Diversity: The Demand for Differential Expert Opinion *

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Abstract

Experts are characterized by their exclusive access to particular knowledge areas, and by specialized vocabularies which refers to those knowledge areas. Firms may choose decision-making teams with different types of experts - diverse teams - because good decision-making typically requires more than one type of information. But diversity acts directly against the firm's other interests in staffing its decision-making team: (a) having *superb* information about any particular knowledge area and (b) ensuring that information collected by the individual members of a team can be passed easily among them. I demonstrate how information quality, communication problems and uncertainty affect a firm's diversity choice, and extend the basic model to demonstrate the effects of effort exertion. I argue that diversity of any type is amenable to analysis with the model, including diversity of race, gender or ethnicity which are the types most commonly discussed.

keywords: diversity, culture, language, management teams

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1 Introduction

One of the most hotly debated recent issues of recent years has been "diversity" - a term which, despite its inherent vagueness, has come to be commonly understood as"the mixing together of people from different races, genders, ethnicities or cultural groups in places of employment or education."[1]So entrenched is this particular popular understanding that a university or a firm which were to announce a decision to increase diversity would be understood by all to be describing this mixing of various types of people, as distinct from its desire to teach both theoretical and applied physics or, in the case of the firm, to produce both hammers and nails. Despite the popular interest, there is not a good understanding about what diversity does for profit-maximizing firms, nor is there a cogent economic story predicting when it is likely to arise in particular settings. Though diversity is fundamentally an issue of labor demand, there has been virtually no previous analysis by economists of firms' diversity decisions, although some work in the economics of discrimination does discuss related issues. I focus directly on diversity in this paper, which asks: What determines whether firms put together a management staffs with different types of managers?

The large literature outside of economics which studies diversity, in fields such as social psychology and organizational behavior, focuses almost exclusively on racial, cultural and gender diversity and contains virtually no formal modeling of the type done by economists. The large number of issues[2]this work touches on makes it initially difficult to see how one might formally model firms' diversity decisions, but a potential avenue is suggested by a recurrent theme in much of this work. This is the idea that firms benefit from having many different types of people around because of the special information that people from different groups bring. Organizational behavior experts Cox and Blake (1991) describe cases where greater cultural diversity among managers in U.S corporations improved the ability of some firms to market their products to particular groups. They describe the experience of the large cosmetics company, Avon. In the 1980's Avon sought to improve its poor sales performance in U.S. inner city markets. The company increased the representation of blacks on its management boards and a sharp increase in central city sales followed. According

to Cox and Blake, Avon's president attributed a significant portion of his firm's improved marketing effort to the fact that the black managers hired by the firm brought information unique to their cultures into his organization.

Combining this simple idea with a recognition of what managers (the people about whom issues of diversity most arise) do in competitive firms forms the basis of a formal description of all types of diversity in management settings. The principal task of managers in a firm is to engage in decision-making on the firm's behalf. Decision-making in firms is typically a collaborative process because even if a single manager on the staff is charged with decision-making authority (as is true for someone like a CEO), he is unlikely to discharge his responsibility without input from others. Other managers on his staff typically have a strong interest that he make good decisions; often have information relevant to a decision that is to be made; and since they work for the same firm, are relatively easy for him to access. Consultation will therefore tend to occur between decision-makers and other managers, and the process of consultation implies, in turn, that the quality of a firm's decisions depends both on managers to whom decision-making authority falls either by chance or fiat and on other managers who provide information and advice. Because of the collaborative aspect of decision-making, the managerial staff assembled by a firm constitutes a management *team*. And, if the specialized knowledge idea is correct, managers on decision-making teams are individual "information gatherers/processors", characterized by their particular areas of *expertise*.

1.1 Basic Idea

1.1.1 What is an Expert? - Specialized Knowledge

Experts either know more about or can more easily learn about some particular set of things than can other people. For example, accountants and plumbers are identified form two distinct groups of experts precisely because the people who belong to these groups know more than other people about accounting and plumbing, respectively. I operationalize the special knowledge idea in two ways.

One way is through the assumption that there is exclusivity associated with expert knowledge. True experts have access to kinds of information which others (non-experts, or experts

about a different thing) do not. If one knows very much about something, and everyone else also knows very much about the same thing, then one is certainly knowledgeable, but one is not expert in the sense in which the term is used here. Since expertise can be broken up into various distinct spheres of knowledge, information which is sought about any particular sphere can only come from people whose training, skills and experience permit them to access the sphere. But what does it mean to be able to access information from a particular knowledge sphere? At the very least, it means being able, however crudely, to distinguish among phenomena within a sphere. So economists are experts regarding the sphere of knowledge associated with choice under constraints, at least in part, because of their ability to distinguish between production and utility functions. Indeed, if economists could not distinguish among *any* of the functions which fall within the sphere of knowledge called "choice under constraints" it would be difficult to argue that they were actually expert about that sphere at all.

The evolution of the distinct expressions "utility function" and "production function" implies that economists using these expressions can distinguish between these two phenomena in their minds, and anticipate that hearing the two expressions evokes two distinct ideas in the mind of another economist who is listening which are closely related to the two ideas the speaker has in his mind. A non-economist who is listening hears two expressions which refer to things contained within a sphere of knowledge which, given the exclusivity argument, he knows little or nothing about. So hearing these expressions will not, in general, evoke the same two mental images that the speaker has, if they evoke any images at all. All of this is simply another way of saying that the second characteristic of expertise is that experts have a specialized vocabulary to refer to their knowledge and speak what are effectively expertise-specific languages.[3] Cross-expertise information exchange about things related to experts' respective areas of expertise is therefore fraught with *miscommunication*.

This language difference among different types of experts is less obvious than the exclusive knowledge assumption, but brief reflection evinces its reasonableness - at least with respect to expertise which derives from education or training. Every-day interactions with experts such as lawyers, mechanics, doctors or even professors often leave the listener confused as to

the meaning of various expressions these persons use.[4]More familiarly, economists certainly find it easier to communicate their information to others of their kind. Terms such as "Coase Theorem" or "marginal" mean very specific things to economists, in a way that other terms do not perfectly capture. Of course, these same terms mean slightly different things to other people (or else are totally incomprehensible), be those other people anthropologists, sociologists or surgeons.

If these two features are all that define expertise then expertise can come from many sources; education and training are merely the most obvious. Another source may be a person's life experiences as delimited his racial, ethnic or cultural identity. People from different cultures are often differentially informed about particular phenomena simply because information is available in particular places or from particular people with whom members of different cultural groups have differential contact. More generally, to the extent that a person's life experiences are shared with people from his culture, then the information held by any individual member of a culture makes him an expert about things related to that culture in a way that others are not.

In linguistics and sociology there is in fact a literature which argues that communication problems exist when members of different cultural groups interact. Tung (1988) has found that people in a business setting who come from different racial or cultural different groups do not process or interpret information the same way. Morishima (1981) finds that there are communication difficulties which surround the differential use of eye-contact between certain Asian and other cultures. A large literature in linguistics shows that members of different cultural groups speak what amount to different dialects, even though they may technically be classified as speakers of the same language. A portion of this literature even argues that men and women speak what are effectively different languages (Tannen, 1991). These examples show a link between group and cultural affiliation and at least one of the two features which I argue define expertise, and reiterate the point that training need not be the sole source of expertise.

Although economists have not written much about either diversity or expertise, some have used the idea that agents' group affiliations either determine their language or provide

them with specialized knowledge. Lang (1986) uses the argument that cultural identity is associated with communication problems in a model to explain persistent wage differentials between blacks and whites. In his model, white entrepreneurs who need to understand their employees are forced to pay a translations costs only if they hire blacks, so the wages received by blacks are lower in a zero-profit environment. Lang provides an exhaustive review of evidence from linguistics which strongly support his idea that blacks and whites belong to different speech communities. Others have argued that cultural identity imparts specialized knowledge. Cornell and Welch (1996) are rare in that they make the specialized knowledge assumption explicit and the center-piece of their analysis. In their paper, black and white employers are better able to judge ability for job applicants of their own race than for those of other races because of shared cultural traits. This assumption in their model is similar in flavor to the statistical discrimination models of Arrow (1974), Phelps (1972) and Cain and Aigner (1977) where firms are presumed to assess the true productivity of blacks with greater error than for whites because the tests to gauge ability are more reliable for whites than for blacks. These models have the implicit assumption that there is such a thing as "race-specific talent-spotting expertise", though only the piece by Cornell and Welch come close to calling it that.

1.1.2 Decision-Making by Groups of Experts and the Diversity Decision

I consider a management situation in which a firm's two[5] managers collaborate before one of them makes a decision on the firm's behalf. The identity of the decision-maker is determined by a random process outside the firm's control,[6] though the owner of the firm has complete control over staffing. Any problem the leader is called upon to confront will likely have the feature that its appropriate resolution depends on knowledge about a number of variables which are outside the ability of anyone to control, and which assume values that no-one knows at the time that the decision is made.[7] These variables combine to form a stochastic effect, or what I shall call the state of the world. The leader tries to guess the state of the world using information which he himself procures and what he understands from information his colleague passes along to him before he makes a decision.

The quality of the leader's decision is higher the better his information about the likely state of the world. His information is better when he knows something about more rather than fewer variables which determine the state of the world and the better informed he is about any *particular* (set of) variable(s). Unfortunately, the owner who puts the management team cannot simultaneously satisfy both of these conditions by his team choice because there are generally only a finite number of management slots to be filled. If he chooses a team consisting entirely of one type of expert (henceforth called a homogeneous team), a decision-maker will know a great deal about a single variable, but at the cost of knowing nothing about other variables. On the other hand, the choice of a team with different types of experts (henceforth a diverse team) ensures that a decision-maker will know something about all of the variables which determine the state of the world, but the limited information he has about each means that he is not as well informed about any particular variable as would otherwise be true. This is the basic tradeoff a firm considers when deciding between a diverse manager workforce and one in which only one type of expertise is represented.

Apart from this basic tradeoff the owner considers the negative effects of miscommunication in diverse settings. When experts collaborate to make decisions, miscommunication is costly. Someone skeptical of this proposition might ask: Could not one expert indicate to another that he does not perfectly understand the second person's communication to him? And then, could they not then jointly engage in a process of clarification? The problem is that the quality of decisions in a market setting is often related to the timeliness in which they are made. Making good decisions often means not only discerning the correct policy, but doing so *quickly*. Since clarification will nearly always take time and other resources, then miscommunication will always be costly. Alternatively, one might ask: Couldn't an expert always state his information in such a way as to ensure that even non-experts could always understand him? This proposal fails to recognize that expertise-specific jargon or vocabulary *means* something. Statements devoid of these expressions may indeed be comprehensible but surely mean something less - which is to say they are of poorer informative quality. A diverse team means that the leader will not perfectly understand the information passed along to him, whereas if the team is homogeneous the owner can be assured that this problem will

not arise.

Diversity or homogeneity arises after the owner has engaged in a simple problem of constrained optimization: he seeks to maximize the quality of decision-making by hiring expert-managers to fill a finite number of managerial slots, weighing the considerations mentioned above. In the model below, I formally show how information quality, underlying variable uncertainty and communication difficulties affect the firm's decision. In an extension to the basic model, I analyze in turn how the results are affected if experts are able to modify the quality of their information and the ease with which others understand them by exerting effort.

Given its focus on decision-making, the paper is somewhat related to work in economics which examines the fallibility of human decision-makers and the optimal organizational structure in firms in the face of that fallibility. Stiglitz and Sah (1990) assume that managers all make a particular type of decision-making error, and ask what the optimal structure of the organization is in the face of those errors. Sah (1990) examines the optimal acceptance rule in committees of various sizes. In both pieces, all of the managers are the same in the models so the papers do not discuss the importance of *who* the various decision-makers are which is the central point of this paper. Also, whereas fallibility stems from a manager's inability to perfectly assess the true value that is to be derived from pursuit of a given policy in both my paper and in the previous work, an explicit explanation for fallibility - in the form of expertise - is given here. I argue that fallibility stems from two sources: the fact that information is imperfect about any particular aspect of policy and the fact that, even if information were perfect, a manager would only know about one aspect of a policy because of the limitations of expertise. A final difference is the prominent role of miscommunication in this paper. The idea that decision-making could be improved if communication were possible is implicit in the previous work. This paper illustrates why, even if communication were technically possible, miscommunication can contaminate the information the people receive.

Lazear (1998) examines diversity in the context of immigration policy. The paper asks: Should the United States encourage the in-migration of people from different countries? The paper makes explicit the reasonable assumption that a diverse country is one in which there

is greater opportunity for people to be more creative, but also is one where people are likely to come across someone with whom it is not possible to trade because of differences in language. This paper analyzes a very different environment that the one considered in the present study, and does not formally model expertise and miscommunication. Nor does it analyze effort incentives in a firm. Lazear (1999) analyzes the formation of "global firms" - entities which consists of workers from different cultures. Possible communication problems play a important role in this analysis, the impact of miscommunication is modeled differently in the present paper.

The remainder of the paper is organized as follows. Section 2 presents the basic model and results. Section 3 extends the model to consider the possibility that experts can vary effort levels, and Section 4 discusses and concludes.

2 Basic Model

2.1 Uncertainty, Decision-Making and Payoffs

Consider a firm which has to fill two management positions. Which of the hired managers will actually have to confront a problem is out of the firm's hands. The manager who is actually called upon by fate to make a decision consults with the others, gathers information himself, and, finally, makes a decision about what action the firm should take in order to deal with the problem.

The quality of a leader's decisions depend on how much they depart from the state of the world. A convenient formulation for demonstrating this assumes that for a state of the world z and an action a chosen by the leader,the firm suffers a loss of

$$L = (a - z)^2. \tag{1}$$

The state of the world depends on more than one variable. Specifically,

$$z = \gamma_x x + \gamma_y y, \tag{2}$$

where $\gamma_x \geq 0$, $\gamma_y \geq 0$, and $\gamma_x + \gamma_y = 1$. If the variables x and y are uncorrelated random variables with 0 means and variances given by σ_x^2 and σ_y^2 respectively, z is a random variable

with

$$E[z] = 0 \quad \text{and} \quad V(z) = \gamma_x^2 \sigma_x^2 + \gamma_y^2 \sigma_y^2 \tag{3}$$

where $V(.)$ means variance. Uncertainty about the values which z might take is summarized by the size of the variance in (3): the $\gamma's$ measure the relative sensitivity of the state of the world to realizations of the two variables, and σ_x^2 and σ_y^2 measure the inherent variability of x and y.

2.2 Experts, Information and Communication

Possible managers belong to one or the other of two expert communities, : type-X and type-Y experts observe information on the variable associated with their particular area of expertise. Specifically let each expert observe the result of a single draw from one or the other of the noisy but unbiased information sources

$$\begin{aligned} t_{ix} &= x + \theta_{ix} \\ t_{iy} &= y + \theta_{iy}. \end{aligned} \tag{4}$$

The variables θ_{ix} and θ_{iy} represent measurement errors which, for simplicity, I assume have mean 0 and variances m_x^2 and m_y^2, respectively and are uncorrelated across people.

Assume that the communication problems which characterize cross-expertise information-exchange take the very simple form that whenever people who speak different expert languages communicate, the listener's understanding of any statement is the speaker's statement, plus some random noise. If we call the statements made by X and Y-experts after they have accessed information s_x and s_y respectively the associated understanding created in the mind of listener, U_{ij} upon receipt of a statement made by person j $(j \in X, Y)$is:

$$U_{ij} = U_i(s_j) = \begin{cases} s_j, & \text{if } i \in X, j \in X, \text{ or } i \in Y, j \in Y \\ s_j + \eta_{ij} & \text{if } i \in X, j \in Y, \text{ or } i \in Y, j \in X \end{cases} \tag{5}$$

The parameters η_{ix} and η_{iy} are uncorrelated mean-zero communication errors, with variances V_{η_x} and V_{η_y}, which measure how hard it is, on average, to understand the statements of a particular type of expert.

Managers always honestly report their information in the model,[8]so if one X-expert were to communicate his information to an another, the second expert receives information exactly equal to the first expert's. There is no randomness associated with information exchange between two X-experts about the information that one of them has, so with collaboration an X-expert's understandings about x consists of two independent draws from the same information source, t_x. If an X-expert were to communicate his information to a Y-expert, the second expert's understanding about x would not, in general, be equal to the x-advisor's report. Instead, it is a random variable drawn from a distribution which has the x-advisor's true report as its mean and has variance of V_{η_x}. So while an expert of a given type would not have *any* information about a variable outside of his area of expertise without cross-expertise consultation, the information consultation provides is more noisy than that available from the true information source associated with that variable. There are two sources of noise in an expert's information about a variable which lies outside his area of expertise: the part associated with the measurement error of the underlying signals and the noise associated with communication problems. Specifically, information about a variable outside of his area of expertise comes from one or the other of

$$\tilde{t}_{ijx} = x + \theta_{ix} + \eta_{ix} \tag{6}$$
$$\tilde{t}_{ijy} = y + \theta_{iy} + \eta_{iy}.$$

In the context of the team, a manager's information at the time he chooses an action, I_j, $j \in X, Y$ is therefore one or the other of the set of understandings given by

$$I_x = \begin{cases} t_{1x}, t_{2x} & \text{if homogeneous team} \\ t_{1x}, \tilde{t}_{1y} & \text{if team diverse} \end{cases}$$

$$I_y = \begin{cases} t_{1y}, t_{2y} & \text{if homogeneous team} \\ \tilde{t}_{1x}, t_{1y} & \text{if team diverse} \end{cases}$$

2.3 The Leader's Best Action

When the firm suffers a loss of L, suppose that each manager suffers a reduction in his reputation which causes his lifetime expected compensation to fall by L. Managers attempt to minimize this reputation costs and so have identical interests to the firm's. Since he seeks to minimize (1), the leader's best policy is to always choose an action which is equal to his conditional expectation of the state of the world. This optimal action, a^*, is

$$a_j^* = E[z|I_j] = \gamma_x E(x|I_j) + \gamma_y E(y|I_j) \tag{7}$$

for a type-j ($j \in X, Y$) leader. The firm's expected *total uncertainty loss* with a particular type of expert as leader is

$$E_{I_j}(z - E(z|I_j))^2, \tag{8}$$

which is the variance of the state of the world, conditional on the leader's understandings or $V(z|I_j)$. If x and y are independent as I assume given the disjoint nature of expertise , the conditional variance is

$$V(z|I_j) = \gamma_x^2 V(x|I_j) + \gamma_y^2 V(y|I_j). \tag{9}$$

2.4 Conditional Variances

The conditional variances are functions of the inherent variability of x and y; how noisy information used by the leader happens to be; and on the noisiness of communication. In fact, since the only effect of miscommunication in the model is to raise the noisiness of the information available about a variable above the noisiness of the underlying information source, define the parameters M_x and M_y which are the *effective variances* of information available to a decision-maker, and are given by

$$M_x = \begin{cases} m_x^2, & \text{if } D_x = 1 \\ m_x^2 + V_{\eta_x} & \text{if } D_x = 0 \end{cases} \tag{10}$$

and

$$M_y = \begin{cases} m_y^2, & \text{if } D_x = 0 \\ m_y^2 + V_{\eta_y} & \text{if } D_x = 1 \end{cases} \tag{11}$$

where the indicator variable $D_x = 1$ if the decision-maker is an x-expert. The various conditional variances are

$$\begin{aligned} V(x|I_x) &= V_{I_x}^x\left(\sigma_x^2, M_x, n_x\right) = V_{I_x}^x\left(\sigma_x^2, m_x^2, n_x\right) \\ V(x|I_y) &= V_{I_x}^x\left(\sigma_x^2, M_x, n_x\right) = V_{I_y}^x\left(\sigma_x^2, m_x^2 + V_{\eta_x}, n_x\right) \\ V(y|I_y) &= V_{I_y}^y\left(\sigma_y^2, M_y, n_x\right) = V_{I_y}^y\left(\sigma_y^2, m_y^2, n_x\right) \\ V(y|I_x) &= V_{I_y}^y\left(\sigma_y^2, M_y, n_x\right) = V_{I_x}^y\left(\sigma_y^2, m_y^2 + V_{\eta_y}, n_x\right) \end{aligned}$$

For any $V_{I_k}^j$, $k = (x, y)$, $j = (x, y)$, I assume that

$$0 < \frac{\delta V_{I_k}^j}{\delta \sigma_j^2} < 1, \quad \frac{\delta V_{I_k}^j}{\delta M_j} > 0, \text{and } \frac{\delta V_{I_k}^j}{\delta n_j} < 0. \tag{12}$$

These assumptions are all consistent with common sense and say, in turn, that irrespective of which type of expert is making the decision, a variable's conditional variance is: (i) larger the more inherently variable the variable happens to be, and is never as large as when there is no information whatsoever to be had about the variable; (ii) larger the worse the quality of the information about the variable the decision-maker happens to be using; and (iii) smaller the more pieces of information a decision-maker has about the variable. Subsumed in the assumption about information quality is the fact that changes in the communication error V_{η_j} raise the conditional variance of the variable j if and only if someone other than a type j-expert is the decision-maker, and have no effect on the conditional variance otherwise. I assume also that:

$$\frac{\delta V_{I_k}^j}{\delta \sigma_j^2 \delta \sigma_j^2} < 0 \quad \frac{\delta V_{I_k}^j}{\delta \sigma_j^2 \delta M_j} > 0 \quad \frac{\delta V_{I_k}^j}{\delta \sigma_j^2 \delta n_j} < 0 \quad \frac{\delta V_{I_k}^j}{\delta n_j \delta n_j} > 0 \quad \frac{\delta V_{I_k}^j}{\delta M_j \delta M_j} < 0. \tag{13}$$

These assumptions say in turn that the increment to a variable's conditional variance caused by an increase in its underlying variability σ_j^2 is smaller the larger σ_j^2 is already; is larger the more noisy is the information used by the decision-maker M_j; and is smaller the greater

the number of people there are gathering information about that variable on the team, n_j. The reduction in the conditional variance which results from an increase in the number of people gathering information about the variable is smaller the greater the number of people already gathering information about the variable and, finally, a worsening in the quality of information causes the conditional variance to rise by a smaller amount the worse information is already.[9] Since having *any* information about a variable will improve one's estimate about values that variable might take, it follows by (13) that

$$(14) \quad \sigma_j^2 > V(j|n_j = 1, M_j = m_j^2 + V_{\eta_j}) > V(j|n_j = 1, M_j = m_j^2) > V(j|n_j = 2, M_j = m_j^2)$$

In general the second derivative

$$\frac{\delta V_{I_k}^j}{\delta M_j \delta n_j}$$

is of ambiguous sign. The clearest way to see this is to consider a change in n_x for different values of information quality. Suppose that M_x is very small. Adding another piece of information (raising n_x) would do very little to lower the person's uncertainty about x; adding more information which simply confirms what the decision-maker already knows for certain cannot appreciably lower uncertainty. On the other hand, suppose that the information about x is very, very imprecise. Adding another piece of information also reduces uncertainty about x by virtually nothing. If the additional piece of information is quite noisy, a decision-maker learns nothing by incorporating it into his conjecture.

2.5 Owner's Team-Composition Decision

The owner seeks to minimize the firm's expected total uncertainty loss by hiring expertise on a competitive market at wages w_x and w_y. He chooses among three options: a diverse team with one each of the two types of experts, or homogeneous teams consisting of two experts of one type. Letting H_x, H_y, and D denote the three team types, the firm's expected loss with the teams the owner could compose is given respectively by

$$L(H_x) = \gamma_x^2 \; V\left(x|\; n_x = 2,\; M_x = m_x^2\right) + \gamma_y^2 \sigma_y^2 + 2w_x,$$

$$L(H_y) = \gamma_x^2 \sigma_x^2 + \ V\left(y|\ n_x = 0,\ M_y = m_y^2\right) + 2w_y,$$

$$\begin{aligned} L(D) = P_x\left[\gamma_x^2\ V\left(x|\ n_x = 1,\ M_x = m_x^2\right) + \gamma_y^2 V\left(y|n_x = 1, M_y = m_y^2 + V_{\eta_y}\right)\right] + \\ P_y\left[\gamma_x^2\ V\left(x|\ n_x = 1,\ M_x = m_x^2 + V_{\eta_x}\right) + \gamma_y^2 V\left(y|n_x = 1, M_y = m_y^2\right)\right] \\ +w_x + w_y, \end{aligned} \tag{15}$$

where, in the last expression, $P_x = 1 - P_y$ is the probability that the x-expert will be called upon to make a decision.

The three expressions in (15) illustrate the firm's two basic tradeoffs when choosing between homogeneous and diverse teams. With a homogeneous team the decision-maker has no information about one of the variables so the firm suffers the largest possible uncertainty loss from that variable - namely the unconditional variance σ^2. But with two experts gathering information about the other variable, that variables's uncertainty loss is small. Choosing a diverse team means that any decision-maker selected from among the managers has information about both variables when he chooses an action for the firm. In the absence of any communication problems ($(V_\eta) = 0$), the expected loss from a diverse team collapses to $\gamma_x^2\ V\left(x|\ n_x = 1,\ M_x\left(m_x^2\right)\right) + \gamma_y^2 V\left(y|n_x = 1, M_y\left(m_y^2\right)\right)$, so the loss from any variable is definitely smaller than the corresponding loss in a homogeneous team where expertise about that variable is not hired, while the loss from the other variable is larger in the diverse team. Also, because communication problems generally *do* exist, the cost of diversity (having only one as opposed to two people collect information about a particular variable) are larger and the gain from it (providing the decision-maker with information about both variables) smaller than is suggested by the comparison of the two types of teams when there is no miscommunication.

In general, it is not possible to say which type of team produces the smallest total expected loss unless we know the values of all of the parameters. However, it is possible to conduct pairwise comparisons to determine how the relative attractiveness of the three team types changes with marginal changes in the various parameters. These comparisons determine how the expected total uncertainty loss changes with respect to a given parameter increase. If the expected loss (the conditional variance of z) rises less for one type of team than for another,

then the first team becomes relatively more attractive in response to the parameter change. I summarize the findings in the following Proposition and prove them in the Appendix. The symbol " $\succ''$ means "becomes more attractive relative to"; " $\sim''$ means "stays just as attractive as"; and " ?" means "is ambiguous whether becomes more attractive relative to". As before, H_j,, H_k, and D refer to homogeneous j, homogeneous k, and diverse teams, respectively.

Proposition 1

The results below are for $j = (x, y)$, $k = (x, y)$ and $j \neq k$.

(a) For a marginal increase in w_j : $H_j \prec D$, $H_j \prec H_k$, $D \prec H_k$.

(b) For a marginal increase in σ_j^2: $H_j \succ D$, $H_j \succ H_k$, $D \succ H_k$.

(c) For a marginal increase in γ_j: $H_j \succ D$, $H_j \succ H_k$, $D \succ H_k$.

(d) For a marginal increase in V_{η_j}: $H_j \succ D$, $H_j \sim H_k$, $D \prec H_j$.

(e) For a marginal increase in m_j^2: $H_j ? D$, $H_j \prec H_k$, $D \prec H_k$.

The first three parts of the proposition have simple, intuitive explanations. Part (a) says that, as we would expect, an owner's enthusiasm for greater representation of specific type of expertise on his staff is a decreasing function of the wage cost that he pays to hire it. Parts (b) and (c) say in turn that an increase in the inherent variability in a particular variable, and an increase in the sensitivity of the state of the world to a particular variable both have the effect of causing the firm to desire more experts associated with that variable, irrespective of how many such experts it already has. Intuitively, as the state of the world becomes more sensitive to a particular variable, the firm's total uncertainty loss becomes more and more completely determined by uncertainty about that variable. Thus, information about the variable becomes more and more crucial. Similarly, the greater a variable's inherent variability, the more useful information about that variable is at reducing total uncertainty. Indeed, if a variable displayed no inherent variability there could be no uncertainty about that variable, and there would be no need on the firm's part for information about it. The

parameters γ_k and σ_k^2 taken together measure a variable's *importance*, and as importance rises, the firm wants to hire more expert information which covers the variable.

The effect of poor communication is also very simple to understand intuitively. Communication problems can only arise on diverse teams, and the greater they are, the larger the loss which the firm receives from such teams. If x-experts become more difficult to understand, a y-expert on a diverse team who is called upon to make a decision is more uncertain about x. The consequent increase in the conditional variance might be large enough for the firm to decide that it does no good to keep any x-experts on staff at all. This policy would mean that any randomly chosen y-leader would have to guess about x which is what he is close to doing anyway in a diverse team. But now he would be equipped with more (and therefore better) information about y when he made his decision. On the other hand, the firm could decide to go the other way and hire only x-experts. If it were to do this would be no worry about the fact that x-experts are difficult for others to understand. Reductions in the quality of communication make *both* types of homogeneous teams preferable to diverse teams. Whereas we know that a firm which has already hired a homogeneous team will not be motivated to change the representation of expertise on the team in response to a change in communication problems, we do not know *which type* of homogeneous team the firm would like to switch to it has a diverse team when communication worsens.

Part (e) of Proposition 1 says that if there is a worsening in the quality of the underlying information about any variable, the firm will not want to alter its labor demand if it has already hired no experts associated with that variable; a worsening in the quality of information cannot affect the expected loss from a team where no such information is collected. The results are ambiguous as to how the firm will want to change the representation of any expert of which it has already a positive amount. This ambiguity is a direct consequence of the fact mentioned previously that it is not possible to say whether a worsening in quality raises a variable's conditional variance by a larger amount when there are many versus fewer pieces of information forthcoming to the decision-maker.

The effect of an increase in m_x on the conditional variance of x in a D team is a weighted sum of the effect of the increase in the conditional variance of x on a D team when an x-expert

is the leader, and the increase in conditional variance on a D team when a y-expert is the leader. From (13) this latter effect is always smaller than the first. If $\frac{\delta V_{I_k}^x}{\delta M_x \delta n_j} > 0$, a worsening in information quality affects the conditional variance *very* badly the more x-experts the firm has, holding constant the effective variance. So, the conditional variance of x rises by more on H_x teams than it does on a D irrespective of which type of manager is the leader on that team. Thus, H_x teams become unambiguously less attractive as information quality about the variable x worsens. If $\frac{\delta V_{I_k}^x}{\delta M_x \delta n_j} < 0$, the increase in $V(x|.)$ is larger on a D team if an x-expert is the leader than it is on an H_x team. But it is ambiguous whether the increase on an H_x team is greater or smaller than that on a D team is a y-expert is the leader (the effective signal variances are not the same on H_x and D on which y-experts lead.) So the sign of the difference in the increase in $V(x|.)$ in D and H_x cannot be determined in this case, and it is theoretically possible which type of team becomes relatively more attractive.

Information quality thus plays a crucial role in determining what kinds of decision-making teams firms choose and, unlike measures of variable importance, unambiguous theoretical predictions cannot always be given about how marginal changes in the things which comprise information quality (the level of noise in the underlying information sources and the difficulty of communication) affect the representation of different types of experts on management teams. The role of the quality of information has not appeared in verbal modeling which characterizes work on diversity outside of economics. Nor has the relationship between variable "importance" and the inherent variability been emphasized. Also, the fact that exclusive information *necessarily* implies communication difficulties is a point that has not previously been discussed nor has the likely effect of these difficulties on the firm's team composition choice been demonstrated.

In the next section, I consider what happens if experts are able to modify the quality of the information by expending effort. I focus on this modification because it adds realism to the model and also because of the interesting effects of information quality suggested by the results to this point.

3 An Extension of the Basic Model - Active Expertise

In Section 2 information access and communication occur with levels of precision which experts can do nothing to affect. In reality, experts routinely change the quality of their information by expending effort. For example, an expert macro economist may simply choose to rely on his recollection of results from the textbook he used in graduate school in order to gauge the likely effect of a particular policy change on the economy's growth rate. But, by working a bit, he can consult the most recent papers written in the top journals on the subject, and, working harder still, can widen his research effort to include telephone calls to various colleagues based overseas who could speak to the effects of similar policy changes in other countries. Of course, since effort exertion is typically onerous, the rational utility maximizing expert only works hard after considering the use to which his expert information will be put, and how he expects to gain from the examination or application of the information he gathers. I examine in turn the effects of experts being able to modify the quality of their expert information and their expert communication through effort exertion.

The sequence of events is as assumed in the previous section. The two managers collect information before the leader is chosen, choosing how much effort to exert in the process. A leader is chosen by a process not in the owner's control. The problem arises, then the advisor communicates his information to the leader who combines this information with that which he has personally accesses and makes a decision on the firm's behalf. Managers' payoffs are equal to the firm's uncertainty loss plus their effort costs, so the interests of the firm and of its various managers are no longer the same.

3.1 Information Quality Modification

Suppose that the precision of a manager's draw from the information source he is able to access is a function of the effort he expends, e_j, so that

$$m_j^2 = m_j^2(e_j) \tag{16}$$

where $(m_j^2)\prime < 0$, $j \in X, Y$. Assume that it costs the expert $C_j e_j$ to exert e_j units of effort, and that all managers exert some positive amount of effort. On a homogeneous team, the

two managers have precisely the same expected payoff and costs structure so they exert the same amount of effort, e_j^H. Their effort is given implicitly by the solution to

$$-\gamma_j^2 \ \frac{\delta m_j^2}{\delta e_j^H} \ \frac{\delta V\left(j|n_j=2, M_j=m_j(e_j^H)\right)}{\delta M_j} = C_j \tag{17}$$

On diverse teams where a type-j leader is chosen with probability P_j, his effort choice, e_j^D, is given by the solution to

$$\begin{aligned} &-P_j\gamma_j^2 \ \frac{\delta m_j^2}{\delta e_j^D} \ \frac{\delta V\left(j|n_j=1, M_j=m_j^2(e_j^D)\right)}{\delta M_j} \\ &-(1-P_j)\gamma_j^2 \ \frac{\delta m_j^2}{\delta e_j^D} \ \frac{\delta V\left(j|n_j=1, M_j=m_j^2(e_j^D)+V_{\eta_j}\right)}{\delta M_j} = C_j. \end{aligned} \tag{18}$$

Since (17) and (18) maximize managers' expected payoffs, the expressions on the left of the equal signs are the expected marginal benefit from effort exertion which is strictly decreasing in effort.

Comparative static analysis applied to (17) and (18) show that

$$\frac{\delta e_j^{H,D}}{\delta \gamma_j} > 0; \frac{\delta e_j^{H,D}}{\delta \sigma_j^2} > 0; \ \frac{\delta e_j^{H,D}}{\delta C_j} < 0; \ \frac{\delta e_j^{H,D}}{\delta (M_j)\prime > 0}; \ \frac{\delta e_j^{H,D}}{\delta (m_j^2)\prime} < 0.$$

Effort is increasing with respect to the sensitivity of the state of the world to the variable j and with respect to the inherent variability of j. It is strictly decreasing with respect to marginal effort costs and is larger the greater the effect of the quality of information on the effective signal variance. Effort expended is smaller the less efficient effort exertion is at improving information quality.

Effort is also affected simply by the kind of team on which a type j-manager happens to find himself. On a diverse team,

$$\frac{\delta e_j^D}{\delta V_{\eta_j}} < 0 \text{ and } \frac{\delta e_j^D}{\delta P_j} > 0.$$

This means that a manager's effort is smaller the more difficult it is for him to be understood by non-experts, and the greater the chance that he has to pass information along to someone who does not understand him. The effort levels of people on experts on diverse teams

are therefore depressed because of a *miscommunication disincentive*. There is another set of effects which differ across teams, but which are unrelated to communication problems. Suppose that there were no communication problems in diverse teams. Then, the difference in a type-j manager's effort incentive on a homogeneous team and on a diverse team would be due solely to the difference in the number of managers of type-j managers on the team. From (17) and (18), without miscommunication a type-j manager's effort in a homogeneous setting exceeds what he would do on a diverse team $\left(e_j^H > e_j^D\right)$, if

$$\frac{\delta V\left(j|n_j=2, M_j=m_j^2(e_j)\right)}{\delta M_j} > \frac{\delta V\left(j|n_j=1, M_j=m_j^2(e_j)\right)}{\delta M_j} \tag{19}$$

and $e_j^H \leq e_j^D$ otherwise. The sign of the inequality in (19) depends completely on the sign of $\frac{\delta V_{I_k}^j}{\delta M_j \delta n_j}$, which is ambiguous. If $\frac{\delta V_{I_k}^j}{\delta M_j \delta n_j} > 0$, managers work harder when there are others of their kind around than they would if they worked alone, and if $\frac{\delta V_{I_k}^j}{\delta M_j \delta n_j} < 0$, they work less hard the greater the number of other managers of their type on a management team. Thus, managers on homogeneous teams are subject either to a *free rider disincentive* which assures that they work less hard than would otherwise be true because there are more managers on a team; or a *synergistic incentive* which makes them work harder because there are two as opposed to only one expert on the team.

The presence of these three disincentives adds another set of considerations a firm makes in choosing between the two types of teams to the two tradeoffs mentioned earlier. Choosing a diverse team means getting information about many variables which affect the state of the world, but at the price of having miscommunication directly raise the expected conditional variance and indirectly lower the incentive for all managers to exert effort. Choosing a homogeneous team means having many pieces of information about a single factor, but at the price of having no information about other possible important factors and at the price(gain) of having managers be exert less(more) effort simply because there are more of their kind around.

Conducting a set of pairwise comparisons similar to the previous section, it is possible to show

Proposition 2

(i) With a marginal increase in w_j: $H_j \prec H_k$, $D \prec H_k$, $H_j \prec D$

(ii) With a marginal increase in C_j: $H_j \prec H_k$, $D \prec H_k$, $H_j \; ? \; D$

(iii) With a marginal increase in γ_j or σ_j^2: $H_j \succ H_k$, $D \succ H_k$, $H_j \; ? \; D$

(iv) With a marginal increase in V_{η_j}: $H_j \sim H_k$, $D \prec H_k$, $H_j \succ D$

For the most part, this proposition is similar to Proposition 1: greater miscommunication makes diverse teams less attractive relative to all others; marginal wage increases make any team relatively more attractive than one with fewer experts hired at that wage; and increases in a variable's importance cause homogeneous teams without any expertise about that variable represented less attractive relative to all other teams. The major difference between the propositions is the fact that, in Proposition 2, increases in a variable's importance as measured by γ^2 and σ^2 do not lead to the unambiguous prediction that the firm would be more drawn away from a D towards a H_x team as was true with passive expertise.

This ambiguity exists because, with the interaction of the three incentive effects, it is not generally possible to identify the type of team on which a particular type of manager's effort level is greatest. These effort differences mean that it is not necessarily the case that the uncertainty loss which comes from a particular variable is strictly decreasing in the number of people who gather information about that variable, and the owner's choice is sometimes not as straightforward as under passive expertise. Suppose, for example, that γ_x were very close to 1. With passive expertise the owner would almost surely put together an H_x team . With active expertise, however, there is the chance that managers on H_x teams might be subject to a very strong free-rider disincentive. Their consequent reluctance to exert effort when two of them work together might actually make the firm willing to hire a diverse team instead, even though the x-expert on that team faces a miscommunication disincentive. But a synergistic effect could operate in homogeneous teams instead, in which case the firm probably prefers H_x to D.

3.2 Communication Quality Modification

Suppose that rather than being able to change the quality of the information they access, managers could affect how well non-experts understood them. Specifically, suppose that

$$V_{\eta_j} = V_{\eta_j}(E_j) \tag{20}$$

where $(V_{\eta_j})\prime < 0$. Let the costs of effort exertion be $C_j E_j$, and the sequence of events as described in the subsection above.

Managers on homogeneous teams never exert effort because they are always perfectly understood by their colleagues. A type-j manager on a diverse teams exerts effort up to the point where

$$-(1-P_j)\gamma_j^2 \frac{\delta V_{\eta_j}}{\delta E_j^D} \frac{\delta V\left(j|n_j=1, M_j = m_j^2 + V_{\eta_j}(E_j^D)\right)}{\delta M_j} = C_j \tag{21}$$

Only with probability $(1-P_j)$ does he anticipate passing information along to someone who does not speak his expert language. Comparative static analysis applied to (21) shows that

$$\frac{\delta E_j^D}{\delta \gamma_j} > 0, \; ; \frac{\delta E_j^D}{\delta \sigma_j^2} > 0; \; \frac{\delta E_j^D}{\delta C_j} < 0; \; \frac{\delta E_j^D}{\delta m_j^2} < 0; \; \frac{\delta E_j^D}{\delta (M_j)\prime} > 0; \; \frac{\delta E_j^D}{\delta V_{\eta_j}\prime} < 0; \; \frac{\delta E_j^D}{\delta P_j} < 0.$$

Effort is increasing in the sensitivity of the state of the world to the variable j and in the degree of inherent variability of j. He exerts less effort the larger the marginal cost of effort exertion and the less precise the information source from which he draws information. Effort is larger the greater the effect of the quality of information on the effective signal variance and is smaller the less efficient it is at improving communication quality. Finally, effort is strictly decreasing in the probability that a person of the manager's type is selected as leader.

Pairwise comparisons like those presented previously imply

Proposition 3

(i) With a marginal increase in w_j: $H_j \prec H_k$, $D \prec H_k$, $H_j \prec D$

(ii) With a marginal increase in C_j: $H_j \sim H_k$, $D \prec H_k$, $H_j \succ D$

(iii) With a marginal increase in γ_j or σ_j^2: $H_j \succ H_k$, $D \succ H_k$, $H_j ? D$

(iv) With a marginal increase in m_k^2: $H_j \prec H_k$, $D \prec H_k$, $H_j ? D$

The effect of changes in wage costs on the relative attractiveness of the three types of teams is straightforward and are identical to the predictions for both passive expertise, and when experts are active along the dimension of information quality enhancement. However, marginal increases in costs have an ambiguous effect of the demand for homogeneous and diverse teams when people are active along the dimension of information quality enhancement, but unambiguously make diversity relative to both types of homogeneous teams when people are active along the margin of communication improvement. The reason is that whereas increases in costs C_j raise the expected loss from *both* homogeneous j and diverse teams (by possibly different amounts) when experts modify information quality, effort cost increases will only raise the firm's expected losses from diverse teams if experts can modify the quality of their communication.

Proposition 3 also shows that it is ambiguous how a firm's relative preference for H_x and D teams changes in response to changes in γ_x, σ_x^2 and m_x^2. Changes in these parameters directly raise $V(x|.)$ on diverse teams and indirectly lower $V(x|.)$ through their effect on managers' effort choices. For example, suppose that m_x^2 rises. The change in total expected loss in H_x teams is definitely positive. But the change on diverse teams consists both of a positive direct effect and an indirect negative effect because increases in m_x^2 cause managers on diverse teams to work harder at making themselves understood which tends to lower the conditional variance. It is generally not possible to say whether the total increase in conditional variance is larger in H_x or D teams in response to a change in m_x^2.

The results for both propositions 2 and 3 demonstrate that whereas changes in γ_x and σ_x^2 do not allow us to ascertain for certain the attractiveness of H_x and D relative to each other, *both* of these types of teams become relatively more desirable than H_y teams as variable importance increases than is true under passive expertise. In other words, if a variable is very important, it is virtually certain that there will be experts associated with that variable on a decision-making team; we simply do not know how many such experts it is best for the

firm to have given the interaction of the various effort incentives.

The similarity between propositions 2 and 3 also masks an important difference between the two types of active expertise - namely that the total effort exerted is always lower if it is communication than can be improved rather than the quality of information if the marginal effect of effort on the information and communication quality are the same; if changes in m_x^2 and V_{η_x} affect the effective variance M_x equally; and if m_x^2 and V_{η_x} are equal across the different situations. On homogeneous teams, experts never improve the quality of their communication since their communication is already perfect, but they do, in general, expend effort on information quality improvement. On diverse teams, notice that for a given level of effort, the expressions on the left hand side of the expressions (18) will always exceed the left hand side of (21) under the assumptions by the strictly positive quantity

$$-P_j\gamma_j^2 \frac{\delta M_j}{\delta m_j^2} \frac{\delta m_j^2}{\delta e_j} \frac{\delta V\left(j|n_j=1, M_j\left(m_j^2(e_j)\right)\right)}{\delta M_j}. \tag{22}$$

Since the two expressions are both strictly decreasing in effort, type- j managers on diverse teams exert more effort if doing so improves the quality of their underlying information rather than the quality of communication. This makes a great deal of intuitive sense. The marginal return from effort exertion is larger in a diverse team when people can modify the quality of information because this activity lowers uncertainty about the variable whichever leader fate happens to choose. Only if fate chooses someone who speaks a different language is there any gain to having spent effort at making one's self better understood. If firms could choose, they would therefore prefer that experts be able to modify the quality of their expert information rather than that they be able to affect how others understand them.

4 Discussion and Conclusion

In this paper, I have presented a simple framework for analyzing firms' labor demand for different types of expertise on decision-making teams of finite size under the most general possible definition of expertise - arguing only that experts have specialized knowledge areas and specialized vocabulary to refer to those knowledge areas. In general, there are three

factors the firm considers when deciding on diversity of expertise. The first is whether it would like a person who makes decisions on its behalf to have information about more than one variable. Diversity is most likely when many variables are important - either because a firm's profit depends on the values which different variables take, or because there is significant uncertainty about more than one variable.

Second, the firm considers the relative quality of the information that different types of experts bring to a decision-maker in the firm. Whereas having very poor information guarantees that a particular type of expert will not be represented at all on teams, having superb information will not increase that expert type's representation much more as the firm can make do with fewer experts of that type. Diversity will tend to occur when the expert information of various types of experts is good but not close to perfect. Third, the firm considers the effect of cross-expertise communication which adversely affects diverse teams. The greater these communication difficulties, the less attractive diversity.

The framework presented can be used to study the demand for any type of diversity, so long as the definition of expertise is appropriate. Given the traditional importance of questions of racial diversity, and some of the ways in which this type of diversity might be peculiar, I mention some of the strengths and limitations of this approach for studying diversity of this type.

The first obvious limitation is that, despite some suggestive evidence, it is not clear that people from different racial or cultural groups are really from distinct expert communities. Another limitation is the possible importance of discrimination. The firms in the model have no animus towards any experts, and do not choose teams devoid of any type because of any bias. But racial prejudice might well cause firms to eschew a policy of diversity even if the results from the model are correct. The model could still be useful, however, if one wanted to model discrimination in representation on decision-making teams. Economic evidence of discrimination requires either that "equals" be shown to be treated unequally, or that "unequals" be shown to be treated equally. But what makes one an equal in a management context? The result suggests how differences in productivity or ability might be made explicit in a decision-making model. A firm could be said to be practicing discrimination in hiring

(or non-diversity) if after controlling for differences in the importance of different expert information, the relative quality of expert opinion, and the ease or difficulty of communication, less diversity is observed than a model would predict.

One of the framework's potential strengths is its possible usefulness as a theoretical guide to empirical work on the diversity and exclusion. Suppose that one wanted to study racial diversity within the magazine industry. The simple model certainly predicts that: (a) blacks should be relatively better represented on management boards of magazines where blacks account for a large fraction of total sales (high γ_x); and (b) blacks should be relatively highly represented on boards where the variance of the magazines sales to blacks readers is very high $\left(\text{high } \sigma_x^2\right)$. Obtaining or even identifying possible measures of information and communication quality is likely to be quite difficult in this and other contexts.

This paper can be extended along several dimensions in future work. First, the demand for diversity could be analyzed under different types of management structures than the one I have assumed. Second, examining diversity in the context of prejudice against a particular type of expert would be a useful extension. Third, this paper does not address the interesting question of how a non-expert knows that someone is actually expert in a particular area. Fourth, and finally, future work could consider the effect of a richer set of payment and monitoring mechanisms for dealing with the effort incentives described in the model. All of these would be very useful,but none is likely to change the simple, basic points made here.

Appendix

Proof of Proposition 1.

(a) For a marginal change in w_x, δw_x, the change in the expected loss in the three types of teams is:
(i) $H_x:\ 2$
(ii) $H_y:\ 0$
(iii) $D:\ 1$

(b) For a marginal change in σ_x^2, $\delta\sigma_x^2$, the change in the expected loss in the three types of teams is:
(i) $H_x : \gamma_x^2 \frac{\delta V(x|n_x=2,M_x=m_x^2)}{\delta\sigma_x^2}$
(ii) $H_y : \gamma_x^2$
(iii) $D : \gamma_x^2 \left[P_x \frac{\delta V(x|n_x=1,M_x=m_x^2)}{\delta\sigma_x^2} + (1-P_x)\,\frac{\delta V(x|n_x=1,M_x=m_x^2+V_{\eta x})}{\delta\sigma_x^2}\right] =$
$\gamma_x^2 \left[P_x \left(\frac{\delta V(x|n_x=1,M_x=m_x^2)}{\delta\sigma_x^2} - \frac{\delta V(x|n_x=1,M_x=m_x^2+V_{\eta x})}{\delta\sigma_x^2}\right) + \frac{\delta V(x|n_x=1,M_x=m_x^2+V_{\eta x})}{\delta\sigma_x^2}\right]$

By (12) and (13):

$\frac{\delta V(x|n_x=2,M_x=m_x^2)}{\delta\sigma_x^2} < \frac{\delta V(x|n_x=1,M_x=m_x^2)}{\delta\sigma_x^2} < \frac{\delta V(x|n_x=1,M_x=m_x^2+V_{\eta x})}{\delta\sigma_x^2} < 1$. This implies that $P_x \left(\frac{\delta V(x|n_x=1,M_x=m_x^2)}{\delta\sigma_x^2} - \frac{\delta V(x|n_x=1,M_x=m_x^2+V_{\eta x})}{\delta\sigma_x^2}\right) < 0$, so the change in the uncertainty loss from a D is definitely less than that for an H_y team, as is the change for an H_x team. Also, because $\frac{\delta V(x|n_x=2,M_x=m_x^2)}{\delta\sigma_x^2}$ is less than both $\frac{\delta V(x|n_x=1,M_x=m_x^2)}{\delta\sigma_x^2}$ and $\frac{\delta V(x|n_x=1,M_x=m_x^2+V_{\eta x})}{\delta\sigma_x^2}$, it is less than their weighted sum.

(c) For a marginal change in γ_x, $\delta\gamma_x$, the change in the expected loss in the three types of teams is:
(i) $H_x : 2\gamma_x V(x|n_x=2, M_x=m_x^2) - 2\,(1-\gamma_x)\,\sigma_y^2$
(ii) $H_y : 2\gamma_x\sigma_x^2 - 2\,(1-\gamma_x)\,V(x|n_x=0, M_y=m_y^2+V_{\eta_y})$
(iii) $D : 2\gamma_x \left[P_x\left(V(x|n_x=1,M_x=m_x^2)\right) + (1-P_x)\,V(x|n_x=1,M_x=m_x^2+V_{\eta x})\right]$-
$2(1-\gamma_x)\left[P_x\left(V(y|n_x=1,M_y=m_y^2+V_{\eta_j})\right) + (1-P_x)\,V(y|n_x=1,M_y=m_y^2)\right]$

The marginal effect of a change in γ_x operates through an increase in the expected loss from x (increase) and a decrease in the expected loss from y. By condition (14) σ_j^2 of any variable j is larger than all three of the conditional variances of j and $V(j|n_j=2, M=m_j^2)$ is definitely the smallest of the j's conditional variances. This means that the increase in x-loss caused by an increase in γ_x is largest for a H_y team and smallest for an H_x team; the

reduction y loss is smallest for an H_y team and largest for an H_x team. The change in total loss in response to this perimeter change is therefore smallest in a H_x team, next smallest in a diverse team, and largest in an H_y team.

(d) For a marginal change in m_x^2, δm_x^2, the change in the expected loss in the three types of teams is:

(i) $H_x : m_x^2 \frac{\delta V(x|n_x=2,M_x=m_x^2)}{\delta m_x^2}$
(ii) $H_y : 0$
(iii) $D : \gamma_x^2 \left[P_x \frac{\delta V(x|n_x=1,M_x=m_x^2)}{\delta m_x^2} + (1-P_x) \frac{\delta V(x|n_x=1,M_x=m_x^2+V_{\eta x})}{\delta m_x^2} \right] =$
$\gamma_x^2 \left[P_x \left(\frac{\delta V(x|n_x=1,M_x=m_x^2)}{\delta m_x^2} - \frac{\delta V(x|n_x=1,M_x=m_x^2+V_{\eta x})}{\delta m_x^2} \right) + \frac{\delta V(x|n_x=1,M_x=m_x^2+V_{\eta x})}{\delta m_x^2} \right]$

Since the change in expected loss is positive for both H_x and D teams, both of these types become less attractive relative to H_y teams. However, while (12) and (13) imply that $\frac{\delta V(x|n_x=1,M_x=m_x^2)}{\delta m_x^2} > \frac{\delta V(x|n_x=1,M_x=m_x^2+V_{\eta x})}{\delta m_x^2}$, the relative magnitudes of $\frac{\delta V(x|n_x=2,M_x=m_x^2)}{\delta m_x^2}$ and $\frac{\delta V(x|n_x=1,M_x=m_x^2)}{\delta m_x^2}$ is ambiguous. It follows that the effect of a marginal change in m_x^2 has an ambiguous effect on the relative attractiveness of H_x and D teams. If $\frac{\delta V(x|n_x=2,M_x=m_x^2)}{\delta m_x^2} > \frac{\delta V(x|n_x=1,M_x=m_x^2)}{\delta m_x^2}$, then H_x teams definitely become less attractive relative to D teams. If $\frac{\delta V(x|n_x=2,M_x=m_x^2)}{\delta m_x^2} < \frac{\delta V(x|n_x=1,M_x=m_x^2)}{\delta m_x^2}$, the result is ambiguous.

(e)For a marginal change in V_{η_x}, δV_{η_x}, the change in the expected loss in the three types of teams is:

(i) $H_x : 0$
(ii) $H_y : 0$
(iii) $D : \gamma_x^2 \left[(1-P_x) \frac{\delta V(x|n_x=1,M_x=m_x^2+V_{\eta x})}{\delta V_{\eta x}} \right]$

Diverse teams clearly become less attractive relative to both types of homogeneous teams as cross-expertise communication worsens, and the relative attractiveness of H_x and H_y teams is unaffected.

Proof of Proposition 2.

I only give the proofs for changes in γ_x^2 and σ_x^2. The results for wages, V_η and effort costs are easy to show.

(a) For a marginal change in γ_x, $\delta\gamma_x$, the change in the expected loss in the three types of teams is:

(i) $H_x : 2\gamma_x V(x|n_x = 2, M_x = m_x^2(e_j^H)) - 2\left(1-\gamma_x\right)\sigma_y^2$

(ii) $H_y : 2\gamma_x\sigma_x^2 - 2\left(1-\gamma_x\right)V(x|n_x = 0, M_y = m_y^2(e_y^D) + V_{\eta_y})$

(iii) $D : 2\gamma_x\left[P_x\left(V(x|n_x = 1, M_x = m_x^2(e_j^H))\right) + (1-P_x)\,V(x|n_x = 1, M_x = m_x^2(e_j^H) + V_{\eta_x})\right]$ -
$2(1-\gamma_x)\left[P_x\left(V(y|n_x = 1, M_y = m_y^2(e_y^D) + V_{\eta_j})\right) + (1-P_x)\,V(y|n_x = 1, M_y = m_y^2(e_y^D))\right]$

The marginal effect of a change in γ_x operates through a change in the expected loss from both x (increase) and y variables (decrease). By (14) σ_j^2 is larger than all three of the conditional variances of a variable j. But the relative sizes of $V(x|n_x = 2, M = m_x^2(e_j^H))$, $V(x|n_x = 1, M = m_x^2(e_j^D))$, and $V(x|n_x = 2, M = m_x^2(e_j^H) + V_{\eta x})$ is unknown, we cannot say whether the increase in x-loss is greater on a H_x or a D team.

(b) For a marginal change in σ_x^2, $\delta\sigma_x^2$, the change in the expected loss in the three types of teams is:

(i) $H_x : \gamma_x^2\left[\frac{V(x|n_x=2,M_x=m_x^2(e_x^H))}{\delta\sigma_x^2} + \frac{V(x|n_x=2,M_x=m_x^2(e_x^H))}{\delta M_x}\frac{\delta m_x^2}{\delta e_x^H}\frac{\delta e_x^H}{\delta\sigma_x^2}\right]$

(ii) $H_y : \gamma_x^2$

(iii) $D : \gamma_x^2 P_x\left[\frac{V(x|n_x=1,M_x=m_x^2(e_x^D))}{\delta\sigma_x^2} + \frac{V(x|n_x=1,M_x=m_x^2(e_x^D))}{\delta M_x}\frac{\delta m_x^2}{\delta e_x^D}\frac{\delta e_x^D}{\delta\sigma_x^2}\right]$ -
$\gamma_x^2(1-P_x)\left[\frac{V(x|n_x=1,M_x=m_x^2(e_x^D)+V_{\eta x})}{\delta\sigma_x^2} + \frac{V(x|n_x=1,M_x=m_x^2(e_x^H)+V_{\eta x})}{\delta M_x}\frac{\delta m_x^2}{\delta e_x^H}\frac{\delta e_x^H}{\delta\sigma_x^2}\right]$

The second term in each of the squared brackets is always negative. By (12), the first term in each squared bracket is less than 1. Thus, H_y teams become less attractive relative to all others. From the first part of the Appendix, notice that the H_y teams are less attractive with active expertise that with diversity. The difference in the change for H_x and D is ambiguous.

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Endnotes

1. Diversity has spawned a contentious debate in American universities. Faced with charges of discrimination, some large university systems have recently defended their racial admission policies on the grounds that those policies are essential given the university's interest in promoting racial diversity on campus, which has led to a debate about the degree to which a racially and culturally diverse environment enriches the educational experience. Interest in managerial diversity in the private sector is evidenced by the numerous newspaper and magazine accounts on the subject such as "Why Women Still Don't Hit the Top" *Fortune* July 30, 1990; and "Over the Rainbow" *The Economist*, Nov. 22, 1997, and by fact that an ever-larger share of public discussion about discrimination focuses on the degree of diversity observed in firms.

2. For example, work on diversity similar to that in this paper includes Nemeth (1986) who focuses on the gains to creativity wrought by diversity. Janis (1982) assesses how "groupthink" is affected by having different types of people in a decision-making situation. Others such as Cox (1995) discuss how firms benefit from diversity.

3. By "languages" I do not mean to imply a distinction like that between French and Spanish, but rather the different meanings (including no meaning) which people with different knowledge bases attach to specific expressions. These language differences are often called "jargon".

4. Sometimes these communication problems are the result of the speaker's desire to *create* confusion. But this itself is evidence of the fact that expertise is associated with particular rules of communication. For example, a customer with mechanical expertise would know that failing to replace an expensive engine part will not cause his car's *wigglitis tradiator* to deteriorate because he would know that there is no such thing. Non-experts, because they do not perfectly know either the vocabulary of mechanics or the specific knowledge to which the vocabulary of mechanics refers, do not know whether the expression *wigglitis tradiator* refers to

an actual mechanical part or not, and are surely ignorant of the likelihood that one might fail.

5. Management teams of size 2 allow for easy exposition of all the points the paper makes. The results are easily generalizable to teams of larger size.

6. There are many management structures of this type. The owner of chain of stores hires managers for each uncertain about which of them will have to deal with a disgruntled customer or a dishonest employee. A large corporation typically has many managers, and though it might state that one of them is its leader, it cannot always direct the calls from the media to any particular person. Whichever person the media happens to call is effectively the firm's leader for a day.

7. I leave vague the exact nature of the problem - decisions about whether to match an outside offer received by a worker in the division; how much of the division's inventory to sell to a loyal customer; or whether to make a job offer to a particular recruit are all possibilities.

8. In the model, advisors gain nothing by deliberately mis-reporting their information. Doing so simply adds noise to the decision-maker's estimate of the state of the world which directly lowers the advisor's expected payoff. The model is therefore not an example of "cheap-talk" models, and is also different from Banerjee and Somanathan (1998) which examines the circumstances under which agents will voice any information to a decision-maker, and when they will voice false information.

9. The assumptions about the shape of the characteristics of conditional variance in (12) and (13) all hold in the special case where the variable z is bivariate Normal.