper that studies the relationship between work force composition and the provision of incentives in firms.[5] In this paper, as in Kandel and Lazear (1992) and Rotemberg (1994), I analyze the effects of social relations among workers on their incentives to cooperate. However, unlike them I assume a principal-agent relationship between a manager and a team of workers. This allows me to study the relationship between the design of incentive contracts and the organization of work. My model assumes that workers may be altruistic towards coworkers, as in Rotemberg (1994).[6] Altruism can be either positive or negative. I assume that the main determinant of altruism is the difference in workers' personal characteristics, i.e. altruism is a function of group loyalty. This is how diversity affects the willingness to cooperate. Group-based incentives have distorted effects when preferences are interdependent, which is the case here. Therefore, workplace diversity and incentive contracts are closely connected.

The paper is organized as follows. In section 2, I describe a model with two agents and one principal,

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[5] Few papers have looked at some related issues. Kandel and Lazear (1992) showed how some nonpecuniary motives, like peer pressure, can improve efficiency in partnerships. Rotemberg (1994) modeled the acquisition of altruism among workers and showed how it increases incentives to cooperate. Both papers claim that partnerships provide incentives for workers to internalize nonpecuniary motives to cooperate. Peer pressure and altruism arise endogenously in their models. However, they limited their analyses to the study of partnerships, leaving aside the agency problems that might arise when teams work for a principal. Prendergast and Topel (1996) analyzed the design of compensation contracts and work practices under the assumption that supervisors are subject to favoritism bias; i.e., supervisors may "like" or "dislike" some of their subordinates. They explicitly work with a principal-agent framework, but, unlike Kandel and Lazear (1992) and Rotemberg (1994), they focus on relations between managers and workers, instead of social relations among workers.

[6] Some other analyses of altruism in principal-agent settings can be found in Prendergast and Topel (1996), Mulligan (1997, chapter 13) and Casadesus-Masanell (1999). For a principal-agent model of trust, see Frey (1993).

in which agents' utilities are interdependent, and in which preference interdependency is affected by how similar agents are. In section 3, I characterize the optimal contract assuming that workers' characteristics can be observed and discuss its main properties. In section 4, I introduce unobserved characteristics into the model and then discuss the incentives for the principal to promote or prevent learning in the workplace. Section 5 describes the data. I discuss the empirical findings in section 6. Section 7 concludes.

2 A Model of Group Loyalty

2.1 Similarity

Consider two workers i and j. Let v_i and v_j be their respective *types*. Types could have many dimensions, some that can be easily observed, like race and gender, and some others that cannot be so easily observed, like religion and political orientation. I assume the existence of a variable which I call *similarity*. Similarity is a function of types:

$$\gamma = \gamma (v_i, v_j) \tag{1}$$

The idea is that a high γ implies that the two agents have characteristics that are in some sense "close" to each other's. I assume that γ is a number on the real line.

Let the *loyalty parameter* α_i represent a measure of how much agent i cares for agent j 's utility, i.e. it is a measure of altruism.[7] What determines α_i? I assume that individuals differ in (possibly unobservable) characteristics and that those characteristics affect how much they care for each other's well-being. More specifically, let us assume that individuals in a population have different characteristics (or types) and that they have a preference for interacting with people that have characteristics that are similar to their own. For example, in a population of Democrats and Republicans, when two persons are randomly matched, a Democrat (Republican) will become more altruistic towards her match if she learns that this person is also a Democrat (Republican). But learning that the other person is of an undesirable type may decrease altruism, which could even be negative (e.g., hatred or envy). The *group loyalty assumption* is then equivalent to assuming that α_i is an increasing function of γ.

However, from agent i's viewpoint, γ may be a random variable, since she may not know the value of v_j for sure. In an ex ante sense, similarity is a random variable whose distribution is determined by the distribution of types in the population. To simplify the problem, I assume that agent i only cares about

[7] I will explain below the precise relationship between α_i and agents' utility functions.

expected similarity. Therefore, the loyalty parameter is given by

$$\alpha_i = E\left[\gamma\left(v_i, v_j\right) \mid I_i\right] \tag{2}$$

where I_i is agent i's information set.[8]

In section 3, I assume that types are known with certainty before contracts are offered and actions are taken, therefore loyalty parameters can be considered exogenous variables. Later I introduce uncertainty about types and then loyalty parameters might be seen as endogenous variables, which depend on how often workers interact and learn about each other's types.

2.2 Technology

A manager (principal) needs exactly two specialized workers (agents) in order to generate profits. It is assumed for simplicity that the manager herself does not have the specific human capital to become a worker. When workers are matched with the manager, they generate revenues that are positively related to their privately chosen effort levels. Output (or revenue) x is given by:

$$x = e_1 + e_2 + \varepsilon \tag{3}$$

where e_i is the effort level chosen by worker i and $\varepsilon \backsim N(0, \sigma^2)$.

The assumption of pure team production (i.e., no individual signal of performance) is made for simplicity. Team production creates free-riding problems, on top of usual moral hazard problems of single-agent settings. I show that diversity worsens free-riding problems because agents become less cooperative when group loyalty (altruism) is low. Therefore, at least some amount of joint production is required for the analysis that follows.

It should be emphasized, however, that what is required here is that optimal contracts be designed in a way that makes compensation of individual workers dependent on the actions taken by all workers. In Mookherjee's (1984) more general analysis of multi-agency problems, individual pay often depends on actions taken by other agents. Furthermore, under interpersonal preferences, there is a natural incentive to adopt technologies and to design tasks such that individual inputs are complements. Therefore, instead of being assumed, teamwork could arise endogenously as in Itoh (1991).[9]

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[8] I relax this assumption in Appendix C. One can download the appendices from http://home.uchicago.edu/~dsferrei/appendix.pdf

[9] Although I will focus only on the free-riding properties of teams, it should be noticed that the noneconomic literature on work teams holds a more positive view on the efficiency of teams than the one implied by a narrow focus on free-

The timing of the game is as follows. In period 0, the manager chooses two workers based on their observed characteristics. In the beginning of period 1, the manager offers a take-it-or-leave-it wage schedule (w_1, w_2) to both workers. Workers can either reject the offers (and get outside utility of U_0) or accept them. If they accept the offers, workers simultaneously and non-cooperatively choose their effort levels (e_1, e_2). Then the manager observes x, which is a noisy signal of the aggregate effort level, and then pays wages and collects profits.

2.3 Preferences

The manager is risk neutral, i.e. her utility function is given by

$$V = E\left[x - w_1(x) - w_2(x)\right] \tag{4}$$

Wages will usually be functions of observed output.

Workers are risk-averse and may be altruistic. I assume that worker i's "egoistic" utility is given by

$$u_i = -\exp\left\{-r\left[w_i(x) - C(e_i)\right]\right\} \tag{5}$$

where r is the (constant) absolute risk aversion coefficient and $C(e_i)$ is the cost of effort. When worker i is altruistic, (5) represents the utility that she derives from her own consumption and effort. Following Stark (1995), I call this function worker i's "felicity".

Worker i's total utility is given by

$$U_i = u_i\left(-u_j\right)^{\alpha_i} \tag{6}$$

The loyalty (or altruism) parameter α_i represents the weight that worker i gives worker j's felicity.

The utility in (6) is analogous to standard utility functions found in the altruism literature, except for the fact that the other worker's utility enters multiplicatively instead of additively.[10] I chose this form in order to preserve the exponential nature of the utility function, which simplifies the computation of the optimal contract. As I show below, this formulation is equivalent to assuming that certainty equivalents are linear functions of each other.

riding problems. This literature usually cites many reasons why teams could increase productive efficiency: they foster participation, communication and cooperation among workers, they increase their sense of responsibility, promote a better work environment, and so on. For examples, see Cohen and Bailey (1997), Cohen and Ledford (1994), Dunphy and Bryant (1996) and Hackman (1990).

[10] For a recent example, see Becker and Murphy (2000), chapter 4.

Assuming this type of altruistic utility function amounts to assuming that agents are willing to sacrifice some of their own "utility" to increase the utility of the other agent. This is one (but not the only) way to generate the type of taste-based cooperation I am concerned with in this paper.[11]

Since the results I derive in this paper crucially depend on the specification of preferences, I want to stress three points regarding the utility in (6).

First, one could have chosen a different specification of altruism in which agent i's total utility is a function of her own felicity and of agent j's total utility. It turns out that utilities like the one in (6) can be seen as reduced-form solutions of a system of "structural" utilities like:

$$U_i = -\left(-u_i\right)^{\beta_i}\left[-U_j\right]^{\eta_i} \tag{7}$$

where $i, j = 1, 2$ (see Stark, 1995). Therefore, I start directly from (6) for simplicity and to save on unnecessary notation.

Second, it might seem natural to restrict the range of α_i. A natural restriction is to impose $\alpha_i \leq 1$. This simply assumes that agents value their own consumption no less than they value others' consumption.[12]

Some may also want to rule out hatred or envy, i.e. to impose $\alpha_i \geq 0$. It turns out that, in the model I develop in this paper, it is more convenient to assume that α_i has an unrestricted range, i.e. $\alpha_i \in (-\infty, \infty)$. All but the last result in this paper do not depend on this assumption, therefore they are still valid if any of the above restrictions are imposed. I will show that, under weak assumptions, α_i will never be negative in equilibrium. Also, one may think of very high or very low values of α_i as being possible but very hard to find in a given population (in other words, they are events with very low probability).

Third, in utility (6), altruism α_i has *level effects*: if a person becomes more altruistic, she becomes "happier". In other words, altruism is a good. A different altruistic utility function that does not display this property is:

$$U_i = -\left[-u_i\right]^{\frac{1}{1+\alpha}}\left[-u_j\right]^{\frac{\alpha}{1+\alpha}} \tag{8}$$

It turns out that the results in this paper are the same with or without level effects. Therefore, the discussion about which one of (6) or (8) is more realistic is largely irrelevant for my results.

[11] Other ways include assuming that workers derive utility from the act of cooperating or that workers are driven by reciprocity considerations. For a recent model in which agents derive utility from cooperation, see Rob and Zemsky (2000). For experimental evidence of reciprocity considerations in contract enforcement, see Fehr, Gatcher and Kirschsteiger (1997).

[12] See Becker and Murphy (2000) and Stark (1995).

2.4 Some Benchmark Cases

For the benchmark cases, I will assume that workers are egoistic (i.e., $\alpha_i = \alpha_j = 0$). I will also assume from now on that the cost of effort is given by $C(e_i) = \frac{k}{2}e_i^2$.

With exponential utilities and normally distributed errors, Holmstrom and Milgrom (1987) rationalized the use of linear contracts like $w_i(x) = a_i x + b_i$.[13] Furthermore, since the only observable (and verifiable) variable is x, wage schedules can depend only on x. Because both workers are ex ante identical in all aspects, it will never be optimal to treat workers differently, so I will focus only on the cases in which $w_1 = w_2 = w$. The outside utility is $U_0 = -\exp\{-rw_0\}$.

2.4.1 The First-Best

The first-best contract is the one in which both workers' efforts are perfectly observable and verifiable (the same outcome could also be implemented as a Nash equilibrium if the principal could only observe the sum of workers' efforts, since she could act as a budget breaker. See Holmstrom (1982)). The first-best levels of effort are $e_1^{FB} = e_2^{FB} = \frac{1}{k}$, while wages are constant $w^{FB} = \frac{1}{2k} + w_0$ and profits are $V^{FB} = \frac{1}{k} - 2w_0$.

2.4.2 The "No-Cooperation" Contract

I call the "no-cooperation" contract the solution to the problem in which the manager can only observe x, which is a noisy measure of the aggregate level of effort, and workers simultaneously and non-cooperatively choose their effort levels. Considering a linear contract like $w(x) = ax + b$, the optimal contract is[14]

$$a^{NC} = \frac{1}{1+kc}, e^{NC} = \frac{1}{k(1+kc)}, b^{NC} = \frac{1}{2}\frac{kc-3}{k(1+kc)^2} + w_0, V^{NC} = \frac{1}{k(1+kc)} + 2w_0 \tag{9}$$

Simple algebra shows that $V^{FB} > V^{NC}$ and $e^{FB} > e^{NC}$; i.e., both effort levels and profits monotonically decrease from the first-best to the no-cooperation solution.

[13] Formally, Holmstrom and Milgrom (1987) assumed that the agent chooses efforts continuously over the time interval $[0, 1]$ to affect the drift of a Brownian motion. They show then that the agent would choose a time-invariant effort level and that the optimal contract is linear in the final output x. Therefore, the one-shot linear-contracts version of this problem will give us the same answer as its continuous-time version.

[14] This case is a relatively straightforward extension of Holmstrom and Milgrom's (1991) model, therefore I omitted the steps in the computation of the optimal contract. The reader can easily check the results by following the same steps as in section 3.

3 Optimal Incentives with Group Loyalty

3.1 The Equilibrium Contract

In this section I characterize the equilibrium of a model in which the similarity parameter between the two workers $\gamma(v_1, v_2)$ is known with certainty by all parts in the ex ante stage. This implies $\alpha_1 = \alpha_2 = \gamma(v_1, v_2) \equiv \alpha$, i.e. both workers have the same loyalty parameter. I start in period 1, when the manager has already chosen workers' types, so α is given. Then I go back one period and determine the optimal α^*.

From the utility given in (6), one can get the certainty equivalent of worker i:[15]

$$CE_i = a(1+\alpha)(e_1 + e_2) + (1+\alpha)b - \frac{k}{2}e_i^2 - \alpha\frac{k}{2}e_j^2 - \frac{r}{2}a^2(1+\alpha)^2\sigma^2 \tag{10}$$

From agent i's viewpoint, a (the bonus rate) and b (salary) are given, as well as the other agent's effort e_j. She will then maximize her certainty equivalent with respect to her own effort level e_i. The first-order conditions for both agents are:

$$e_i^* = \frac{a(1+\alpha)}{k} \text{ for } i = 1, 2 \tag{11}$$

The second-order conditions are always satisfied, because the certainty equivalents are strictly concave in effort.

The first-order conditions in (11) already tell us many things. We can see right away that group loyalty α magnifies the incentive effect of the bonus rate a: for a given bonus rate a, an increase in group loyalty α increases effort. Furthermore, an increase in group loyalty α increases the marginal effect of the bonus rate a on effort. Therefore, an incentive pay compensation scheme is more effective when group loyalty is high.

Notice also that since I am allowing α to assume negative values, we can see that if $\alpha < -1$, the only possible solution involves a *negative* bonus rate ($a < 0$), because effort cannot be negative. I will shortly rule out this empirically irrelevant case, but it is important to understand what it means. When similarity is so low that α is less than -1, an agent is willing to pay more than one dollar to make the other agent lose one dollar. Therefore, any positive bonus rate will induce agents to exert no effort. This implies that, from the principal's viewpoint, it makes sense to offer a negative bonus rate. The conclusion is that the negativity of the bonus rate is not unreasonable. We may not observe this case because such

[15] After applying the formula for the moment generating function for normal distributions.

extreme negative altruism might be too rare. Therefore, we could impose $\alpha < -1$ in order to get rid of this case. I take an alternative route and show that, under arguably weak assumptions on the costs of homogeneity, the case of negative bonus rates never arises in equilibrium.

The principal is concerned about designing the compensation contract in a way that maximizes her expected profits. The principal's program is to

$$\max_{a,b} \{(1-2a)(e_1+e_2) - 2b\} \tag{12}$$

subject to the incentive compatibility (IC) constraints in (11) and the individual rationality (IR) constraints:

$$a(1+\alpha)(e_1+e_2) + (1+\alpha)b - \frac{k}{2}e_i^2 - \alpha\frac{k}{2}e_j^2 - \frac{r}{2}a^2(1+\alpha)^2\sigma^2 \geq w_0, \text{ for } i = 1,2. \tag{13}$$

where w_0 is the wage equivalent of workers' outside option. I set $w_0 = 0$ to slightly simplify the algebra. All propositions are exactly the same as in the case of an arbitrary w_0. Incidently, assuming a zero w_0 makes the optimal contract look exactly like the one that would have arisen in case we had used a "no-level effects" utility such as (8). This is because the level effects of altruism operate through the IR constraints: if group loyalty is a good, more loyal workers are willing to work for less pay. This explains my previous claim that the results I get in this paper do not depend on whether altruism is itself a good or not.

Because the principal has all the bargaining power in this game, she will extract all surpluses from the agents. That is, both IR constraints must be binding, $CE_1 = CE_2 = 0$. Plugging the IC's and the IR's in the principal's objective function and solving the program, we get

$$a^* = \frac{1+\alpha}{kc+(1+\alpha)^2}, \; e^* = \frac{(1+\alpha)^2}{k\left[kc+(1+\alpha)^2\right]}, b^* = \frac{\left[(1-\alpha)^2 - 4 + kc\right](1+\alpha)^2}{2k\left[kc+(1+\alpha)^2\right]^2}$$

$$V^*(\alpha) = \frac{(1+\alpha)^2}{k\left[kc+(1+\alpha)^2\right]} \tag{14}$$

If $\alpha = 0$, the solution above is equivalent to the "no-cooperation" one. One can easily see that, as long as α is positive, we have $V^{FB} > V^*(\alpha) > V^{NC}$.

3.2 The Optimal Level of Work Force Homogeneity

The loyalty (or altruism) parameter α is greater the more similar workers are. Therefore, α can be seen as a measure of *work force homogeneity*.[16] Now we go back one period to the point in which the

[16] From now on, I will use the terms "group loyalty" and "work force homogeneity" interchangeably.

principal has to choose which workers to hire. By observing workers characteristics, the principal is able to infer α. She will be inclined to choose workers based on their observable characteristics, therefore one can say that the principal *chooses* α. This choice, however, is not without costs. Finding people with very similar characteristics demands time and resources. This cost should increase with the degree of desired similarity, because no two people are exactly alike. By the same token, it is also very difficult to find people that are extremely different from each other. Therefore, one would expect that there is an "average" level of similarity $\overline{\alpha}$ that is easy to find and deviations from it will be increasingly costlier.[17]

I formalize this idea by assuming that it costs $R(|\alpha - \overline{\alpha}|)$ to hire a group of workers with a degree of homogeneity equal to α. I summarize the properties of function R in the following assumption:

Assumption A1 *(i)* $R(0) = 0$,*(ii)* $R'(x) > 0$ *for any* $x > 0$,*(iii)* $R''(x) > 0$ *for any* $x > 0$, *(iv)* $\lim_{x\to\infty} R'(x) = \infty$,*(v)* $\lim_{x\to 0} R'(x) = 0$.

The properties above are very standard: (i) just normalizes the minimum cost to zero, (ii) assumes that costs increase as one deviates from the average similarity $\overline{\alpha}$, (iii) imposes convexity and (iv) and (v) are Inada conditions that are sufficient for the existence of an interior solution to the problem that follows. The most crucial assumption, however, is implicit in the definition of R: the symmetry around $\overline{\alpha}$. Since there are no *a priori* reasons to believe that these costs are asymmetric around $\overline{\alpha}$, this assumption seems natural.

Now we can specify the principal's problem in period 0. The principal can choose the degree of work force homogeneity α of her work force. Formally, the problem is to

$$\max_{\alpha} V^*(\alpha) - R(|\alpha - \overline{\alpha}|) \tag{15}$$

where $V^*(\alpha)$ is given by (14).

The following assumption will sometimes be used:

Assumption A2 $\overline{\alpha} > -1$.

Notice that this assumption just says that the "average" match between two persons is not "too bad". It says that extreme negative altruism is possible, but not too easy to find.

The following proposition establishes the existence and uniqueness of the solution:

[17] It is not only direct searching and recruiting costs that matter, but there may also be some other indirect costs in hiring a less diverse work force. For example, Athey et al. (2000) assume that "the opportunity cost of a homogeneous upper-level is an inability to take advantage of the scarce talent of entry-level minority employees" (p.767). Another way to endogeneize the costs of homogeneity is by assuming that similar workers find it easier to collude among themselves, which is bad for the principal (I thank Maitreesh Ghatak for suggesting this possibility).

Proposition 1 *If A1 and A2 hold, there is a unique α^* that solves the principal's problem in (15). Furthermore, $\alpha^* > -1$.*

Therefore, we can safely talk about an optimal homogeneity level α^*. If assumption A2 does not hold, solution is still generically unique,[18] but it may involve negative bonus rates. Therefore, A2 is a weak assumption that rules out that case.

3.3 Comparative Statics

I call c *perceived risk*, or simply *firm risk*.[19] Perceived risk c, which is the product of the risk-aversion coefficient r and the underlying technological uncertainty σ^2, can be seen as the cost of providing incentive pay: for the same piece-rate a, the principal will have to pay agents higher salaries b the greater uncertainty $\left(\sigma^2\right)$ or risk-aversion (r) are. In the standard Holmstrom-Milgrom model, an increase in c unambiguously reduces the optimal bonus rate a^*. Does this property hold in the current model? Differentiating a^* with respect to c yields

$$\frac{da^*}{dc} = \frac{\partial a^*}{\partial c} + \frac{\partial a^*}{\partial \alpha^*}\frac{d\alpha^*}{dc} \tag{16}$$

It is easy to check that $\frac{\partial a^*}{\partial c} < 0$, which is the standard trade-off between incentives and risk one encounters in these types of models. However, this is not the total effect here, since the principal can also adjust the degree of homogeneity after a change in perceived risk c, and that will also affect the bonus rate a. The direct effect of homogeneity on the bonus rate is given by

$$\frac{\partial a^*}{\partial \alpha^*} = \frac{c - (1+\alpha^*)^2}{\left[c + (1+\alpha^*)^2\right]^2} \tag{17}$$

which can be either positive or negative. The direct effect of risk on homogeneity will depend on how risk affects the marginal value of homogeneity; i.e.

$$sign\left\{\frac{d\alpha^*}{dc}\right\} = sign\left\{\frac{\partial^2 V^*(\alpha)}{\partial\alpha\partial c}\right\} \tag{18}$$

A little algebra gives us

$$\frac{\partial^2 V^*(\alpha)}{\partial\alpha\partial c} = 2(1+\alpha^*)\frac{(1+\alpha^*)^2 - c}{\left[c + (1+\alpha^*)^2\right]^3} \tag{19}$$

which can also be either positive or negative.

Simple inspection of the equations above proves the following result:

[18] It is not unique only when $\overline{\alpha} = -1$.

[19] I borrow the term "perceived risk" from Casadesus-Masanell (1999).

Proposition 2 *The relationship between risk and homogeneity has the opposite sign as the relationship between homogeneity and incentive pay:*

$$sign\left\{\frac{d\alpha^*}{dc}\right\} = -sign\left\{\frac{\partial a^*}{\partial \alpha}\right\}$$

Therefore, we still have the traditional trade-off between risk and incentives:

Proposition 3 *Increases in risk decrease the bonus rate:*

$$\frac{da^*}{dc} < 0$$

An analog trade-off exists between work force homogeneity and its marginal cost. Let the informal notation dR' denote a shift of the whole marginal cost curve $R'(\alpha)$ to the right. Then, the next proposition follows from the problem in (15):

Proposition 4 *Increases in the marginal cost of homogeneity reduce work force homogeneity:*

$$\frac{d\alpha^*}{dR'} < 0 \tag{20}$$

The results so far are neither surprising nor new. They simply show that both incentive pay and work force homogeneity decrease when their respective costs increase. A new question that emerges, however, is the degree of substitutability between the two mechanisms of providing incentives. Are incentive pay and work force homogeneity complements or substitutes? In other words, How does one change when the price of the other changes?

We have already seen that $\frac{d\alpha^*}{dc}$ can be either positive or negative. The other cross-effect is given by

$$\frac{da^*}{dR'} = \frac{\partial a^*}{\partial \alpha^*}\frac{d\alpha^*}{dR'} \tag{21}$$

which also has an ambiguous sign. However, from Proposition 2 and (21) we have the following result:

Proposition 5 *The relationship between risk and homogeneity has the same sign as the relationship between the marginal costs of homogeneity and incentive pay:*

$$sign\left\{\frac{d\alpha^*}{dc}\right\} = sign\left\{\frac{da^*}{dR'}\right\}$$

This means that the concept of substitution (or complementarity) is well-defined: If work force homogeneity and incentive pay are substitutes, work force homogeneity increases with risk and incentive pay increases with R'. The opposite occurs if they are complements.

How can one go from these results to testing the model? Notice first that empirical proxies for risk c and for the strength of incentives a^* are found in many empirical papers.[20] Measures of homogeneity (or its inverse, diversity) α^* can be constructed with demographic data on workers. While the marginal cost of homogeneity R' does not have an obvious empirical counterpart, it might be possible to find a proxy for it in some data sets. However, in my own empirical work I do not have any convincing proxy for R', therefore I cannot directly test Propositions 4 and 5.

Proposition 3 is testable. However, it is not a new implication of my model. The trade-off between risk and incentives is already an old idea in the principal-agent literature. It is well-known by now that the evidence is mixed, sometimes finding incentives decreasing with risk and sometimes finding incentives increasing with risk.[21]

I will focus on Proposition 2. This is a truly new implication of my model that can be tested with the data I have. It imposes a very strong restriction on observed behavior: *the effect of risk on diversity should have the opposite sign as the effect of diversity on incentive pay.* In order to test this proposition, I regress diversity on risk (and other controls) and incentive pay on diversity *and risk* (since I am concerned about the *partial* effects of diversity on incentive pay, keeping risk constant). I need both coefficients (diversity on risk and incentive pay on diversity) to be significantly different from zero and to *have opposite signs*.

In order to appreciate the empirical strategy, suppose that one finds (as I do) that diversity is significantly negatively related to firm risk. This finding can be easily explained by the theory: homogeneity and incentive pay are substitutes, therefore increasing risk makes the firm substitute incentive pay for homogeneity. However, although the result is interesting by itself, it is still not a test of the theory. The theory implies that, if homogeneity and incentive pay are substitutes, more diversity should increase incentive pay, after controlling for the direct effects of risk on incentive pay. Therefore, if one finds zero or negative effects of diversity on incentive pay, the theory will be rejected.

3.4 Discussion

Here I discuss the intuition behind the results above. The symmetry property of Proposition 5 implies that the concept of substitutability is well-defined; i.e. if incentive pay increases with the marginal cost of homogeneity, work force homogeneity also increases with risk. But when can we expect to see incentive pay and work force homogeneity being complements or substitutes? In what follows, I will focus on the

[20] See Prendergast (1999) for a survey.

[21] See Prendergast (2000).

equilibrium relationship between work force homogeneity and incentive pay in (17), because they will be complements if that derivative is positive and substitutes if it is negative.

Real world compensation contracts seem to offer weak explicit incentives to exert effort.[22] It is controversial, however, whether standard moral hazard models imply that incentives should be high-powered. Another view is that the basic moral hazard model that emphasizes the trade-off between risk and incentives is oversimplified and do not account for the main reasons why incentives might be weak. Models along these lines can be found in Holmstrom and Milgrom (1991) and Baker (1992), among others. The common feature of these models is that incentives linked to observable performance measures may induce agents to take dysfunctional actions.[23] In this section, I show that group loyalty may imply weak incentives due to a related but different reason. Although in my model there is only one action that can be taken, this action has two different effects that agents care about: it affects the worker's own pay and it affects her colleague's pay.

The first thing to notice is that when group loyalty is at its minimum (in this case it may be more accurate to call it *group rivalry*), incentives are muted:[24]

$$\lim_{\alpha \to -1} a^* = 0 \tag{22}$$

This happens because each agent is motivated by two different objectives: to increase her own pay and to decrease the other worker's pay. While this might not be the most reasonable case (if firms have any choice over α, they would never choose this level of group loyalty), it logically follows from the fact agents have only one instrument (effort) to achieve two conflicting goals. The limiting case is the one in which these two opposing forces completely offset each other.

More interestingly, the power of incentives is also decreasing for high levels of group loyalty. Again, when group loyalty unboundedly increases we have

$$\lim_{\alpha \to \infty} a^* = 0 \tag{23}$$

When group loyalty is positive, the only instrument (effort) can be used to achieve two congruent goals. Therefore, the *perceived* power of incentives may be strong, even when the bonus rate a is low. Therefore, with more homogeneity α, the same level of effort can be achieved with a lower a, implying that there is

[22] A well-known study that suggests that incentives are low-powered in executive compensation is Jensen and Murphy (1990). See also Prendergast (1999) for a comprehensive review of the empirical literature on incentives in firms.

[23] This interpretation is in Gibbons (1998).

[24] Proposition 1 implies that α can never be lower than -1 in equilibrium.

a point in which more homogeneity will be used as a means of reducing a in order to decrease the amount of risk faced by the agents.[25]

Assuming a given uncertainty parameter c, the slope of equilibrium relationship between incentive pay and work force homogeneity is given by (17). Simple algebra reveals that incentive pay first increases and then decreases with homogeneity. This implies that:

Proposition 6 *Incentive pay increases with diversity when the marginal cost of homogeneity is low and decreases with diversity when the marginal cost of homogeneity is high.*

We also have a related result:

Proposition 7 *Incentive pay increases with diversity when risk is low and decreases with diversity when risk is high.*

Propositions 6 and 7 do not tell us whether work force homogeneity and incentive pay are complements or substitutes, but they give us a hint. Because profits monotonically decrease with both risk and the marginal cost of homogeneity, market selection will drive most firms with high risk and high homogeneity costs out of the market. In other words, *firms in which incentive pay and work force homogeneity are complements are always less profitable than firms in which incentive pay and work force homogeneity are substitutes.* Therefore, the substitution effect is the one most likely to be found, especially when observed diversity is low.

4 Learning

In this section I extend the previous model to allow workers to learn about each others' types. I assume that workers do not know each others' characteristics, but repeated interactions among them lead to gradual learning about each others' types. Learning will affect group loyalty; therefore, to the extent that managers can organize work in ways that make interactions among workers more or less frequent, managers will have some control over the loyalty level of their work force. This creates a link between the organization of work and the provision of incentives in firms. The way work is organized depends not only on technological or organizational constraints, but also on "human relations" constraints: how different people are expected to react when interacting in the workplace.

[25] This result may have interesting consequences. Luttmer (2001) argues that the relative low levels of redistribution in the United States as compared to western European countries may be explained by the relative heterogeneity of U.S. population. My model implies a similar result: work force heterogeneity may explain the greater reliance on performance-based compensation in U.S. when compared to Europe or Japan.

The main result in this section can be summarized as follows. From the principal's standpoint, allowing workers to meet very often in the workplace introduces risk, because learning can either increase or decrease group loyalty. Therefore, whether the principal wants to promote or prevent interactions among workers depends on her degree of risk-tolerance. I show that the profit function is convex for low values of group loyalty and concave for high values of group loyalty. Therefore, the principal is more likely to prevent interactions when workers are expected to be similar and more likely to promote interactions when workers are expected to be different from each other. The intuition is that, when expected similarity is high, there is not much to gain if expectations are confirmed, but a lot to lose if they are not. With the extra assumption that observable and unobservable similarity are positively correlated, the testable implication is that the number of interactions (meetings) in the workplace should be positively related to observed diversity.

4.1 Similarity

When allowing for uncertainty about workers' types, many types of asymmetric information problems may arise. For example, each worker may know her own type, but not her coworker's type. The principal may know more than some of the agents, or the agents may know each other's type better than the principal. To abstract from these problems and focus only on the learning problem, in this section I assume that both agents and the principal have the same information at all stages of the game; i.e.,

$$\alpha_i = E\left[\gamma\left(v_i, v_j\right) \mid I_i\right] = E\left[\gamma\left(v_i, v_j\right) \mid I_j\right] = \alpha_j = \alpha \tag{24}$$

and that the principal always knows α. The assumption here is that knowledge of their own type does not affect the expected value of similarity.[26] Without this assumption, α_i may differ between workers, which complicates the analyses without any expected extra implications.[27]

The timing of the game is modified as follows. In period 0, the manager chooses two workers based on their observed characteristics. Now, because there are some characteristics that are not observable, one can think of the principal choosing a distribution of the random variable α, which may depend on observed characteristics. In period 1, before contracts are written, manager and workers jointly observe a

[26] One possible situation in which that happens is one where types are uniformly distributed on a circle and similarity is a function of distance between two types.

[27] In Appendix C, I sketch an alternative model that allows for asymmetric information about similarity and show that the results are qualitatively the same. In appendix E I analyze the case in which information is symmetric among agents but workers are better informed than the principal. The appendices can be downloaded from http://home.uchicago.edu/~dsferrei/appendix.pdf

common signal s of the true unknown variable γ. Then, they estimate the loyalty parameter based on the observed signal and the prior distribution of γ. Then, everything is as before. In principle, there could be many rounds of learning, as workers interact more and more over time. The manager can promote or reduce interactions by the organization of work and task design, but she must do this before signals are observed.

I assume that the prior distribution of γ is normal with mean γ_0 and variance σ_0^2. This means that, in the ex ante stage, the principal chooses a pair $\left(\gamma_0, \sigma_0^2\right)$.

4.2 Learning Technology

The learning technology is given by

$$s_t = \gamma_t + u_t \tag{25}$$

where u_t is a zero-mean independent normal random variable with variance σ_u^2.[28]

Equation (25) represents a standard signal-extraction problem. Both workers want to estimate the true similarity between them γ_t given a collectively observed noisy signal s_t. Let the common prior be given by γ_0 and σ_0^2. Workers optimally update their beliefs. In this normal environment, Bayesian updating is equivalent to least squares learning.

The least squares updating rule is given by

$$\widehat{\gamma}_{t+1} = (1 - \beta_t)\,\widehat{\gamma}_t + \beta_t s_t \tag{26}$$

$$\sigma_{t+1}^2 = (1 - \beta_t)^2\,\sigma_t^2 + \beta_t^2 \sigma_u^2 \tag{27}$$

$$\beta_t = \frac{\sigma_t^2}{\sigma_t^2 + \sigma_u^2} \tag{28}$$

It is assumed that perceived similarity will positively affect group loyalty. Of course, learning can only occur when workers interact. More socializing leads to lower σ_u^2. Whether this increases or decreases group loyalty depends on the true similarity between workers relative to their prior beliefs.

[28] One could also have a state-space representation of the learning technology by adding the following equation:

$$\gamma_{t+1} = \rho\gamma_t + \varepsilon_{t+1}$$

where ε_{t+1} is also a zero-mean independent normal random variable with variance σ_ε^2. This equation describes the dynamics of similarity over time: it reflects changes in types (or values) or preferences. Firms can change types by "indoctrination" or by affecting the likelihood of interaction between workers. This case obviously encompasses the case of stable types and preferences, which is given by $\rho = 1$ and $\varepsilon_t = 0$, all t. This is a natural starting point, which allow us to focus only on the effects of learning about other people's values.

4.3 Interactions in the Workplace

Let us define the amount of interactions as the precision of the signal $\omega = \left(\sigma_u^2\right)^{-1}$. Assume now that the firm can choose the amount of interactions ω between workers. For example, firms can put two workers to work in the same room or in separate rooms, therefore affecting the likelihood that they interact. Also, firms can assign two workers to different non-overlapping shifts or to the same shift.

For each firm, there is an optimal amount of interactions determined by technological and organizational parameters. For example, suppose a machine needs to be operated 24 hours a day, requiring the supervision of only one worker at any time. Then, three workers working 8 non-overlapping hours a day will be the efficient arrangement. But then workers will not interact. If the firm wants to increase the amount of interactions, it can pay one extra hour to each worker so their shifts will overlap an extra hour each. Therefore, there is a cost in choosing a different amount of interactions than the one that is technologically efficient. The same can be said when firms want to reduce interactions. Suppose it is optimal to have workers in the same room because they can communicate faster. However, if firms want to reduce the amount of interactions, they can put workers in separate rooms, but then communication will be costlier.

Let ω' be the optimal amount of interactions determined only by technological and organizational conditions. If ω is the level of interactions chosen by the firm, interaction costs are $C\left(\frac{\omega}{\omega'}\right)$, with $C(1) = 0$, $C' > 0$ if $\omega > \omega'$, $C' < 0$ if $\omega < \omega'$and $C'' > 0$.

4.4 Equilibrium

Suppose that the manager randomly selects two workers from a population with mean similarity γ_0 and variance σ_0^2. Workers also have the common priors γ_0 and σ_0^2 . In section 3, I derived a profit function for the firm as a function of group loyalty, $V^*(\alpha)$ from equation (14). Now, profits also depend on the similarity between the two types and on the level of interactions:

$$\pi\left(\omega_1, ..., \omega_T; \omega', \gamma, \gamma_0, \sigma_0^2\right) = \sum_{t=0}^{T} \beta^t E\left[V^*\left(\widehat{\gamma}_{t+1}\right) - C\left(\frac{\omega_t}{\omega'}\right)\right] \tag{29}$$

The manager must choose an amount of interactions, which is a sequence $(\omega_1, ..., \omega_T)$, that maximizes (29) subject to (26), (27) and (28). Let us focus on the simplest case in which $T = 1$.[29] The maximization

[29] I sketch an analysis of the multi-period case in appendix D.

problem can be written as

$$\max_{\omega_0} E\left[V^*\left(\gamma_0 + \frac{\sigma_0^2}{\sigma_0^2 + \frac{1}{\omega_0}}(s_0 - \gamma_0)\right) - C\left(\frac{\omega_0}{\omega'}\right)\right] \tag{30}$$

Assuming an interior solution,[30] the first-order condition is

$$\frac{\sigma_0^2}{\left(\sigma_0^2\omega_0 + 1\right)^2} E\left[(s_0 - \gamma_0) V^{*\prime}(\widehat{\gamma}_1)\right] = \frac{1}{\omega'} C'\left(\frac{\omega_0}{\omega'}\right) \tag{31}$$

Whether the manager wants to facilitate ($\omega_0 > \omega'$) or hinder interactions ($\omega_0 < \omega'$) depends on the sign of $E\left[(s_0 - \gamma_0) V^{*\prime}(1 - \widehat{\gamma}_1)\right]$. It is easy to show that

$$cov\left[s_0 - \gamma_0, V^{*\prime}(\widehat{\gamma}_1)\right] \gtrless 0 \text{ if } V^{*\prime\prime} \gtrless 0 \tag{32}$$

From manager's viewpoint,

$$E(s_0 - \gamma_0) = \gamma_0 - \gamma_0 = 0 \tag{33}$$

Therefore, the following proposition is straightforward:

Proposition 8 *The manager wants to promote interactions if V^* is convex and to avoid interactions if V^* is concave.*

The intuition is that the principal would like to promote interactions whenever learning is likely to increase perceived similarity between the two workers. But the learning process is unbiased ex ante, therefore from the manager's viewpoint it only introduces uncertainty. Thus, the manager is more likely to profit from learning the more risk-tolerant she is. This is why the concavity of function V^* matters.

The question now is to know when V^* is going to be concave or convex. Manipulation of V^* leads to the following proposition:

Proposition 9 *There exists $\lambda \geq 0$ such that V^* is convex whenever $\alpha \in (-1-\lambda, -1+\lambda)$ and concave otherwise.*

Therefore, this proposition says that V^* is concave whenever work force homogeneity is expected to be very high or very low, while it is convex for low absolute values of α.[31]

[30] A sufficient condition for the solution to be interior is $\lim_{x\to\infty} C(x) = \lim_{x\to 0} C(x) = \infty$.

[31] How can we understand this result? Notice first that function $V^*(\alpha)$ is bounded below by zero and above by V^{FB}, the first-best level of profits. As we have seen before, profits are increasing in α for $\alpha > -1$, therefore $V^*(\alpha)$ has to eventually become concave for α sufficiently large. For values of α less than -1, the opposite occurs: $V^*(\alpha)$ is decreasing in α. This is because group rivalry is so strong that firms can actually profit from it in a rather bizarre way: the piece-rate a is negative, which makes worker i exert effort because of her desire to harm worker j. (For evidence that individuals are sometimes willing to incur in losses in order to punish other people, see for example Fehr, Gachter and Kirchsteiger (1997)). When α approaches -1, either from above or from below, profit approaches zero. The differentiability of $V^*(\alpha)$ then guarantees that this function is convex for a sufficiently small interval that includes -1.

I have assumed an unbounded support for α so I could work with normal distributions. However, while logically plausible, compensation contracts with negative piece-rates (the case implied by $\alpha < -1$) are not observed in the real world. For the interpretation of the results, I will then focus on the empirically relevant case of $\alpha > -1$.

If the firm expects workers to be very similar, i.e., γ_0 is very high, profits are close to the first-best level. Therefore, there is not much to gain on the upside, but a lot to lose on the downside: if workers learn that they are not as similar as they once thought they were, profits can fall dramatically. Therefore, the more similar workers are expected to be, the less likely firms are to promote interactions between them in the workplace. On the other hand, for values of γ_0 close to -1, firms can gain a lot on the upside and do not lose much on the downside, therefore they would be more willing to promote learning.

Finally, let η be a (scalar) measure of similarity between two workers *based only on their observable characteristics*. I make the following assumption:

Assumption A3 $E[\gamma \mid \eta]$ *is non-decreasing in* η.

This assumption just says that people who are similar in observable characteristics expect themselves to be similar after they learn about unobservable characteristics as well. Notice that this assumption will hold unless similarity in observable characteristics is very negatively correlated with similarity in unobservable characteristics.

The following assumption is similar to A2:

Assumption A4 $E[\gamma \mid \eta] > -1$.

With the assumptions above and Propositions 8 and 9, we finally have:

Proposition 10 *If A3 and A4 hold, the principal will choose to prevent interactions when workers are expected to be similar. When they are expected to be different, she will choose to promote interactions.*

In what follows, I test this implication by regressing a measure of interactions in the workplace on observed diversity. If the model is true, interactions should be positively related to diversity.

4.5 When Social Interactions Increase Group Loyalty

I have assumed so far that the only way that interactions among workers affect group loyalty is through their effects on learning. However, repeated interactions may foster cooperation among workers for other reasons. The mere fact that workers meet with each other very often (socializing) may induce cooperation among them. I have ignored the direct effect of interactions on cooperation, so here I consider the case in which more meetings imply more cooperation. To simplify the argument, I now ignore any learning considerations.

The result here is almost trivial:

Proposition 11 *If more interactions in the workplace increase cooperation, then the principal always wants to promote interactions.*

The proof is immediate given that $C'(1) = 0$, that is, a small increase in the frequency of meetings has negligible costs, but it has a positive effect on profits. However, it can also be shown that the effect of diversity on meetings in this case can be either positive or negative. Therefore, if we assume that both forces (learning and socializing) are operating, one would still expect a positive correlation between diversity and interactions.

5 Data

In the next section, I provide new evidence that is compatible with the main implications of the model. I focus on three empirical relationships: diversity and firm risk, diversity and incentives, and diversity and interactions in the workplace. The relevant unit of study will be the board of directors of 1462 publicly traded firms in fiscal year 1998.

In what follows, it is important to understand the role of the model in the design of the empirical strategy. As we have seen above, the model predicts certain correlations between diversity and other variables. I look for these correlations in the data. In order to do that, I have to find empirical proxies for the theoretical variables. Some of these proxies capture the spirit of their theoretical counterparts, but they may not be exact analogs of the variables in the model. For example, in the model I work with the concept of pairwise diversity (or similarity) for simplicity. When I get to the data, teams (boards of directors) have many members, so I have to empirically define diversity at the team level instead of using pairwise measures. Also, reality is too complex, so many other issues that are ignored in the model may be present in the data. Therefore, I use many variables that were not explicitly taken into consideration in the theoretical part of this paper. Finally, the model is too simplified to be useful in structural estimation, therefore I only look for correlations between relevant variables using empirically-motivated functional forms.

5.1 Why Use Corporate Boards?

Corporate boards are good empirical examples of teams because the individual output of each director cannot be directly measured. Compensation is linked to firm performance mainly through grants of restricted shares and options. Director compensation has a simple structure. Directors are paid a fixed annual salary, plus fees for attending meetings and shares and stock options. Therefore, if directors have any effect on the market value of their firms, this compensation scheme suffers from the 1/n problem (free-riding).

The theory assumes that firms can choose both compensation contracts and the composition of the work force as means of providing incentives to agents.[32] Therefore, directors must be subjected to performance-based compensation contracts in order for the theory to be valid. A substantial fraction of non-employee directors' compensation is composed of restricted shares and stock options (about 45% of total compensation, on average. See Table 1).[33] About 80% of the firms in my sample granted shares and/or options to their directors. Shares and options almost always come with restrictions. Although restrictions vary across firms, usually directors are granted restricted stock which they then get once they leave the firm. Options usually come with vesting requirements and they may or may not be exercisable if the director leaves the firm.[34] Assuming that directors cannot completely hedge firm-specific risks that come with restricted shares and options (or that it is too costly to do so), an increase in the grant of shares and/or options will increase their alignment with shareholders' objectives, provided everything else is constant.[35]

Because information on directors is usually available to the public (due to regulations, listing require-

[32] Other papers have also looked at the determinants of board composition. For example, Hermalin and Weisbach (1988) have found that inside directors are more likely to be replaced by outside directors after poor firm performance. Klein (1998) finds that firms with more complex financing have more investment bankers, pharmaceutical firms have more academics, defense industry firms have more ex-politicians and ex-military on the board. Aggarwal and Knoeber (2001) relate the number of political directors on the board to variables characterizing the firm's need for political directors. As in this paper, they all find evidence consistent with firms optimally choosing directors for their characteristics. However, this paper is the first to study the homogeneity of the board as an endogenously determined variable.

[33] Here I only consider non-employee directors. Employee directors are usually not specifically paid for their duties as directors and have individually designed compensation contracts.

[34] As an example, the American Home Products Corporation's proxy statement says "the options become exercisable at the date of the next annual meeting or earlier in the event of the directors termination of service, provided that the optionee has completed at least 2 years of service as a director at the time of exercise or termination".

[35] If directors could always hedge firm-specific risks, no incentive contract could ever be binding. Both theoretical and empirical literature on the provision of incentives to executives either implicitly or explicitly assume that executives are limited in their abilities to "undo" their incentive contracts in the market. Notice also that if shares and options could be freely traded in the market at any time, they would be equivalent to riskless assets.

ments or shareholder activism), measures of diversity can be constructed using demographic information on individual directors. In this paper I use the proportion of women on boards as a measure of diversity. I also briefly discuss the distinction between inside and outside directors as a measure of diversity. The analysis in this paper could also be extended to include other variables such as ethnicity, tenure in the firm, educational background, and so on, provided one is willing to collect these data.[36]

Another good reason for using data on boards is that we know how many meetings they have every year. Therefore, we have an intuitive measure of interactions in the workplace, which is the number of board meetings. A board meeting is an important input in the production of advising and monitoring (Adams, 2001), but it is also costly because directors are usually paid for attending meetings. This fits well with the theoretical assumption that interactions have both benefits and costs that are unrelated to the composition of the work force.

Also important is the fact that boards perform roughly the same functions in different firms, which makes cross-sectional comparisons of boards more palatable than of most other kinds of work teams.

One possible problem with using corporate boards, however, is that although directors are shareholders' agents, the shareholders themselves are not acting as the principal in the theory, i.e. they are not the ones writing incentive contracts. Therefore, the assumption here is that compensation contracts, hiring decisions and organizational choices are such that they maximize shareholder value, even if we could not directly observe an active principal making all these choices. The tests that follow can be seen as joint tests of the effects of diversity on behavior and of value-maximizing corporate behavior.[37]

5.2 Data Description

The choice of the sample was driven mainly by data availability. I started with the data set collected by Adams (2001) and Adams, Almeida and Ferreira (2001).[38] It contains detailed firm-, board- and director-level data from 358 Fortune 500 firms (excluding utilities and financial firms) in fiscal year 1998. Data from previous years were also used to construct measures of volatility. Sources are proxy statements, Compustat, CRSP, ExecuComp, Moody's Manuals and firms' web sites.

This initial sample was then expanded in two ways. First, by collecting director compensation variables for the original firms. Second, by increasing the sample size in the following manner. I selected all firms

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[36] I intend to collect data on where directors went to school, the states they came from, and so on.

[37] For a survey of the economic literature on boards of directors, see Hermalin and Weisbach (2001).

[38] I thank my co-authors Renée Adams and Heitor Almeida for letting me use these jointly collected data here.

in the ExecuComp database for which at least some data on directors' compensation were available.[39] Then, I looked for the names of their directors in the 1999 "Directory of Corporate Affiliations".[40] The final sample has 1462 firms.

To construct the variable measuring the sex composition of boards, I had to infer gender from directors' first names. In the original sample that was done directly from proxy statements. For the remaining observations in the final sample, I relied on the information in the "Directory of Corporate Affiliations". In order to minimize errors, I used many name dictionaries, including some language-specific ones (English, Hebrew and Arabic). Still, some ambiguities remained, especially in some few cases in which first names were abbreviated.

I constructed a simple measure of diversity, which is the fraction of female directors on boards.[41] As one can see from Table 1, the proportion of women on boards ranges from zero to 50%. Therefore, the proportion of women is a monotonic measure of diversity: higher fractions of women imply more diversity. Few women sit on boards. On average, only about 8% of directors are women (see Table 1).

In order to test the relationship between diversity and risk, I need a measure of firm risk that affects directors' compensation. Following Aggarwal and Samwick (1999), I use the standard deviation of monthly stock returns to proxy for σ in Holmstrom and Milgrom's linear contracts model. Since incentives to directors are mainly provided by stock ownership, this measure seems reasonable. This standard deviation was computed using monthly stock returns from 1993 to 1998.[42]

Incentive pay to directors is provided by grants of shares and stock options. Shares and options are usually granted at annual meetings. In order to be precise and to avoid having to adjust for stock splits, I collected data of market prices of shares at the end of the month of each firm's annual meeting for the 1998 fiscal year. It is unfeasible to correctly price restricted shares and options. Restricted shares should not have the same value as ordinary shares and restrictions vary too much across firms to justify any simple adjustment procedure. Options are even more complicated because, on top of their vesting requirements, they can only be priced using some option-pricing theory. As in virtually all compensation papers (see Jensen and Murphy, 1990, and Aggarwal and Samwick, 1999), I ignore restrictions and vesting

[39] This expanded sample is also being used by Adams and Ferreira (work in progress). I thank Renée Adams for spending a great part of her time in actual collecting and helping me collect these data.

[40] Directory of Corporate Affiliations, Volume 3, U.S. Public Companies, 1999, published by National Register Publishing.

[41] When a given director's gender could not be inferred by his/her name, I attributed the sample mean proportion of women to that director, instead of 1 (woman) or 0 (man).

[42] Data are from CRSP.

requirements and assume that options and shares are priced as if they had no restrictions.[43] However, one should keep in mind that the estimates of total compensation are biased upwards, or that they can be best interpreted as an upper bound on actual total compensation.

Options are priced using the Black-Scholes formula, assuming continuously-paid dividends. Estimates of firm volatility, dividend-yield and the risk-free rate are from ExecuComp. Strike prices are assumed to be equal to current prices, since this is the case for virtually all firms. Expiration usually occurs in ten years; I used seven years to be consistent with ExecuComp's procedure in valuing options for the top 5 executives in each firm.[44]

Table 1 provides summary statistics for all variables used in this paper. I describe the other variables when they are first used.

5.3 A Note on the Effects of Gender on Behavior

There is a large literature that tries to assess the effects of gender on economic behaviors. Most relevant to this paper are the effects of gender on altruism and cooperation. The experimental literature, as a whole, is not conclusive, sometimes finding men to be more cooperative (Brown-Kruse and Hummels, 1993), sometimes finding women to be more cooperative (Nowell and Tinkler, 1994), and sometimes finding no differences between sexes (Brown and Taylor, 2000). Andreoni and Vesterlund (2001) find that the men are more altruistic than women when the cost of altruism is low, while women are more altruistic than men when the cost of altruism is high. Therefore, the use of proportions of women as measures of diversity may introduce biases due to gender differences in altruism, but we have no clear idea what these biases might be.

Evidence on risk-aversion is also mixed. While Jianakoplos and Bernasek (1998) find evidence of women being more risk-averse, Gneezy et al. (2001) find no independent effect of risk on behavioral differences between men and women.

While it would be desirable to work with measures that are not subjected to possible direct gender effects, it is not clear how these biases are affecting the results in this paper. On the other hand, there are also good reasons to believe that the proportion of women may be a good measure of diversity. For example, Kanter (1977) argues that firms in which output is difficult to measure will hire relatively more

[43] Hall and Murphy (2000) show how undiversified executives will value their stock options and restricted shares less than what is implied by usual option-pricing formulas (like Black-Scholes). In their simulations, they show that the gap between true values and Black-Scholes values can be quite substantial.

[44] ExecuComp estimates the value of options granted to the top five executives in each firm, but they do not have prices for directors' options. The procedure I use is chosen to be as close as possible to ExecuComp's.

men in top-management because they need to rely more on trust among managers to improve their performances. This is fully compatible with my model.

6 Empirical Results

I can test three propositions in this paper with the data I have. These are propositions 2, 3 and 10. Proposition 3 is not really new. It simply says that the power of incentives decreases with risk, a traditional implication of linear models of moral hazard that use Holmstrom and Milgrom's (1987) framework. Therefore, I do not attempt to systematically test this result. I chose to focus on the new implications of my model instead. However, the evidence that I will show below is consistent with Proposition 3, as one can see from the regressions of different components of compensation on firm risk. In the tables below, more risk leads to a shift from other forms of compensation (such as shares) to stock options, whose values actually increase with risk.[45]

Therefore, I focus on Propositions 2 and 10. From an empirical standpoint, it is more intuitive to use a measure of diversity (instead of its inverse, homogeneity). I restate these two propositions as follows:

Testable Implication 1 *(Proposition 2) The relationship between risk and diversity has the opposite sign as the relationship between diversity and incentive pay.*

Testable Implication 2 *(Proposition 10) The amount of interactions among workers in the workplace should be positively related to the degree of diversity of the work force.*

Here I briefly summarize my findings. The details can be found in the sections that follow.

In order to test the first implication, I first regress my measure of diversity on firm risk. I find a very strong and robust negative relationship between diversity and risk. According to my theory, this is consistent with work force homogeneity and incentive pay being substitutes. I show that other competing explanations do not seem to fit the evidence as well as my model does. Section 6.1 discusses the empirical tests in greater detail.

This finding, although surprising, is still not a definitive test of Implication 1. Because I found a negative relationship between risk and diversity, it follows that one must find a positive relationship between diversity and incentive pay. In section 6.2, I present results showing that firms with more diverse boards use restricted shares as a greater part of their compensation to directors, reduce the relative

[45] It is well-known by now that the evidence is mixed, sometimes finding incentives decreasing with risk and sometimes finding incentives increasing with risk. See Prendergast (2000).

importance of the fixed salary and keep the fraction of options more or less the same. This implies that more diverse firms will provide their directors with more pay-performance incentives.

These two results together are in striking accordance with Implication 1.

In order to test the second implication, I regress my measure of diversity on the number of board meetings in 1998. The number of board meetings is an intuitive proxy for the amount of interactions among directors. Consistent with Implication 2, I find that more diverse firms hold more meetings in a given year. Section 6.3 discusses the empirical strategy and the robustness of this result.

Concluding, the two new empirical implications of this paper are confirmed by these tests. In what follows, I discuss the strengths and limitations of the empirical analysis in this paper and propose some directions for further empirical research.

6.1 Risk and Diversity

Table 2 (column I) shows the output of regressing the proportion of women on boards on firm risk and industry dummies characterized by their two-digit SIC code (I do not report the coefficient estimates for the industry dummies). All t-statistics are calculated using a heteroscedasticity-consistent variance-covariance matrix. This regression shows a statistically significant negative effect of firm risk on diversity. This effect is also economically significant, in the sense that changes in risk lead to changes in the proportion of women that are substantial if compared to observed levels of diversity, but not implausibly large. An increase in risk of one standard deviation decreases the proportion of women by 2 percentage points. If the firm initially had a proportion of women equal to 8% (which is roughly the sample mean), this would imply a reduction of 25% in the proportion of women.[46]

Due to uncertainty in the true specification of the empirical model, I ran many different specifications using other variables as controls. I report these regressions in columns (II) to (VI) in Table 2. One might worry that board size may have a direct (perhaps almost mechanical) effect on the proportion of women, so I include it in column (II). Board size enters positively in the regression and its estimated coefficient is statistically significant. The firm risk coefficient shows a substantial drop in its absolute value, from -0.46 to -0.35. The estimated coefficient is still significant, however, with an extremely low p-value.

[46] Other thought experiments can also be useful in understanding the magnitudes here. Consider a firm that initially has a proportion of women of 8%, which is roughly equal to the sample mean. Suppose this firm initially had firm risk equal to value of the 75% percentile of the empirical distribution and then risk jumps down to the value in the 25% percentile. The proportion of women will then increase in 32% (to a level of 10.5%). Going from the 95% to the 25% percentile increases the proportion of women in 70% of its initial value. Going from the largest level of firm risk to the lowest level more than triples the original proportion of women.

Profitability may also affect the proportion of women on boards. I included one measure of firm value (Tobin's Q) and one accounting measure of performance (return on assets - ROA) to control for profitability (current and future).[47] Column (III) displays the results. The estimated coefficient on firm risk shows a slight increase on its absolute value and on its t-statistic. Tobin's Q enters positively and significantly as a determinant of the proportion of women on boards. This suggests that firms with many future investment opportunities have relatively more women on their boards of directors. Another interpretation is that firms that use relatively more human capital have more women as directors. While it is not the goal of this study to interpret this finding, it is interesting to register the fact that higher market valuation is associated with more women on boards. ROA has a negative but statistically insignificant effect on diversity.

Column (IV) shows the results of the regression including four different measures of firm size: sales, the number of employees, assets (book value) and the total market value of equity. The effect of including these variables on the previously estimated coefficients is virtually non-existent. The only one of these variables that enters significantly is sales. Large firms as measured by sales revenues employ relatively more women as directors.

6.1.1 Alternative Explanations, Causality, and Robustness Checks

Do more complex firms have fewer women on their boards? One possibility is that the standard deviation of stock returns proxies for complexity of tasks and that discriminating boards trust women less when tasks are more complex. I used the number of business segments as a measure of complexity in column (V) of Table 2. In column (VI), I also included a different measure of variability, the standard deviation of the return on assets.[48] As we can see, both variables that are reasonable measures of complexity do not significantly affect the proportion of women and do not significantly affect the effect of firm risk on diversity. A third measure of complexity would be firm age. I do not have data on firm age for the whole sample, but I do have the number of years since incorporation for the initial sample of 358 firms. In this restricted sample, firm age does not significantly affect the proportion of women and its inclusion does not affect the firm risk coefficient.[49]

[47] Tobin's Q is the ratio of the firm's market value to its book value. The firm's market value is calculated as book value of assets minus the book value of equity plus the market value of equity. ROA is the ratio of net income before extraordinary items and discontinued operations to its book value of assets.

[48] This is calculated using annual values from 1992 to 1998.

[49] The regressions for the initial sample have very similar results as the ones for the final sample, therefore are not reported here. The output of these regressions is available upon request. I am currently working on collecting incorporation dates so

Are results due to some sectorial biases? For example, what if hi-tech firms have both few women and high volatility? The inclusion of industry dummies is an attempt to control for that possibility. Industry biases do not seem to be the main cause of the correlation between diversity and risk.

While causality can never be inferred from regression results alone, one can check whether some specific stories of reverse causality are consistent with the data. One possible story is that, for some reason, women are more "stabilizing". That is, women take actions that reduce volatility in stock returns. To test this hypothesis I included a different measure of variability, the standard deviation of the return on assets. This variable has no significant effect on the fraction of women on boards (see Table 2, column VI). In my theory, the only volatility that matters is the one that affects compensation. Director compensation is not sensitive to ROA, therefore ROA should not matter. Therefore, any story that says that women reduce risk would have to explain why women seem to reduce stock return risk but not the riskiness of accounting measures.[50]

Another story has to do with self-selection. There is some evidence that women are more risk-averse than men (Jianakoplos and Bernasek, 1998). Therefore, fewer women would be willing to work for firms that offer highly risky compensation. This story is observationally equivalent to my prediction. However, we will see that the evidence on compensation seems to contradict the "women-are-more-risk-averse" hypothesis, while being fully consistent with my theory. Firms with more performance-based compensation have more women on boards (see Section 6.2), which is evidence against the self-selection story.[51]

The magnitude of the effect of firm risk is robust across specifications. Excluding column (I), all other five regressions have coefficients around -0.35. t-statistics are consistently high across specifications as well.

What about other measures of diversity? Are the results presented in this section specific to the choice of measuring diversity as antagonism between sexes? I also used a different measure of diversity: the proportion of inside directors on boards. Inside directors are company employees, as opposed to outside directors, who only meet during board meetings. Therefore, one would expect a board with more inside directors to be more homogenous (since more of them work together in the same firm) than one with

that I could include firm age in the expanded sample.

[50] I also experimented with the variability of return on equity (ROE) instead of ROA and the results were the same. The outputs of these regressions are available upon request.

[51] I do not claim to provide evidence that women are not more risk-averse than men. Rather, while it may be the case that women are on average more risk-averse than men, this does not imply that they will be more risk-averse than men *conditional on being corporate directors*. Women that succeed in business may well be as risk-averse as men.

more outside directors (who usually work in other firms). The use of the fraction of inside directors as a measure of homogeneity has one important problem. Unlike gender, the distinction between insiders and outsiders may have direct consequences for governance. It is common to assume that outside directors are better monitors of managers than inside directors. Therefore, outside directors are more valuable the greater the possibilities for misbehavior are. Firms in more uncertain environments would then demand more outside directors. Notice that this predicts a negative relationship between insiders and risk.

Table 3 shows the outputs of regressions of the proportion of insiders on firm risk. I only have data on insiders for a sub-sample of 332 firms of my initial sample of 358 Fortune 500 firms.[52] All regressions include 2-digit industry dummies. In column (I), I report the output of regressing the proportion of insiders on firm risk alone. Consistent with the results I found when I used the proportion of women as a measure of diversity, the coefficient is positive, although only significant at 10%. In column (II), I try to control for the problem mentioned in the paragraph above by including the standard deviation of ROA as a control. This variable can be seen as a measure of the riskiness in the environment, but it should not matter for diversity since it does not affect compensation. Consequently, I expect this variable to enter negatively in the equation. As we can see, the coefficient on the standard deviation of ROA is negative and significant at 1%, and its inclusion increases the positive effect of firm risk on the proportion of insiders, making this effect significant at 5% (and almost at 1%). Columns (III) and (IV) report additional regressions with more controls. None of the additional control variables seem to be significant, except for the number of employees. The main result persists, with somewhat lower t-statistics.

These results regarding insiders and outsiders should be considered exploratory due to small sample considerations, but they do conform remarkably well with the theoretical predictions, especially when one takes into account the expected bias in the other direction and the loss in degrees of freedom from introducing 2-digit industry dummies in a sample of only 332 observations.

Finally, the linear regression approach adopted here is clearly inappropriate, because the dependent variable is restricted to lie between 0 and 1, but this restriction is ignored in ordinary least squares estimation. Using the fact that directors can either be a woman or a man, I estimated (grouped-data) probit regressions in which the dependent variable is an indicator variable that equals 1 when the respective

[52] I am currently working on collecting data on insiders for the whole sample.

director is a woman and 0 if the director is a man:[53]

$$\Pr(d = woman) = \Phi\left(\boldsymbol{\beta}'\mathbf{X}\right) \tag{34}$$

where $\mathbf{X}$ is a vector of firm characteristics (always including firm risk), $\boldsymbol{\beta}$ is a vector of coefficients and Φ is the standardized normal cumulative distribution function. The estimated probability can also be seen as a measure of diversity.[54] Table 4 reports the results. I replicate all previous regressions. The reported "slope" is the marginal effect of an infinitesimal increase in the respective independent variable on the probability of a director being a woman. The slope is calculated at the means of the data.

The probit results confirm the earlier findings concerning diversity and risk. The estimates of the marginal effects of risk on diversity (the slopes) are very similar to the OLS estimates.[55] Other variables that were significant before, like board size and sales, are not robust to this change in specification. Tobin's Q is also not significant in column (VI). Therefore, the probit results are even more striking. They show that firm risk is the only robust determinant of the proportion of women on boards among all the variables considered here.

6.2 Incentive Pay and Diversity

In this section, I look at additional evidence relating incentive pay and diversity. Given that the evidence so far shows that diversity decreases with risk, the theory then implies that work force homogeneity and incentive pay should be substitutes. Therefore, incentive pay should increase with diversity (keeping risk constant). Notice that only with this extra result one can claim to have tested the theory. So far, the evidence, although striking, is not a test of the model. At best, one can say that the model rationalizes the evidence, but finding a positive relationship between diversity and risk is still consistent with the model.[56]

I find a positive relationship between incentive pay and diversity. Because diversity decreases with risk, this finding is what the theory predicts. Finding no relationship or a negative one would have meant rejection of the theory. Finding a negative relationship between incentive pay and diversity is also what

[53] Observations were dropped if gender could not be inferred.

[54] A robust variance-covariance matrix is used, allowing for heteroscedasticity and correlation among directors from a same firm.

[55] Again, this is true at the means of the data.

[56] It would have been harder to believe the model if one had found that more risk increases diversity, because then one would have to argue that 8% of women on boards represents a very high degree of diversity.

the "women-are-more-risk-averse" story predicts, therefore the findings in this section are consistent with my model but not with the risk-aversion explanation.

I divide compensation in three main groups: (value of) shares, (value of) options and salary.[57] I make the standard assumption that shares and options give directors more incentives than salaries. The comparison between shares and options is a little trickier. Clearly, which one is more sensitive to performance will depend on the specific restrictions they come with. It also depends on how one defines "pay-performance sensitivity". Hall and Murphy (2000) show that if one defines pay-performance sensitivity as the derivative of the value of an option with respect to the price of the underlying stock, then pay-performance sensitivity is maximized when the option is deeply in-the-money, that is, when the option is actually restricted stock (which are options with a strike price of zero). It seems reasonable then to assume that 1 dollar in restricted stock is more sensitive to firm performance than 1 dollar in options. For diversified investors, the sensitivity of options to the price of the underlying stock is measured by the *hedge ratio*, or *delta*. In their simulations, Hall and Murphy (2000) show that this sensitivity may be much lower than the one implied by the delta, when executives hold undiversified portfolios. Therefore, I do not attempt to measure pay-performance sensitivity by using deltas. I simply assume that a compensation package that has more restricted stock than options (in relative terms) will provide more pay-performance incentives.

Table 5 shows the outputs of regressions of the proportion of the value of restricted shares in total compensation on diversity and other controls. We see in column (I) that the proportion of women is positively related to the fraction of shares in total compensation. This relationship is statistically significant. It is also economically significant. For example, an increase of one standard deviation in the proportion of women increases the value of shares relative to total compensation in 3.6 percentage points. This increase in non-trivial, since the average proportion of restricted stock in total compensation is 13.5%.

Columns (II) to (V) show the output of regressions using other control variables. The coefficients on diversity are reasonably stable across specifications, ranging from 0.38 to 0.46, and they are always significant at 1%. As expected, firm risk has a significant negative effect on the use of restricted shares in director compensation. Board size has small positive effect on compensation through shares. Sales have a positive effect on shares. Firm value and performance (Tobin's Q and ROA) are not significantly related to shares/total compensation.

[57] I define the salary variable as the sum of the annual retainer plus meeting fees times the number of meetings.

Table 6 shows the results for the analog regressions using the proportion of the fixed part of compensation (salary) in total compensation on the same variables as above. After controlling for risk, the effect of diversity on salary is negative and significant at 1%. It is interesting to notice that the coefficient estimates on the proportion of women in Tables 5 and 6 are very similar in absolute value but with opposite signs. This suggests that increases in the proportion of women lead to increases in the fraction of shares at the expense of the fixed part of the compensation, leaving the fraction of options in compensation more or less the same. In fact, in a SUR estimation of the equations in Tables 5 and 6, I could not reject the cross-equations restrictions of equality of coefficients on diversity (with opposite signs). In the analog regression for the fraction of options in total compensation, the estimated diversity coefficients were never significantly different from zero.[58]

In Table 7, I check the effects of diversity on the levels of each compensation component, rather than the proportions. I cannot reject that boards with relatively more women grant more shares to their directors. The value of options, salaries and total compensation are not conclusively associated with diversity.

Finally, OLS estimates also seem inappropriate here because fractions are restricted to lie between 0 and 1. To impose that restriction, I estimate the following model:

$$y = \Phi\left(\boldsymbol{\beta}'\mathbf{X}\right) + \varepsilon \tag{35}$$

where y is the respective compensation fraction (shares, salary or options), $\mathbf{X}$ is a vector of firm characteristics (always including the proportion of women), $\boldsymbol{\beta}$ is a vector of coefficients and Φ is the standardized normal cumulative distribution function. Notice that this is a non-linear regression that generates fitted values that are always between 0 and 1. I estimated (35) by the non-linear least squares method.

Tables 8 and 9 display the results. Overall, the relationship between shares and diversity and between salary and diversity are robust to this non-linear specification. The marginal effects of diversity on shares and salary (the "slopes") are similar to the OLS ones (when calculated at the means of the data).

In summary, firms with more women on boards seem to use restricted shares as a greater part of their compensation to directors, reducing the relative importance of the fixed salary and keeping the fraction of options more or less the same. This implies that more diverse firms will provide more pay-performance incentives to their directors.

[58] I do not report these regressions to save space and because they are somewhat redundant. The SUR estimates are the same as the ones from equation-by-equation OLS, therefore only the standard errors are different. The effects on options/total compensation are implicitly estimated by 1-shares/totcomp - salary/totcomp. However, the output of these regressions is available upon request.

6.3 Interactions and Diversity

In this section, I test the prediction that more diversity leads to more interactions in the workplace. I use the number of board meetings in 1998 as a proxy for the amount of interactions among directors.

Meetings are count data, therefore I ran a Poisson regression of meetings on diversity and controls:

$$E[meet \mid \mathbf{X}] = \exp\left(\boldsymbol{\beta}'\mathbf{X}\right) \tag{36}$$

where $\mathbf{X}$ is a vector of firm characteristics (always including the proportion of women) and $\boldsymbol{\beta}$ is a vector of coefficients.[59]

Table 10 displays the results. From column I we can see that, as predicted by theory, firms with relatively more women on their boards have more meetings. This result is statistically significant, but its economic significance is small. For example, at the means of the data, one needs to increase the proportion of women in 3 standard deviations to have one extra meeting. Given that the average number of meetings is 7.2, one extra meeting does make a difference. However, an increase in three times the standard deviation of the proportion of women is a rare event.

Columns II to V check the robustness of this effect to the inclusion of other controls. Statistical significance is not much affected by the inclusion of controls. The estimated coefficient on the proportion of women is always significant at 5%. The economic significance, however, is not improved.

The evidence in this section is consistent with the predictions of the model. The estimated magnitude of the effects of diversity on interactions is small, at least at the means of the data. However, one should keep in mind that the marginal effects of diversity on the number of meetings is not the same at all points of the empirical distribution.[60]

7 Conclusions and Further Research

Organizational scholars and sociologists believe that numbers and proportions of different types of people matter (Blau, 1977; Kanter, 1977; Pfeffer, 1983). Heterogeneity in personal characteristics may affect

[59] The estimation method is maximum likelihood.

[60] For an empirical paper on board meetings, see Vafeas (1999). As in this paper, Vafeas finds a negative relationship between Tobin's Q and the number of meetings and a positive relationship between board size and the number of meetings. My results are similar, but statistical significance in these cases is dubious. I find risk (the standard deviation of stock returns) to be positively related to board meetings, which is compatible with his findings that lagged returns are negatively related to the number of meetings. He does not look at the correlation between sales and meetings, which is positive and significant in my regressions.

behaviors in work groups. In this paper, I looked at diversity in the workplace from an economist's standpoint. I developed a simple model in which organizations choose the optimal demographic composition of their work groups. I showed that the composition of the work force affects the design of incentive contracts and the organization of work.

In a sample of boards of directors, I find evidence that is consistent with the main implications of the model. The empirical evidence in this paper supports the view that diversity matters for incentives. Riskier firms have fewer women on their boards of directors. A larger proportion of women on boards also means that directors have higher fractions of their total compensation linked to firm performance. Finally, I cannot reject that directors meet more often when the board is more diverse.

The empirical work can be extended in many ways. The most promising one is to try to replicate the results found here using alternative measures of diversity, such as geographic or educational measures. However, such extensions are limited by the costs of collecting these measures. Therefore, the analysis of other work groups, such as sports teams, is also a promising topic for further empirical research.

The demography of organizations has been an active field of research among researchers in management and organizational behavior. Kanter (1977) was one of the first to analyze the relationship between the proportion of women in top management teams and organizational issues. Pfeffer (1983) introduced the concept of organizational demography, which deals with the description of organizations "in terms of their sex composition, their racial composition, their age or length of service distributions, the educational level of their work forces, the socioeconomic origins of their members, and so forth" (p.303). Empirical papers in this tradition have looked both at the effects of demography on outcomes and at the determinants of organizational demography.[61]

Economists, on the other hand, have studied the demography of organizations only indirectly. They have focused mainly on gender and race through the development of economic theories of discrimination, that are either taste-based (Becker, 1957) or statistical (Phelps, 1974; Coate and Loury, 1993). One of the few economics papers in which proportions matter is the one by Athey et al. (2000), in which they analyze the phenomenon of the "glass ceiling".

My findings suggest that organizational demography matters for incentives. The interactions between workers' characteristics and incentives may become a promising line of research in the provision of incentives in organizations.

[61] For examples, see Haveman (1995), O'Reilly, Caldwell and Barnett (1989), Pelle, Eisenhardt and Xin (1999) and Wagner, Pfeffer and O'Reilly (1984).

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Table 1: Summary Statistics

Variables	# observations	mean	median	Std. Deviation	min	max
Proportion of women	1462	0.078	0.077	0.078	0.000	0.500
Value of shares	1447	9.467	0.000	20.920	0.000	230.625
Value of stock options	1392	42.960	10.130	92.975	0.000	888.780
Salary	1420	26.590	26.000	13.422	0.000	87.000
Total compensation	1340	80.348	54.174	93.850	0.500	888.780
Shares/total compensation	1340	0.135	0.000	0.225	0.000	1.000
Options/total compensation	1340	0.318	0.243	0.336	0.000	1.000
Salary/total compensation	1340	0.547	0.518	0.320	0.000	1.000
Firm risk (sd. of stock returns)	1175	0.100	0.091	0.042	0.038	0.436
Std. dev. of ROA	1328	4.571	6.643	2.593	0.026	74.833
ROA (return on assets)	1439	3.663	4.223	11.224	-162.531	49.849
Tobin's Q	1455	2.085	1.484	1.936	0.551	38.051
Number of employees	1423	19.650	6.224	49.137	0.035	910.000
Assets (book value)	1459	8589	1400	33131	5	668641
Market value of equity	1456	7048	1208	22032	2	333672
Sales	1458	4121	1237	10140	4	158514
Number of board meetings	1408	7.232	7.000	3.066	1.000	41.000
Board size	1462	9.906	9.000	3.596	2.000	45.000
Number of segments	1380	4.087	3.000	2.713	1.000	18.000

Note: All values are for fiscal year 1998. See text for details on sample selection. Sources are proxy statements, Compustat, CRSP, ExecuComp and the Directory of Corporate Affiliates (1999). Proportion of women is the fraction of female directors on boards. All compensation variables are measured in thousands of dollars. "Value of shares" is the market value of shares granted to directors using the stock price of the end of the same month of the firm's annual meeting. "Value of options" is the Black-Scholes value of options granted to directors assuming continuously-paid dividends. Estimates of firm volatility, dividend-yield and the risk-free rate are from ExecuComp. Strike prices are assumed to be equal to current prices and expiration is in seven years. Salary is the sum of the annual retainer plus meeting fees times the number of meetings. Total compensation is the sum of shares, options and salary. "Firm risk" is the standard deviation of monthly stock returns from 1993 to 1998. The standard deviation of ROA is calculated using annual values from 1992 to 1998. Tobin's Q is the ratio of the firm's market value to its book value. The firm's market value is calculated as book value of assets minus the book value of equity plus the market value of equity. ROA is the ratio of net income before extraordinary items and discontinued operations to its book value of assets. Employees are measured in thousands. Sales are thousands of dollars. The book value of assets and the market value of equity are measured in millions of dollars.

Table 2: OLS Estimates of the Effects of Firm Risk on Diversity

Dependent variable: fraction of female directors on corporate boards

Indep. variables	**(I)**	**(II)**	**(III)**	**(IV)**	**(V)**	**(VI)**
Firm risk	**-0.460**	**-0.346**	**-0.364**	**-0.352**	**-0.337**	**-0.365**
t	-7.236	-5.151	-5.279	-5.175	-4.947	-4.685
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Board size		**0.0040**	**0.0038**	**0.0032**	**0.0030**	**0.0031**
t		4.029	3.974	3.425	3.324	3.335
p-value		<0.001	<0.001	0.001	0.001	0.001
Tobin's Q			**0.00517**	**0.00461**	**0.00495**	**0.00445**
t			3.583	2.602	2.775	2.511
p-value			<0.001	0.009	0.006	0.012
ROA			**-0.00018**	**-0.00015**	**-0.00014**	**-0.00005**
t			-0.933	-0.779	-0.724	-0.251
p-value			0.351	0.436	0.470	0.802
Sales				**1.1E-06**	**1.0E-06**	**1.0E-06**
t				2.792	2.608	2.574
p-value				0.005	0.009	0.010
Employees				**-0.00005**	**-0.00006**	**-0.00006**
t				-1.009	-1.086	-1.075
p-value				0.313	0.278	0.283
Assets				**-9.2E-08**	**-8.9E-08**	**-8.9E-08**
t				-1.209	-1.191	-1.196
p-value				0.227	0.234	0.232
Market value				**-1.9E-08**	**-2.6E-08**	**-1.1E-08**
t				-0.158	-0.221	-0.093
p-value				0.875	0.825	0.926
Number of segments					**0.0013**	**0.0013**
t					1.396	1.379
p-value					0.163	0.168
Std. dev. of ROA						**0.0005**
t						0.974
p-value						0.330
R2	0.173	0.193	0.201	0.210	0.211	0.212

Note: Values are for fiscal year 1998. The sample is composed of data from 1066 publicly traded firms for which no variable was missing. See text for details on sample selection. All regressions include 2-digit industry dummies. <0.001 means that p-value is less than 0.001. The reported t-statistics are corrected for heteroscedasticity.

Table 3: OLS Estimates of the Effects of Firm Risk on the Proportion of Insiders

Dependent variable: fraction of inside directors on corporate boards of 332 Fortune 500 firms

Indep. variables	**(I)**	**(II)**	**(III)**	**(IV)**
Firm risk	**0.385**	**0.551**	**0.485**	**0.422**
t	1.797	2.399	2.150	1.741
p-value	0.073	0.017	0.032	0.083
Std. dev. of ROA		**-0.0044**	**-0.0049**	**-0.0044**
t		-2.719	-2.899	-2.437
p-value		0.007	0.004	0.015
Board size			**-0.0046**	**-0.0044**
t			-1.522	-1.450
p-value			0.129	0.148
Tobin's Q			**0.0010**	**-0.0009**
t			0.259	-0.184
p-value			0.796	0.854
Sales			**4.6E-07**	**1.3E-06**
t			1.560	1.490
p-value			0.120	0.137
ROA				**0.0010**
t				1.181
p-value				0.238
Employees				**-0.0002**
t				-1.950
p-value				0.052
Assets				**1.1E-07**
t				0.262
p-value				0.793
Market value				**-6.7E-08**
t				-0.239
p-value				0.811
Number of segments				**-0.0040**
t				-0.971
p-value				0.332
R2	0.217	0.228	0.239	0.259

Note: Values are for fiscal year 1998. Sample is composed of data from 332 Fortune 500 firms (excluding utilities and financial firms) for which no variable was missing. See text for details on sample selection. All regressions include 2-digit industry dummies. The reported t-statistics are corrected for heteroscedasticity.

Table 4: Probit Estimates of the Effects of Firm Risk on Diversity

Dependent variable: 1 if woman, 0 if man

Indep. variables	**(I)**	**(II)**	**(III)**	**(IV)**	**(V)**	**(VI)**
Firm risk	**-3.741**	**-3.416**	**-3.701**	**-3.549**	**-3.467**	**-3.822**
t	-5.444	-4.746	-4.954	-4.738	-4.625	-4.707
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
slope	-0.490	-0.446	-0.483	-0.462	-0.451	-0.497
Board size		**0.0115**	**0.0117**	**0.011**	**0.0106**	**0.0108**
t		1.370	1.415	1.381	1.345	1.357
p-value		0.171	0.157	0.167	0.179	0.175
slope		0.002	0.002	0.001	0.001	0.001
Tobin's Q			**0.03537**	**0.03576**	**0.03756**	**0.02631**
t			2.438	2.306	2.454	1.505
p-value			0.015	0.021	0.014	0.132
slope			0.005	0.005	0.005	0.003
ROA			**-0.00174**	**-0.00164**	**-0.00147**	**-0.00017**
t			-0.776	-0.732	-0.654	-0.074
p-value			0.438	0.464	0.513	0.941
slope			-0.00023	-0.00021	-0.00019	-0.00002
Sales				**7.5E-06**	**6.2E-06**	**5.7E-06**
t				1.138	0.964	0.906
p-value				0.255	0.335	0.365
slope				9.7E-07	8.0E-07	7.4E-07
Employees				**0.00139**	**0.00125**	**0.00135**
t				0.707	0.643	0.694
p-value				0.479	0.520	0.488
slope				0.00018	0.00016	0.00018
Assets				**-6.1E-07**	**-4.7E-07**	**-4.8E-07**
t				-0.945	-0.729	-0.758
p-value				0.345	0.466	0.449
slope				-7.9E-08	-6.1E-08	-6.3E-08
Market value				**-1.8E-06**	**-1.6E-06**	**-1.3E-06**
t				-0.546	-0.517	-0.419
p-value				0.585	0.605	0.675
slope				-2.3E-07	-2.1E-07	-1.7E-07
Number of segments					**0.0085**	**0.0079**
t					0.990	0.922
p-value					0.322	0.357
slope					0.0011	0.0010
Std. dev. of ROA						**0.0055**
t						1.428
p-value						0.153
slope						0.0007

Note: Values are for fiscal year 1998. The sample is composed of data from 1066 publicly traded firms for which no variable was missing. See text for details on sample selection. The estimation uses 6961 observations on individual directors. The dependent variable is 1 if the director is a woman and 0 if the director is a man. Observations were dropped if gender could not be inferred. The method of estimation is maximum likelihood. A robust variance-covariance matrix is used, allowing for heteroscedasticity and correlation among directors from the same firm. The reported "slope" is the marginal increase in the predicted probability that a given director is a woman due to an infinitesimal increase in the respective independent variable. Slopes are calculated at the means of the data. All regressions include 2-digit industry dummies. <0.001 means that p-values are smaller than 0.001.

Table 5: OLS Regressions of Directors' Compensation on Diversity and Other Controls

Dependent variable: shares/total compensation

Indep. variables	**(I)**	**(II)**	**(III)**	**(IV)**	**(V)**
Proportion of women	**0.461**	**0.454**	**0.419**	**0.380**	**0.380**
t	5.318	4.777	4.424	3.967	3.919
p-value	<0.001	<0.001	<0.001	<0.001	<0.001
Firm risk		**-1.309**	**-1.132**	**-1.090**	**-1.125**
t		-7.648	-6.491	-6.341	-5.985
p-value		<0.001	<0.001	<0.001	<0.001
Board size			**0.0065**	**0.0045**	**0.0048**
t			2.778	1.929	1.984
p-value			0.006	0.054	0.048
Sales				**2.5E-06**	**2.5E-06**
t				3.025	2.956
p-value				0.003	0.003
Tobin's Q					**-0.0022**
t					-0.458
p-value					0.647
ROA					**-0.0009**
t					-1.477
p-value					0.140
# of observations	1340	1119	1119	1117	1103
R^2	0.094	0.152	0.159	0.169	0.169

Note: Values are for fiscal year 1998. The sample is composed of data from publicly traded firms. Sample size varies due to data availability. See text for details on sample selection. All regressions include 2-digit industry dummies. <0.001 means that p-value is less than 0.001. The reported t-statistics are corrected for heteroscedasticity.

Table 6: OLS Regressions of Directors' Compensation on Diversity and Other Controls

Dependent variable: fixed salary/total compensation

Indep. variables	**(I)**	**(II)**	**(III)**	**(IV)**	**(V)**
Proportion of women	**-0.201**	**-0.421**	**-0.417**	**-0.358**	**-0.334**
t	-1.810	-3.250	-3.175	-2.714	-2.533
p-value	0.070	0.001	0.002	0.007	0.011
Firm risk		**-1.615**	**-1.638**	**-1.687**	**-1.697**
t		-5.038	-4.863	-4.974	-4.694
p-value		<0.001	<0.001	<0.001	<0.001
Board size			**-0.0008**	**0.0020**	**0.0019**
t			-0.254	0.584	0.571
p-value			0.800	0.559	0.568
Sales				**-3.2E-06**	**-2.9E-06**
t				-3.632	-3.436
p-value					0.001
Tobin's Q					**-0.0212**
t					-3.233
p-value					0.001
ROA					**0.0005**
t					0.528
p-value					0.598
# of observations	1340	1119	1119	1117	1103
R^2	0.091	0.136	0.136	0.144	0.155

Note: Values are for fiscal year 1998. The sample is composed of data from publicly traded firms. Sample size varies due to data availability. See text for details on sample selection. All regressions include 2-digit industry dummies. <0.001 means that p-value is less than 0.001. The reported t-statistics are corrected for heteroscedasticity.

Table 7: OLS Regressions of Directors' Compensation on Diversity and Other Controls

Dependent variables: shares, options, salaries and total compensation (in thousands of $)

	Dependent Variables			
Indep. variables	**shares**	**options**	**salary**	**total compensation**
Proportion of women	**25.693**	**-44.941**	**2.719**	**-14.363**
t	3.146	-1.579	0.504	-0.497
p-value	0.002	0.115	0.614	0.619
Firm risk	**-83.724**	**595.714**	**-51.606**	**449.804**
t	-4.883	4.627	-4.134	3.657
p-value	<0.001	<0.001	<0.001	<0.001
Board size	**0.5391**	**-0.2055**	**0.6523**	**0.7412**
t	2.370	-0.256	4.392	0.922
p-value	0.018	0.798	<0.001	0.357
Sales	**0.0003**	**0.0004**	**0.0003**	**0.0010**
t	2.948	1.922	3.007	2.934
p-value	0.003	0.055	0.003	0.003
Tobin's Q	**1.0233**	**16.5910**	**0.4924**	**18.0849**
t	1.120	4.645	1.898	5.418
p-value	0.263	<0.001	0.058	<0.001
ROA	**-0.0717**	**0.3208**	**-0.1080**	**0.2503**
t	-1.617	1.141	-2.938	0.930
p-value	0.106	0.254	0.003	0.353
# of observations	1154	1134	1127	1107
R2	0.177	0.259	0.221	0.254

Note: Values are for fiscal year 1998. The sample is composed of data from publicly traded firms. Sample size varies due to data availability. See text for details on sample selection. All regressions include 2-digit industry dummies. <0.001 means that p-value is less than 0.001. The reported t-statistics are corrected for heteroscedasticity.

Table 8: NLLS Regressions of Directors' Compensation on Diversity and Other Controls					
Dependent variable: shares/total compensation					
Indep. variables	**(I)**	**(II)**	**(III)**	**(IV)**	**(V)**
Proportion of women	**1.701**	**1.912**	**1.926**	**1.772**	**1.743**
t	4.990	4.700	4.660	4.270	4.160
p-value	<0.001	<0.001	<0.001	<0.001	<0.001
slope	0.313	0.282	0.270	0.257	0.261
Firm risk		**-11.233**	**-10.083**	**-9.888**	**-10.463**
t		-7.430	-6.580	-6.480	-6.460
p-value		<0.001	<0.001	<0.001	<0.001
slope		-1.656	-1.412	-1.432	-1.567
Board size			**0.0252**	**0.0176**	**0.0175**
t			2.460	1.700	1.680
p-value			0.014	0.090	0.094
slope			0.004	0.003	0.003
Sales				**5.7E-06**	**5.5E-06**
t				2.660	2.520
p-value				0.008	0.012
slope				0.000	0.000
Tobin's Q					**0.0079**
t					0.350
p-value					0.726
slope					0.001
ROA					**-0.0067**
t					-1.980
p-value					0.048
slope					-0.001
# of observations	1340	1119	1119	1117	1103

Note: Values are for fiscal year 1998. The sample is composed of data from publicly traded firms. Sample size varies due to data availability. See text for details on sample selection. The reported estimates are for the coefficients of the following model:

$$y = \Phi(\beta' \mathbf{X}) + \varepsilon$$

where y is the proportion of shares in total compensation, $\mathbf{X}$ is a vector of firm characteristics (always including the proportion of women), β is a vector of coefficients and Φ is the standardized normal cumulative distribution function.The method of estimation is non-linear least squares. The reported "slope" is the marginal increase in the proportion of shares in total compensation due to an infinitesimal increase in the respective independent variable. Slopes are calculated at the means of the data. All regressions include 2-digit industry dummies. <0.001 means that p-value is less than 0.001.

Table 9: NLLS Regressions of Directors' Compensation on Diversity and Other Controls

Dependent variable: salary/total compensation

Indep. variables	**(I)**	**(II)**	**(III)**	**(IV)**	**(V)**
Proportion of women	**-0.534**	**-1.143**	**-1.129**	**-0.943**	**-0.901**
t	-1.790	-3.310	-3.240	-2.700	-2.570
p-value	0.073	0.001	0.001	0.007	0.010
slope	-0.210	-0.450	-0.444	-0.371	-0.356
Firm risk		**-4.774**	**-4.864**	**-5.111**	**-5.311**
t		-6.390	-6.150	-6.420	-6.140
p-value		<0.001	<0.001	<0.001	<0.001
slope		-1.878	-1.913	-2.010	-2.100
Board size			**-0.0029**	**0.0052**	**0.0040**
t			-0.350	0.600	0.450
p-value			0.730	0.550	0.656
slope			-0.001	0.002	0.002
Sales				**-1.1E-05**	**-9.1E-06**
t				-3.310	-2.970
p-value				0.001	0.003
slope				0.000	0.000
Tobin's Q					**-0.0560**
t					-2.770
p-value					0.006
slope					-0.022
ROA					**0.0008**
t					0.300
p-value					0.764
slope					0.000
# of observations	1340	1119	1119	1117	1103

Note: Values are for fiscal year 1998. The sample is composed of data from publicly traded firms. Sample size varies due to data availability. See text for details on sample selection. The reported estimates are for the coefficients of the following model:

$$y = \Phi(\beta' \mathbf{X}) + \varepsilon$$

where y is the proportion of salary in total compensation, $\mathbf{X}$ is a vector of firm characteristics (always including the proportion of women), β is a vector of coefficients and Φ is the standardized normal cumulative distribution function.The method of estimation is non-linear least squares. The reported "slope" is the marginal increase in the proportion of salary in total compensation due to an infinitesimal increase in the respective independent variable. Slopes are calculated at the means of the data. All regressions include 2-digit industry dummies. <0.001 means that p-value is less than 0.001.

Table 10: Poisson Estimates of the Effects of Diversity on the Number of Board Meetings

Dependent variable: number of board meetings

Indep. variables	**(I)**	**(II)**	**(III)**	**(IV)**	**(V)**
Proportion of women	**0.410**	**0.449**	**0.407**	**0.332**	**0.371**
t	2.837	2.660	2.413	1.953	2.163
p-value	0.005	0.008	0.016	0.051	0.031
slope	2.919	3.184	2.885	2.354	2.620
Firm risk		**0.853**	**1.077**	**1.127**	**0.814**
t		2.619	3.170	3.326	2.369
p-value		0.009	0.002	0.001	0.018
slope		6.046	7.633	7.991	5.754
Board size			**0.0085**	**0.0051**	**0.0041**
t			2.209	1.301	1.080
p-value			0.027	0.193	0.280
slope			0.060	0.036	0.029
Sales				**3.5E-06**	**3.6E-06**
t				3.442	3.440
p-value				0.001	0.001
slope				0.000	0.000
Tobin's Q					**-0.0141**
t					-1.580
p-value					0.114
slope					-0.100
ROA					**-0.0038**
t					-2.641
p-value					0.008
slope					-0.027
# of observations	1408	1137	1137	1135	1119

Note: Values are for fiscal year 1998. The sample is composed of data from publicly traded firms. Sample size varies due to data availability. See text for details on sample selection. The Poisson distribution implies:

$$E\left[y \,\middle|\, \mathbf{X}\right] = \exp\{\boldsymbol{\beta}' \mathbf{X}\}$$

where y is the number of board meetings, **X** is a vector of firm characteristics (always including the proportion of women) and $\boldsymbol{\beta}$ is a vector of coefficients. The method of estimation is maximum likelihood. A heteroscedascity-consistent variance-covariance matrix is used. The reported "slope" is the marginal increase in the predicted number of meetings due to an infinitesimal increase in the respective independent variable. Slopes are calculated at the means of the data. All regressions include 2-digit industry dummies.

Workplace Diversity and Incentive Contracts: Extensions

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Abstract

This is a collection of extensions of the model developed in "Workplace Diversity and Incentive Contracts: Theory and Evidence", which is my job market paper. Please go to http://home.uchicago.edu/~dsferrei to download a copy of that paper.

A IC versus IR Constraints Effects

There can be two different effects of group loyalty on the optimal contract. One operates through the incentive compatibility constraint: more loyalty makes workers more willing to exert effort. This is the one I have been focusing so far. The other operates through the individual rationality constraint: individuals may value group loyalty per se. The utility function (6 in the main paper) allowed us to isolate the IC effect from the IR effect; by construction, group loyalty is neither a good nor a bad in utility (6 in the main paper).

In this section I consider the case in which group loyalty may have level effects; i.e., it might scale the egoistic utility up or down. Let us start with the (reduced-form) utility

$$U_i = u_i \left[-u_j\right]^{\alpha} \tag{1}$$

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It can be shown that with this utility function the optimal contract is

$$a_L^* = a^*, e_L^* = e^*, b_L^* = b^* - \alpha w_0, V_L^*(\alpha) = V^*(\alpha) + 2\alpha w_0$$

where the subscript L denotes the use of the level-effects utility. Now, all previous results hold with the important exception of part 1 of Proposition 1: work force homogeneity has value even in the absence of uncertainty. The intuition should be straightforward: functional form (1) makes homogeneity a *good*, therefore more homogeneity means that workers are willing to work for less pay, which of course makes the manager better off.

One of the nice features of the set up in this paper is that it allows us to completely separate the role of group loyalty in its effects on the IC and on the IR constraints. The enhancement of group loyalty among the members of a team can increase principal's profits in two ways. First, it fosters cooperation among team members, which increases their willingness to exert effort. This benefits the principal because it slacks agents' incentive compatibility (IC) constraints. Second, it increases non-pecuniary benefits from working in that team, thus workers are happy to work for less pay. This benefits the principal because it slacks agents' individual rationality (IR) constraints. With utility function (6 in the main paper), group loyalty does not affect workers IR constraints, therefore all benefits from work force homogeneity come from its effects on workers incentives to cooperate. When uncertainty is zero, cooperation is achieved through contracts, so work force homogeneity has no value. With utility function (1), group loyalty affects workers' IC constraints in the same way that (6 in the main paper) does, but it has an extra effect on workers' IR constraints: it reduces principal's required equivalent wage payment by $2\alpha w_0$. Therefore, profits with level effects equal profits without level effects plus the IR effect:

$$V_L^*(\alpha) = V_N^*(\alpha) + 2\alpha w_0 \tag{2}$$

B Comparison with Partnerships

In this section I analyze the case of partnerships and compare it with the results derived above. To simplify the problem, I assume right away that both individuals are identical and that they equally share the surplus. Worker i certainty equivalent is given by

$$CE_i = \frac{1}{1+\alpha}\left[\frac{1}{2}(1+\alpha)(e_1+e_2) - \frac{k}{2}e_i^2 - \alpha\frac{k}{2}e_j^2\right] - \frac{r}{8}\sigma^2 \tag{3}$$

The first order condition for e_i in a Nash equilibrium is

$$e_i = \frac{(1+\alpha)}{2k} \tag{4}$$

Plugging it back in (3), we have

$$CE_i = \left[\frac{4(1+\alpha) - (1+\alpha)^2}{8k}\right] - \frac{r}{8}\sigma^2 \tag{5}$$

or

$$CE^* = -\frac{1}{8}\frac{\alpha^2 - 2\alpha - 3 + kr\sigma^2}{k} \tag{6}$$

provided that $CE^* \geq CE_0$ (the reservation certainty equivalent). If $CE_0 \geq 0$, a necessary condition for participation is $\left(-\alpha^2 + 2\alpha + 3\right) \geq kr\sigma^2$.

What is the effect of group loyalty on workers' surplus? Differentiating (6) with respect to α yields

$$\frac{\partial CE^*}{\partial \alpha} = \frac{1-\alpha}{4k} > 0 \tag{7}$$

Therefore, the agents' surplus increases with group loyalty, as expected. The interesting thing to notice is that, unlike the proprietorship case, uncertainty has no effect on the marginal value of group loyalty. The intuition is that contractibility is not increased with lower uncertainty in this case, therefore there is no substitution of contracts for group loyalty when uncertainty is reduced.

However, risk also affects the IR constraints. Therefore, more risk requires more group loyalty for agents to participate, so we have the following result:

Proposition 1 *In partnerships, risk and diversity are negatively related.*

C An Alternative Model

My main result on learning says something like that: "When workers are expected to be similar, the principal will choose to prevent learning, and when they are expected to be different, she will choose to promote learning". In short, diversity breeds learning. The goal here is to obtain this result without relying on two assumptions that I have used so far: (1) altruism (group loyalty) depends on expected distance and (2) private information about own types does not affect expected distance. Here I make the assumption that altruism is *equal* to similarity (which depends negatively on distance), therefore when distances are not known, altruism is a source of risk. Also, in the framework I develop below, agents' privately known types (usually, but not always) affect their expected distances.

In order to solve this problem without the previous simplifying assumptions, I had to give up using Holmstrom-Milgrom's model and to adopt a more conventional Grossman-Hart-type of model. There are two agents, one principal, two actions and two outcomes. Utilities are interdependent as before and they depend on the distance between agents. There are also two types in the population, and every agent knows only her own type and the type distribution. After workers are hired, the principal can choose an amount of learning (in this case, the amount of learning is a probability of learning each other's type).

Model

There are two types of persons in the population: R (right-winged) and L (left-winged). Both R and L are real numbers. The proportion of right-winged people in the population is r.

The firm hires two workers. Workers' utilities are interdependent:

$$V_i = (1 - \alpha_i) U_i + \alpha_i U_j \tag{8}$$

where u_i is the standard "egoistic" utility function:

$$U_i (w_i, e_i) = u (w_i) - e_i \tag{9}$$

where w is money and e is effort, and $u' > 0$, $u'' < 0$. In this set up, it is easier to interpret the results when $0 < \alpha < 1$.

Group loyalty is a function of similarity (distance)

$$\alpha = h - d(i, j) \tag{10}$$

where h is a positive real number and $d(i, j)$ is the euclidean distance between types i and j. Notice that d is a natural measure of diversity.

There are only two levels of effort: $e = e_H > e_L = 0$. There are two possible outcomes: G and B. The firm prefers G to B. High effort by both agents increases the probability of the good state: $p_{HH} > p_{HL} \geq p_{LL}$.

When workers interact, they learn each other's type with probability q. Revenue is a function of states: $\Pi_G > \Pi_B$. Principal offers the contract $\{w_G, w_B, q\}$.

It is assumed that the principal cannot control the fraction of R and L people that applies to the firm. I assume that advertising contracts is costly, therefore workers apply to firms before they know which contracts they would get (this is to prevent firms from using contracts to screen people of a given type only).

In what follows, I will initially assume that learning has no direct costs to the firm. Therefore, the firm will always choose either $q = 0$ or $q = 1$. In the case in which learning has costs, we could have $0 < q < 1$. This case is a trivial extension of the case of zero costs and will be ignored for simplicity. I will also assume for simplicity that $r = \frac{1}{2}$. The analysis is only slightly modified when the proportion of left- and right-winged is not the same.

Results

First, let us think about what would happen if the firm decided to induce low effort, for any agents of any type. In that case, IC can be ignored and the IR for an individual of any type would be

$$p_{LL} u_G + (1 - p_{LL}) u_B \geq u_0 \tag{11}$$

where u_G is $u(w_G)$, i.e., the utility of wage in the good state (same for u_B). Notice that α does not affect IR, therefore, the IR is the same regardless of whether agents learn each other's type or not. Thus, we have proved the first result:

Proposition 2 *If the principal does not want to induce effort, group loyalty has no value and learning is irrelevant.*

This is a good check of consistency between this model and my other model. I want a framework in which group loyalty has no intrinsic value for the firm, except through its effects on the IC constraints. When there are no incentive problems, ICs don't bind and group loyalty (and learning) has no value. This result comes from my assumption on utilities (i.e., no level effects).

Let us now look at the case in which the principal wants both types (i.e., matched or unmatched types) to exert high effort. There are two ways she can do that: allowing for learning or not allowing for learning.

Case 1: Learning. I am assuming full learning $(q = 1)$. Therefore, after workers learn each other's types, they know that their group loyalty parameter is either h or $h - d$. In a Nash equilibrium, they also know what the other agent knows. The firm offers the contract $\{w_G, w_B, q = 1\}$ before learning occurs. Agents take actions after learning occurs. Therefore, the relevant IC constraints are the interim ones (after types are known) but the relevant IRs are ex ante (before types are known). Qualitative results do not change if we work with interim IRs too.

IC constraints are:

$$p_{HH}(u_G - e_H) + (1 - p_{HH})(u_B - e_H) \geq p_{HL}(u_G - he_H) + (1 - p_{HL})(u_B - he_H) \tag{12}$$

$$p_{HH}(u_G - e_H) + (1 - p_{HH})(u_B - e_H) \geq p_{HL}(u_G - he_H + de_H) + (1 - p_{HL})(u_B - he_H + de_H) \tag{13}$$

IR constraint is (for both types)

$$p_{HH}(u_G - e_H) + (1 - p_{HH})(u_B - e_H) \geq u_0 \tag{14}$$

Profits are:

$$p_{HH}\left(\Pi_G - 2w_G\right) + \left(1 - p_{HH}\right)\left(\Pi_B - 2w_B\right) \tag{15}$$

Case 2: No learning. In this case, all constraints are in the ex ante stage.

The IC constraint is

$$p_{HH}\left(u_G - e_H\right) + \left(1 - p_{HH}\right)\left(u_G - e_H\right) \geq$$

$$\frac{1}{2}\left[p_{HL}\left(u_G - he_H\right) + \left(1 - p_{HL}\right)\left(u_B - he_H\right)\right] + \frac{1}{2}\left[p_{HL}\left(u_G - he_H + de_H\right) + \left(1 - p_{HL}\right)\left(u_B - he_H + de_H\right)\right] \tag{16}$$

The IR constraint is:

$$p_{HH}\left(u_G - e_H\right) + \left(1 - p_{HH}\right)\left(u_B - e_H\right) \geq u_0 \tag{17}$$

Profits are:

$$p_{HH}\left(\Pi_G - 2w_G\right) + \left(1 - p_{HH}\right)\left(\Pi_B - 2w_B\right) \tag{18}$$

Comparison between the two cases.

Notice that in case 1, the IC in (12) is redundant, since it is implied by the IC in (13). In case 2, the IR is the same as in case 1 and the IC in (16) is less restrictive than the one in (13). Therefore, since in both cases the principal is inducing the same amount of effort, she could be no worse under case 2 than she would have been under case 1. Therefore, we have proved that

Proposition 3 *If the principal chooses to induce both agents to exert high effort, regardless of whether their types match or not, she should prevent learning.*

The intuition here is that there is nothing to gain from allowing workers to learn about each other: they will exert high effort anyhow, but the principal will have to pay them more in case they find their types don't match.

When not everyone works hard

Therefore, we can conclude that the only case in which learning may have any value is when the principal would like to induce high effort when types match (because then it costs her little to do so) but low effort when types do not match (because then it costs her a lot to do so). We can already predict the result: learning will be better when it costs a lot to induce high effort from agents with different types. That is, learning is more valuable when diversity is high, which is the result I am trying to prove. It is actually remarkably simple to prove that.

If the principal wants to induce high-effort only when types match (after learning), only the IC for high-loyalty people is relevant:

$$p_{HH}\left(u_G - e_H\right) + \left(1 - p_{HH}\right)\left(u_B - e_H\right) \geq p_{HL}\left(u_G - he_H\right) + \left(1 - p_{HL}\right)\left(u_B - he_H\right) \tag{19}$$

The IR constraint when learning is allowed is:

$$\frac{1}{2}\left[p_{HH}\left(u_G - e_H\right) + \left(1 - p_{HH}\right)\left(u_B - e_H\right)\right] + \frac{1}{2}\left[p_{LL}u_G + \left(1 - p_{LL}\right)u_B\right] \geq u_0 \tag{20}$$

Profits are

$$\frac{1}{2}\left\{p_{HH}\left(\Pi_G - 2w_G\right) + \left(1 - p_{HH}\right)\left(\Pi_B - 2w_B\right)\right\} + \frac{1}{2}\left\{p_{LL}\left(\Pi_G - 2w_G\right) + \left(1 - p_{LL}\right)\left(\Pi_B - 2w_B\right)\right\} \tag{21}$$

We can see right away why the result will hold: profits do not depend on the diversity parameter d in this case. This happens because, when diversity matters (when types don't match), the principal chooses not to induce effort, therefore the relevant IC constraints are not affected by d.

Let Π_l denote profits when learning is allowed. We already know that Π_l is invariant to changes in d. Let Π_{nl} denote profits when learning is not allowed. With little algebra (actually by solving for the optimal contract) it can be shown that Π_{nl} is monotonically decreasing in d. Therefore, we have proved our main result

Proposition 4 *Learning is relatively more valuable when diversity is expected to be high; i.e.,*

$$\frac{\partial\left(\Pi_l - \Pi_{nl}\right)}{\partial d} > 0 \tag{22}$$

A minor point: I have not shown that Π_l will ever be greater than Π_{nl}. What if, for example, $\lim_{d\to\infty}\Pi_{nl} > \Pi_l$? The proposition above will still be true, but empirically irrelevant: learning should never occur. While one cannot rule out this possibility for all sets of parameters, it can be shown that learning may be optimal for most reasonable cases. In particular, with suitable assumptions on the third derivative of the utility function, it can be shown that $\lim_{d\to\infty}\Pi_{nl} = -\infty$, therefore we will have that for low values of d, learning is unambiguously better, while for high values of d, the "no-learning" contract is better.

D Learning with Many Periods

The insights from the case outlined above can be extended to the general case in which $T \geq 1$. The updating rule has two standard results that are important for the current problem. First, since true similarity do not change, the law of large numbers implies that

$$\lim_{t\to\infty}\widehat{\gamma}_{t+1} = \gamma \tag{23}$$

That is, the "perceived similarity" converges to its true value. As time passes, workers will eventually know each other's true values with an arbitrarily high precision.

Second, one can rewrite (29 in main paper) as

$$\sigma_{t+1}^2 = \frac{\sigma_u^2}{\sigma_t^2+\sigma_u^2}\sigma_t^2 \tag{24}$$

which implies that the variance of the prediction will converge to zero and, more importantly, that the speed of convergence is negatively related to σ_u^2.

Therefore, the organization of work has an extra effect in the multi-period case: it affects the speed of convergence of the learning process. To see this, let us assume that the sequence $(\omega_1, ..., \omega_T)$ has to be chosen in $t = 0$. The Bellman equation for this problem is (after some manipulation)

$$J(\omega_{t-1}) = \max_{\omega_t} E\left\{V^*\left[\widehat{\gamma}_t + h_t(s_t - \widehat{\gamma}_t)\right] - C\left(\frac{\omega_t}{\omega'}\right) + \beta J(\omega_t)\right\} \tag{25}$$

$$\frac{\omega_t\sigma_{t-1}^2}{\sigma_{t-1}^2(\omega_t+\omega_{t-1})+1} = h_t \tag{26}$$

The first-order condition is

$$E\left\{\frac{\partial h_t}{\partial \omega_t}\left(s_t-\widehat{\gamma}_t\right)V^{*\prime}\left(\widehat{\gamma}_{t+1}\right)-\frac{1}{\omega'}C'\left(\frac{\omega_t}{\omega'}\right)+\beta J'\left(\omega_t\right)\right\}=0 \tag{27}$$

where

$$\frac{\partial h_t}{\partial \omega_t}=\frac{\left(\sigma_{t-1}^2\omega_{t-1}+1\right)\sigma_{t-1}^2}{\left[\sigma_{t-1}^2\left(\omega_t+\omega_{t-1}\right)+1\right]^2} \tag{28}$$

How does (27) compare to the first order condition for the one-period case (**??**)? Since $\omega_{-1}=0$ and $\sigma_{-1}^2=\sigma_0^2,$ we see that (27) differs from the one-period first-order condition by the additional term $E\left[\beta J'\left(\omega_t\right)\right]$, which reflects the effect of changing the level of interaction today on expected future profits. From the envelope condition we get

$$J'\left(\omega_t\right)=E\left\{\left[\frac{\partial h_{t+1}}{\partial \omega_t}\left(s_{t+1}-\widehat{\gamma}_{t+1}\right)+\left(1-h_{t+1}\right)\frac{\partial h_t}{\partial \omega_t}\left(s_t-\widehat{\gamma}_t\right)\right]V^{*\prime}\left(\widehat{\gamma}_{t+2}\right)\right\} \tag{29}$$

where

$$\frac{\partial h_{t+1}}{\partial \omega_t}=-\frac{\omega_{t+1}\left(\sigma_t^2\right)^2}{\left[\sigma_t^2\left(\omega_{t+1}+\omega_t\right)+1\right]^2}<0$$

Therefore, the Euler equation can be written as

$$E\left[\upsilon_t\left(s_t-\widehat{\gamma}_t\right)V_t^{*\prime}\right]=\frac{1}{\omega'}C'\left(\frac{\omega_t}{\omega'}\right)+\beta E\left\{\left[\phi_{t+1}\left(s_{t+1}-\widehat{\gamma}_{t+1}\right)-\psi_{t+1}\upsilon_t\left(s_t-\widehat{\gamma}_t\right)\right]V_{t+1}^{*\prime}\right\} \tag{30}$$

where

$$\upsilon_t=\frac{\partial h_t}{\partial \omega_t},\ \ \phi_{t+1}=-\frac{\partial h_{t+1}}{\partial \omega_t},\ \ \psi_{t+1}=1-h_{t+1}$$

It can be shown that

$$\phi_{t+1}\psi_t-\psi_{t+1}\upsilon_t<0 \tag{31}$$

which implies the future gains from increasing precision today more than offset the losses from slower convergence from $t+1$ on. (It is important to notice that the final effect of an increase in precision today on the speed of convergence is positive: the faster convergence implied by increased precision today more than compensate the decrease in speed in the following periods).

Therefore, we arrived at a final intuitive conclusion: when workers interact for many periods, promoting socializing is even more beneficial when true similarity is high, and, by the same token, avoiding socializing is even more beneficial when similarity is small. Repeated interactions between workers in a given firm increases the value of manipulating socializing in the workplace.

E Asymmetric Information

In this section, I study a simple case of asymmetric information: I assume that workers learn each other's type before the principal does. Contrary to Section 4 (in the main paper), I assume that the principal cannot affect learning in the workplace and focus instead on the effects of adverse selection on the value of homogeneity.

For simplicity, suppose that there are only two types in the population: v_1 and v_2, with proportions q and $(1-q)$ respectively. Therefore, randomly selecting two workers from this population will give the manager a homogeneous work force with probability $p = q^2 + (1-q)^2$. Let us assume that, after being hired by the firm, workers learn each other's types. If their types match, they display high group loyalty (the loyalty coefficient is h). If types do not match, the loyalty coefficient is $l < h$.

The question is whether the manager learns workers' types at the same time or after workers do. If the manager learns workers' types before offering them the contract, the optimal contract is like the one described in section 3 (in the main paper). Therefore, ex ante expected profits are

$$EV^* = (1-p)\,V^*(l) + pV^*(h) \tag{32}$$

When the manager has to offer the contract after workers learn types but before she does, a private information problem arises. There is an incentive for high-loyalty teams to pretend that they are low-loyalty teams, as we can see from the following Lemma:

Lemma 1 *If high-loyalty teams accept the optimal contract intended for low-loyalty teams, they will get a strictly positive surplus.*

This lemma shows that if the manager wants to separate types by offering two different contracts, the incentive compatibility constraint for the high type in this adverse selection problem has to bind (I will use the notation IC_l^A and IC_h^A to denote the IC constraints for low and high types in the adverse selection problem). This is a standard adverse selection problem, in which it is easy to show that IC_l^A and IR_h do not bind, while IR_l and both IC's from the moral hazard problem do. If there is separation, ex ante expected profits are

$$EV_s^* = (1-p)\, V^*(l) + p\left[V^*(h) - w^i\right] \tag{33}$$

Where

$$w^i = (1+l)^2 \frac{(1-l)^2 - (1-h)^2}{(r\sigma^2 k + 1 + 2l + l^2)^2\, k} > 0 \tag{34}$$

is the information rent of the high-loyalty agents.

Let us assume that separation of types is optimal. Say now that p is not given, but rather a function of how much the manager spends in recruiting R. The more the manager spends in recruiting, the more likely she will get a homogeneous work force; that is, $\frac{dp}{dr} > 0$. Then, it follows immediately that

Proposition 5 *Work force homogeneity is more valuable when the manager learns types before she has to offer the contracts; i.e.,*

$$\frac{dEV^*}{dR} = p'\left[V^*(h) - V^*(l)\right] > p'\left[V^*(h) - V^*(l) - w^i\right] = \frac{dEV_s^*}{dR}$$

This implies not only that profits will be lower under adverse selection, but also that expenditures in recruiting and work force homogeneity will be lower when adverse selection is present.