

# UC Berkeley

## UC Berkeley Electronic Theses and Dissertations

**Title**

Essays in Team Economics

**Permalink**

<https://escholarship.org/uc/item/3pv539n8>

**Author**

Tumlinson, Justin

**Publication Date**

2011

Peer reviewed|Thesis/dissertation

Essays in Team Economics

By

Justin Lamonte Tumlinson

A dissertation submitted in partial satisfaction of the requirements for the degree of

Doctor of Philosophy

in

Business Administration

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Professor John Morgan, Chair

Professor Steven Tadelis

Professor Robert Anderson

Spring 2011



## Abstract

### Essays in Team Economics

By Justin Lamonte Tumlinson

Doctor of Philosophy in Business Administration

University of California, Berkeley

Professor John Morgan, Chair

This dissertation addresses teamwork with the tools of economics in three specialized settings—I examine (1) how teams form under discrimination, (2) what shareholders can accomplish for themselves and society when operating as group that they cannot as individuals, and (3) ethnicity's role in the performance of pairings between venture capitalists and entrepreneurs.

### **Adverse Selection in Team Formation under Discrimination**

The decision to be an entrepreneur or an employee is among the most consequential any individual will ever face. Does race or gender influence that choice? Could discrimination affect occupational performance? Several empirical studies on occupational segregation suggest (1) minorities are more likely to choose (or be chosen for) occupations in which teamwork plays a minimal role and (2) that minorities excel in these individualistic positions.

Teamwork and discrimination are fundamentally linked because while teamwork can be synergistic, it obscures team members' individual contributions: managers can try to infer unobservable individual contribution from observable characteristics like race or sex. Thus, a talented minority worker should choose entrepreneurship or other occupation where his individual accomplishments cannot easily be attributed to others, if doing so will make him better off.

Could this self-selection sustain discrimination even if managers paid workers proportional to their expected ability; that is, according to their merit? This paper shows that it can. Furthermore, among those choosing to work as entrepreneurs or in other individualistic occupations, discrimination victims outperform beneficiaries. Since beliefs about discrimination influence which teams forms, discriminatory equilibria may be more productive than egalitarianism—the implications are discussed. The model presented here distinguishes itself in a rich literature on statistical discrimination, by explaining empirically observed behavior that has not yet been addressed, elucidating why the prescriptions derived from extant model have had limited success, and by enabling the analysis of additional forms of discrimination.

### **Social Responsibility of Firms beyond Profits**

Corporate social responsibility (CSR) expenditures are often seen as a perquisite of the manager at shareholder expense or an indirect form of profit maximization. The former explanation creates an agency puzzle and ethical dilemma—who should/do managers work for? Empirical support for the latter explanation is mixed, at best. I highlight another possibility consistent with recent findings that absentee managed plants in the US emit more toxins, on average, than other

plants (Grant, Jones and Trautner 2010). I develop a model in which a manager who maximizes *shareholder* welfare will optimally engage in CSR that leaves shareholders with less money. Furthermore, no behavioral motives, such as “warm glow” are required—instead, the familiar public economics framework of *pure altruism* is used; i.e. shareholders care only about their own private material consumption and their *own private benefit* from public goods, like clean air.

In this framework, (1) a manager will provision more public goods, say by supporting environmental causes, from the profits of the firm than if the manager distributed all profits to shareholders as dividends and left shareholders to contribute in a decentralized manner on their own. (2) If the firm generates negative externalities, like pollution, the firm always produces less than the profit maximizing output. (3) If shareholders would have their manager contribute anything at all to the public good at the socially optimal level of production, the firm will, in fact, produce the socially optimal quantity and provision the public good, *without intervention by a social planner*. Thus, when this condition holds, government regulation to control the quantity produced by firms can do no better for society than a manager who works only on behalf of her shareholders. Reasons why this condition may be expected to hold in many real world settings are discussed. (4) Finally, when this condition holds, decreasing marginal production costs increase public goods as much as decreasing marginal externalities. This neutrality result implies that government subsidization of technology, which improves the cost-effectiveness of production, may yield cleaner air than subsidization of less polluting technology, if the former is cheaper to develop. The model also yields a number of distinct empirically testable hypotheses, including that, all else being equal, more widely held firms will engage in greater CSR than more closely held firms. At a broader level, the model reveals not only a novel explanation for costly CSR but that making managers more accountable to *shareholders* confers a *social* benefit.

### **Can Birds of a Feather Fly Together?—Evidence for the Economic Payoffs of Ethnic Homophily**

How do ethnic networks influence venture capitalists’ choice of companies to invest in, and the performance of the investments? We investigate this question by using data on the ethnic origins of over 22,000 U.S.-based V.C. partners and the 98,000 top-level executives of the startup companies they invested in during the years 1991-2010. We construct measures of “ethnic distance” for each potential VC-company pair and find that after controlling for the sorting of ethnic groups into certain industries and geographic areas, a 1% decrease in ethnic distance for the pair increases the probability of investment by up to 0.05%. Evidence for the influence of ethnicity is particularly strong during early-rounds of investment when information costs of the relationship are high, and for ethnic populations associated with “collectivist” cultures such as Japanese, Korean and Chinese. Conditional on investment, a 1% increase in ethnic closeness increases the probability that the portfolio company advances to successive rounds (the effect being strongest for the early rounds), and the probability of successful exits through IPO by 0.6-1.2%. This translates to a striking estimated *ex ante* increase in IRR between 7% and 15% for the average VC. We conclude that co-ethnic networks have a profound economic influence on venture investments.

In gratitude for years of unwavering support,  
this dissertation is dedicated to  
my loving wife Cassie,  
and my sons Gavin and Xander;  
they were the reason when things went well,  
and my strong foundation when they did not.

I would like to thank my mentor, John Morgan, for leading me to discover the joy of research,  
and my friend, Deepak Hegde, for his exemplary conviction in the pursuit of sincere science, for  
his unwavering encouragement and persistent intellectual challenge.

# Contents

|                                                          |    |
|----------------------------------------------------------|----|
| Adverse Selection in Team Formation under Discrimination | 1  |
| Social Responsibility of Firms beyond Profits            | 35 |
| Can Birds of a Feather <i>Fly</i> Together?              | 60 |
| Evidence for the Economic Payoff of Ethnic Homophily     |    |

Note: Bibliographic references for each chapter are self-contained.

# Adverse Selection in Team Formation under Discrimination

## 1 Introduction

A young black man finishes law school. He wonders, “Should I join a large firm or hang out my own shingle?” A newly minted Latina engineer ponders whether she should join a tiny startup or accept the job offer of a giant technology multinational. The decision to be an entrepreneur or an employee is among the most consequential any individual will ever face. Does race or gender influence that choice? Could discrimination affect occupational performance?

Several empirical studies on occupational segregation suggest (1) minorities are more likely to choose (or be chosen for) occupations in which teamwork plays a minimal role and (2) that minorities excel in these individualistic positions. For example, Clark and Drinkwater (2000) document minority over-representation in the British self-employment sector, even though most new firms fail within four years (Shane, 2008). Lempert, Chambers and Adams (2000) report that among Michigan Law School graduates choosing private sector employment, minorities are far more likely to open their own practice or join very small practices. Strikingly, they also find that minority graduates enjoy higher income than their white peers, despite the fact that salaries of small firm attorneys are significantly lower than those of large firms (NALP 2009).<sup>1</sup>

Popular media has recently focused attention on heightism, i.e. discrimination over physical stature.<sup>2</sup> Judge and Cable (2004) calculate that a worker, on average, earns \$789 (1991 USD) more annually for each inch of physical height. Djankov, *et al.* (2005) conducted a survey of Russian entrepreneurs. Among individual characteristics, two of the top three strongest predictors of entrepreneurship were found to be cognitive ability (positively correlated) and physical height (negatively correlated). Both proved more robust than such stereotypical characteristics such as risk-taking. Although Djankov, *et al.* do not explain why smart, short individuals choose entrepreneurship more often, the model presented here can.

Even in team sports, minorities disproportionately occupy positions where contribution is individualistic and more measurable. Loy and Elvogue (1970) categorize the various positions in baseball and football as either central or peripheral based on their interaction

---

<sup>1</sup>Though Lempert *et al.* (2000) find a positive correlation between non-white ethnicities or minority status and log income, it is not always significant.

<sup>2</sup>Discrimination in the model presented here can be over any attribute. I generally use minority as a synonym for victim of discrimination and non-minority for beneficiary of discrimination.

level with other players. They observe that minorities occupy the majority of peripheral, or so-called “[measurable] skill,” positions while whites dominate central ones. Similarly, in hockey, Lavoie, Grenier and Coulombe (1987) observe that Francophones are overrepresented at goalie and underrepresented on defense. By objective measures, like points scored, minority players outperform non-minorities in all of these sports (see Kahn 1991 for a review).

How are teamwork and discrimination linked? Teamwork facilitates discrimination because it obscures team members’ individual contributions: managers can try to infer unobservable individual contribution from observable characteristics like race or sex. A minority worker should choose entrepreneurship, or other occupation where his individual accomplishments cannot easily be attributed to others, *if doing so will make him better off*. And indeed, Clark and Drinkwater (2000) verify that self-employed minorities earn more than their traditionally employed counterparts. But clearly, individuals who are most talented relative to their employers’ perceptions have the greatest incentive to eschew teamwork—if high ability minorities believe they will face discrimination on teams, they will avoid them. Could this self-selection sustain discrimination even if managers paid workers proportional to their expected ability; that is, according to their merit?

This paper shows that it can. In the model, discrimination arises because workers endogenously choose either to work as part of a team, where individual merit is hard to measure, or as an individual, where it is easy to measure. Workers differ in unobservable ability as well as *ex ante* uncorrelated, observable characteristics, like race. If high ability minority workers mostly elect to work outside of teams, then meritocratic managers will rationally discriminate when rewarding team members. This effect reinforces itself, since high ability minorities will be better off working individually than facing discrimination on a team. How does discrimination impact those who choose individualistic work?

Race becomes an *ex post* indicator of ability not just for team workers but for those who work alone—among individualistic workers, minorities will outperform non-minorities on average. Thus, if the fraction of team credit allocated to minority team members quantifies the level of discrimination, then this measure always overestimates the relative disadvantage minorities face overall. In fact, under certain circumstances, minorities receive higher average compensation than non-minorities when both team and solo workers are considered.

Discrimination may induce teamwork that would not occur under egalitarianism. For example, if credit is to be split evenly, a highly skilled non-minority worker (with no taste for discrimination) may be unwilling to collaborate with anyone less competent than himself, but under discrimination he may be willing to team up with a minority worker who happens to be less competent than he is, since he will get most of the credit anyway. If synergy between these teammates is high enough, discrimination is socially preferable in that total societal output is higher than under egalitarianism; in fact, under certain circumstances, both non-minorities and minorities alike (as groups) earn more under discrimination.

The model presented here distinguishes itself in a rich literature on statistical discrimination, both by explaining empirically observed behavior that has not yet been addressed and by enabling the analysis of additional forms of discrimination. First, the existing class of models is silent on career choice. Second, existing models require that victims differ from beneficiaries at the time of employment either in (a) discourse or (b) (endogenously) acquired human capital. Thus, extant theory implies powerful, pervasive mechanisms that transform individuals from birth. But when teams form endogenously, selection can lead to statistical

discrimination, which leaves all victim and beneficiary attributes, except the one over which discrimination occurs, *statistically identical across the population at all times*. In addition to explaining traditional forms of discrimination such as racism and sexism, the model here also covers forms of discrimination that alter individuals less forcefully or may exist in only certain occupations.

The next section highlights related literature. The third presents a basic model of endogenous team formation, production and credit allocation. The fourth section illustrates the basic intuitions when workers are only of two abilities. The fifth tests the robustness of these intuitions in more general settings, and the sixth concludes. Technical proofs are contained in the appendix.

## 2 Related Literature

The economics literature stresses that workplace discrimination either stems from employer tastes (Becker 1957) or from conditioning expected worker contribution on observable characteristics, like race, to (partially) resolve imperfect observability of employee productivity. Phelps (1972) and Arrow (1973) pioneered work on this latter type, known as statistical discrimination.<sup>3</sup>

Arrow and later Coate and Loury (1993) showed that because minorities respond strategically to lower incentives to invest in unobservable skill sets prior to employment, employers' discriminatory beliefs can be confirmed *ex post*, even when minorities and non-minorities have identical ability *ex ante*. The discriminatory equilibrium resembles the one presented here, but “*ex ante*” in their models means “at birth” Since minorities and non-minorities acquire different human capital, they no longer possess identical ability when they take jobs.

In this paper discrimination is classically statistical, arising from imperfect observability of worker productivity. Team synergy both incents workers to collaborate and obscures their individual contributions. Although minorities who select into teams differ from those who do not, the overall populations of minorities and non-minorities always have statistically identical ability. The signal in this sorting model is slightly more complex than in others. In Arrow's and Coate and Loury's models, race alone (eventually) correlates to ability, but in this model, it is the interaction of race and *observable* self-selection, which informs the manager.

The model relates in a secondary way to the literature on team productivity. Since Alchian and Demsetz' (1972) discussion of the free-rider problem inherent in teams, the team literature has focused on moral hazard in effort.<sup>4</sup> Hamilton, Nickerson and Owan (2003) empirically suggest that this focus on free-riding in teams is too narrow, because even when individual incentives are feasible, many firms implement group incentives to increase productivity.<sup>5</sup> Accounting for such synergies, my model examines the selection in team formation that occurs before any moral hazard can—imperfect observability of individual

---

<sup>3</sup>The body of literature after Phelps' tradition relies on employers being able to extract a less noisy signal of ability from employees they most closely resemble (e.g. in race or sex). It does not inform the model presented here.

<sup>4</sup>See Holmström 1982, McAfee and McMillan 1991, Legros and Matthews 1993 among many others.

<sup>5</sup>First, Hamilton et al (2003) capture an 18% productivity increase in a garment factory after a change from individual piece rate compensation to group piece rate pay. Second, they attribute about a fifth of

contributions in teams drives both. Because teamwork is always synergistic in the model this selection into individualistic work is adverse for society and firm alike—incomplete information causes both to suffer a productive loss.

This adverse selection creates a link between discrimination and occupational choice, especially with respect to the entrepreneurial decision, that the literature has not discussed. But adverse selection in team formation also happens in traditional firms, even though most employees cannot choose their coworkers. When a manager hires all employees, the teamwork decision and, hence, adverse selection often remain. Presented with a menu of tasks, an employee may choose an individual task with high management visibility over another, in which his contribution may be lost because of the number and rank of other contributors.<sup>6</sup> The common managerial performance critique, “(not) a team player” indicates that even when tasks are completely assigned, how they are performed can be an expression of the teamwork decision. The model applies to any situation in which workers can trade off synergy for visibility.

### 3 Basic Model

Two workers,  $A$  and  $B$ , decide to produce individually, say as entrepreneurs, or together, say as employees at a large firm.  $A$  and  $B$  have positive abilities,  $\alpha$  and  $\beta$  respectively, drawn randomly from identical independent distributions. Abilities are known to both  $A$  and  $B$  but unobservable to management. Worker names (i.e.  $A$  or  $B$ ) are the only available attribute of discrimination.

$A$  and  $B$  produce their respective abilities when working individually (i.e. individualistic technology is linear in ability with slope 1). Teams produce  $g(\alpha, \beta)$ . Assume team production is

$$\begin{aligned} \text{Symmetric:} \quad & g(x, y) = g(y, x) \\ \text{Synergistic:} \quad & g(\alpha, 0) \geq \alpha \text{ and } g(\alpha, \beta) > \alpha + \beta \quad \forall \alpha, \beta > 0, \end{aligned}$$

A manager determines the portion of team credit (or production) due each worker. This credit may be compensation or a manager identifying her next promotee. The fraction of team credit assigned to  $A$  is denoted by  $\gamma$ , where  $\gamma$  lies in the unit interval.  $B$  receives the remainder. Thus,  $\gamma$  represents the strength of discrimination:  $\gamma = 1$  represents a world in which  $A$  gets all credit from group work and  $\gamma = 0$  one in which he gets none. Without loss of generality, I restrict  $\gamma \in [\frac{1}{2}, 1]$ , so that  $B$  always denotes the minority. For every discriminatory equilibrium belief,  $\gamma > \frac{1}{2}$ , favoring  $A$ , model symmetry induces another,  $1 - \gamma < \frac{1}{2}$ , favoring  $B$ . Analysis, though, is limited to  $\gamma \geq \frac{1}{2}$ . Importantly, a solo worker

---

that increase to the fact that high ability workers were more likely to join teams but the remaining 14% is attributable to the synergistic team effect. High ability workers were no more likely to leave the company than low ability ones after joining a team. These findings counter the free-riding theories, which have dominated economic analysis of teams.

<sup>6</sup>Even such characteristics such as job title or seniority can be attributes of discrimination to the extent they are imperfectly correlated to private ability. A gifted junior employee may rather work alone than share a majority of credit with a mediocre senior one.

always receives all credit for his work.  $A$  and  $B$  have common beliefs on  $\gamma$ .<sup>7</sup>

Each worker chooses teamwork if and only it would make him (weakly) better off than working individualistically. A team forms if and only both workers choose teamwork (Table 1 describes the game in normal form). Thus, each worker has a clear dominant strategy. Worker  $A$  chooses *Team* if and only if

$$g(\alpha, \beta) \gamma > \alpha \quad (C_A)$$

Otherwise he chooses *Solo*. Similarly, worker  $B$  chooses *Team* if and only if

$$g(\alpha, \beta) (1 - \gamma) > \beta \quad (C_B)$$

and *Solo* otherwise.

|            |             | Worker $B$                                               |                 |
|------------|-------------|----------------------------------------------------------|-----------------|
|            |             | <i>Team</i>                                              | <i>Solo</i>     |
| Worker $A$ | <i>Team</i> | $g(\alpha, \beta) \gamma, g(\alpha, \beta) (1 - \gamma)$ | $\alpha, \beta$ |
|            | <i>Solo</i> | $\alpha, \beta$                                          | $\alpha, \beta$ |

Table 1. Normal form of the simultaneous game.

Employment law constrains the manager to allocate credit according to employees' relative contributions as well as she can with available information.<sup>8</sup> Each team member should receive rewards commensurate with his relative contribution to the team, but since teamwork obscures individual contribution, the manager has limited information about team members' individual contributions. However, the manager has a useful piece of information: her employees chose to work for her rather than for themselves—they chose teamwork. Thus, a central quantity of interest is the non-minority's average fraction of ability in all teams that form *under a given set of beliefs*,  $E \left[ \frac{\alpha}{\alpha + \beta} \mid team, \gamma \right]$ .<sup>9</sup> If work was completed as a team, the manager credits  $A$  equal to his expected proportion of total team ability, given that the work was done as a team. In a Bayesian Nash Equilibrium (BNE), if the manager is assigning credit according to merit, this fraction must, in expectation, equal the credit split,  $\gamma$ , that  $A$  and  $B$  believed when they decided to form a team:

$$\gamma = E \left[ \frac{\alpha}{\alpha + \beta} \mid team, \gamma \right] \quad (1)$$

In other words, a particular set of teams will form in a society that believes discrimination of level  $\gamma$  exists; if  $\gamma$  is also non-minorities' expected relative contribution on those teams then the discrimination is fair ex post and the beliefs are self-reinforcing.

<sup>7</sup>Assuming that victims and beneficiaries believe that discrimination exists to a common degree is strong, but the assuming common beliefs is standard in BNE analysis. Likewise, one may assume that the abilities of *previous* employees working on teams have been revealed to the manager to give some basis for beliefs, but this is not strictly necessary for the analysis.

<sup>8</sup>Statistical discrimination is illegal in the US; however, since the burden of proof that an employer is not paying equally for equal work belongs to the employee, this constraint of the model is practical.

<sup>9</sup>Although the denominator does not reflect the total output of the team in the above definition of meritocracy, it is trivial to show that the alternative formulation,  $\gamma = E \left[ C \frac{\alpha}{g(\alpha, \beta)} \mid team, \gamma \right]$ , where  $C = \frac{g(\alpha, \beta)}{\alpha + \beta}$  is the unique normalizer such that  $1 - \gamma = E \left[ C \frac{\beta}{g(\alpha, \beta)} \mid team, \gamma \right]$  is equivalent.

## 4 Analysis

In deciding whether or not to join the team, a worker compares his fraction of (realized) total team ability to the fraction of team credit he believes he will receive. I refer to the ratio of these two quantities as his *discriminatory alignment*. The discriminatory alignment of  $A$  is  $\frac{\alpha}{\alpha+\beta}/\gamma$ , while  $B$ 's is  $\frac{\beta}{\alpha+\beta}/(1-\gamma)$ . If this discriminatory alignment is less than unity then team production must be sufficiently synergistic for that worker to choose teamwork.<sup>10</sup> For example, if team production were only slightly synergistic (i.e.  $g(\alpha, \beta) = \alpha + \beta + \varepsilon$ , where  $\varepsilon > 0$  is very small) it is easy to see that  $(C_A)$  and  $(C_B)$  would only be satisfied by pairs of workers whose discriminatory alignment is approximately equal to 1 (i.e.  $\frac{\alpha}{\alpha+\beta} = \gamma$  and  $\frac{\beta}{\alpha+\beta} = (1-\gamma)$ )—only worker pairs whose abilities mirror their beliefs about discrimination will team up. At the other extreme, suppose that team production were extremely synergistic, say  $g(\alpha, \beta) = +\infty$ . Then, regardless of the workers' discriminatory alignments, a team forms—both workers will choose teamwork regardless of each other's ability or the perceived level of discrimination.

It is easy to visualize the effects of synergy and beliefs about discrimination by graphing  $(C_A)$  and  $(C_B)$  over the workers' joint ability sample space. Figures 1 and 2 depict the team forming regions of the ability sample space (in  $\mathbb{R}^+ \times \mathbb{R}^+$ ) under two different scenarios.<sup>11</sup> Figure 1 depicts highly synergistic team production under very discriminatory beliefs; the environment depicted in Figure 2 is both less synergistic and less discriminatory ( $g_H(\alpha, \beta) > g_L(\alpha, \beta) \forall \alpha, \beta > 0$  and  $\gamma_H > \gamma_L$ ). The meshed region of each figure bordered by a dashed line represents all of the realizations of  $\alpha$  and  $\beta$ , which would jointly satisfy  $(C_A)$ . Analogously the shaded region of each figure bordered by a dot-dashed line represents all of the realizations of  $\alpha$  and  $\beta$ , which would jointly satisfy  $(C_B)$ . Teams form only from realizations in the overlap of these regions. The solid line, which runs through the interior of the team forming region, represents the locus of realizations of  $\alpha$  and  $\beta$  for which discriminatory alignment equals unity—this locus of pairings will form teams regardless of the synergy level. Comparing the two figures, one observes that as synergy increases, the team forming region expands to include more and more pairings besides just those with discriminatory alignment equal to 1. Note also that as beliefs about discrimination change, the boundaries of the team forming region created by  $(C_A)$  and  $(C_B)$  both move in the direction of the change in beliefs—the composition of teams (at least) loosely reflects society's discriminatory beliefs. What is not shown in the figures, but will be a focus of the analysis, is the probability density of abilities over the sample space—for it is the expectation of abilities over the team forming regions and regions of individualistic work that lead to the main results.

To illustrate the basic insights of the model, I analyze a simple two-type case. More general settings are analyzed in Section 5.1. For exposition assume the following team production function:  $g(\alpha, \beta) = (\alpha + \beta)\kappa$  where  $\kappa$  measures synergy ( $\kappa > 1$ ). Let  $\alpha, \beta \in \{H, L\}$ , where  $H > L > 0$ , be independently and identically distributed as follows:

$$\Pr\{\alpha = H\} = \Pr\{\beta = H\} = p \in [0, 1] \quad (2)$$

<sup>10</sup>If it is greater than unity for one worker then it is less than unity for the other.

<sup>11</sup>Figure 1 was generated with  $g_H(\alpha, \beta) = \alpha + \beta + \alpha\beta$  and  $\gamma_H = \frac{5}{8}$ . Figure 2 was generated with  $g_L(\alpha, \beta) = \alpha + \beta + \frac{1}{4}\alpha\beta$  and  $\gamma_L = \frac{7}{13}$ .

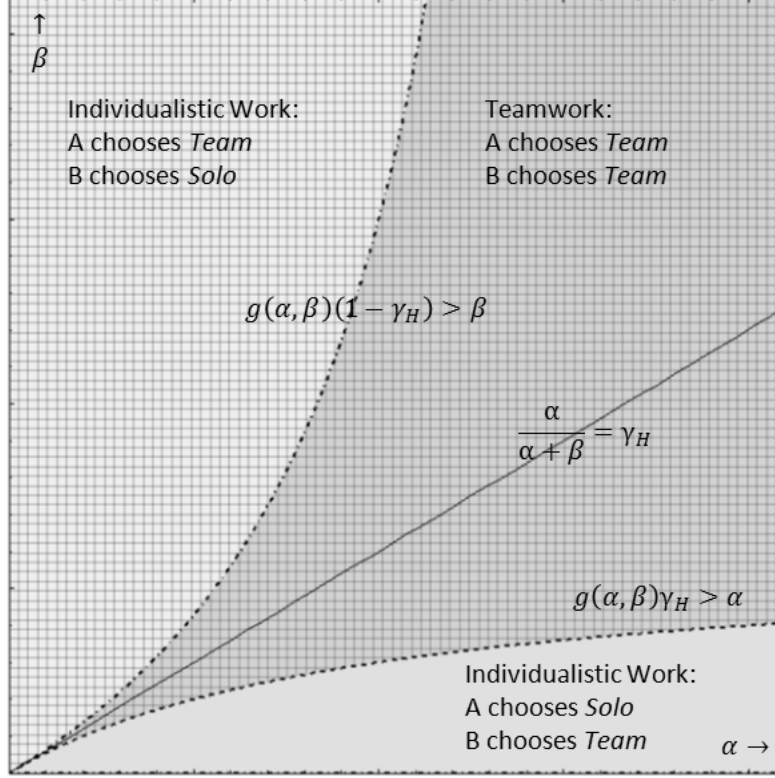


Figure 1: The joint ability sample space. Teams form in the (dark) overlapping region where both A chooses teamwork (meshed region with dashed border) and B chooses teamwork (shaded region with dot-dashed boarder).

I first establish the intuitive result that if workers believe that no discrimination exists, then, in this completely symmetric world with fair management, none will. But such beliefs are not enough to guarantee that talented individuals will cooperate with those less so—in fact, as we will see, egalitarianism may impede it.

**Proposition 1** (a) *Egalitarianism (i.e.  $\gamma = \frac{1}{2}$ ) is always an equilibrium.* (b) *Under egalitarianism, teams always form if synergy is strong enough (i.e.  $\kappa > \kappa_4$ , where  $\kappa_4 = \frac{2H}{H+L}$ ), but low synergy (i.e.  $\kappa \leq \kappa_4$ ) induces only homogeneous (i.e.  $\alpha = \beta$ ) teams.*<sup>12</sup>

**Proof.** When  $\kappa > \frac{2H}{H+L}$ ,  $(C_A)$  and  $(C_B)$  are satisfied for all  $\alpha$  and  $\beta$ . When  $\kappa \leq \frac{2H}{H+L}$ ,  $(C_A)$  and  $(C_B)$  are satisfied if and only if  $\alpha = \beta$ . In both cases  $\frac{1}{2} = E \left[ \frac{\alpha}{\alpha + \beta} \mid team, \gamma = \frac{1}{2} \right]$  by symmetry. ■

Since workers have iid ability, if they believe management thinks observable characteristics are orthogonal to ability, workers will disregard observables in choosing teammates.

<sup>12</sup>The notation for indexing key synergy levels can be thought of in the following way:  $\kappa_4$  is the threshold above which all four possible ability realizations form a team under egalitarianism,  $\kappa_3$  and  $\kappa_4$  represent the thresholds between which three but not four realizations will form teams if beliefs are those specified in Proposition 2. Finally  $\kappa_2$  represents the threshold below which one realization, but not two will form if beliefs are those specified in Proposition 3.

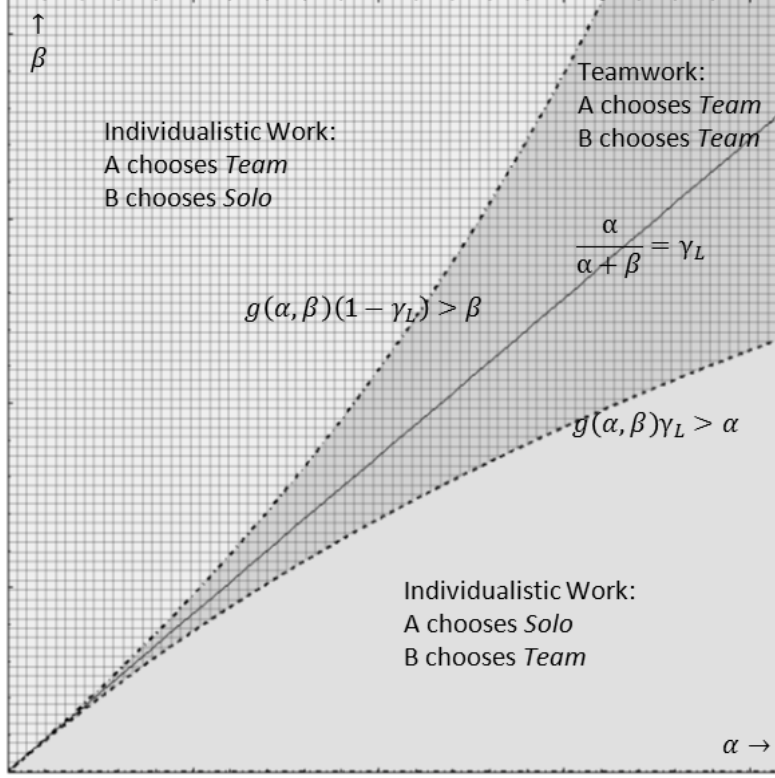


Figure 2: Belief that discrimination is lower rotates the team forming region toward the 45 degree line. Lower synergy shinks the team forming region around the central locus of pairings with discriminatory alignment = 1.

Fair managers will then disregard observables too, and egalitarianism will be an equilibrium. Proposition 1 part (a) holds for all distributions and production functions (see the Appendix for a proof).

Even absent any discrimination, teams will not always form, though teamwork is efficient. Thus, egalitarianism does not alleviate adverse selection. Proposition 1 part (b) can be restated for general distributions and productions functions: *Under egalitarianism, a team will form iff the synergy of production is greater than the difference in worker abilities* (see the Appendix for a proof).

As synergy declines in an egalitarian world, only individuals of very similar ability will team up. If synergy results from labor specialization or leadership, this homogeneity may be undesirable. In fact, Hamilton, *et al.* (2003) find that, with average ability held constant, heterogeneous teams are more productive.<sup>13</sup> Figure 3 graphically depicts the team forming region of the ability sample space when  $\kappa < \kappa_4$ ; observe that heterogenous pairings  $\langle H, L \rangle$

<sup>13</sup>The reader will observe that  $g(\alpha, \beta) = (\alpha + \beta)\kappa$  does not increase with heterogeneity of ability. Although a team production function with negative cross partials with respect to ability may reflect Hamilton et al's empirical findings better, the example function is conservative in that it overstates productivity under egalitarianism relative to discrimination. An in depth study of group production is beyond the scope of this paper.

and  $\langle L, H \rangle$  fall outside of the team forming region; they result in individualistic work.

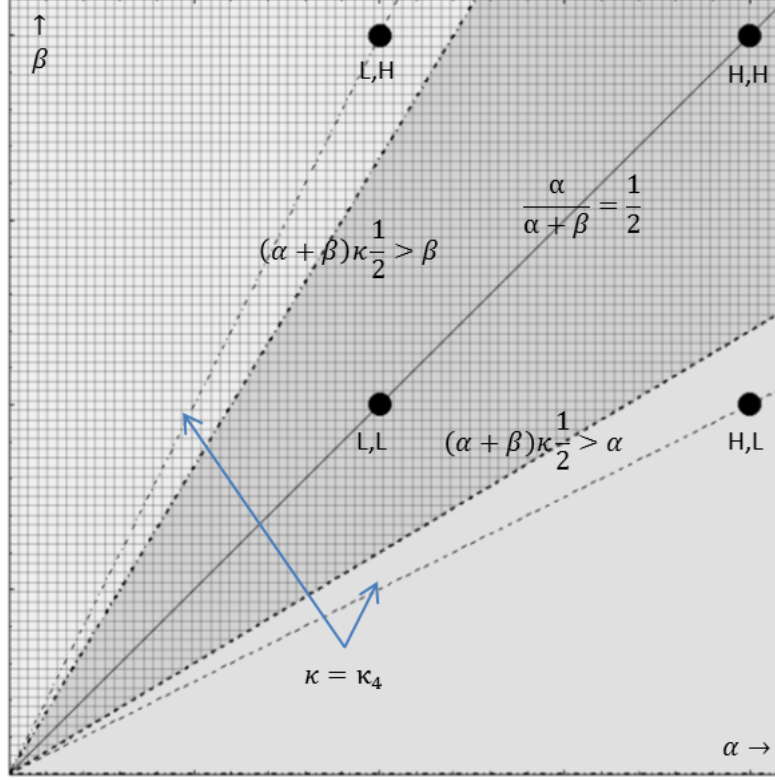


Figure 3: Egalitarianism is always an equilibrium, but when synergy is low ( $\kappa \leq \kappa_4$ ) adverse selection prevents teamwork between heterogenous pairings.

Each of the following two propositions identifies a discriminatory equilibrium. That is, if workers believe that discrimination (of a particular level) exists, they will form teams such that a fair manager will reinforce those beliefs. The first equilibrium is mild, causing both homogeneous and heterogeneous ability teams to form. The second equilibrium is severely discriminatory, and only heterogeneous teams form. Figures 4 and 5 illustrate the shift in team forming regions of the ability sample space as beliefs change.

**Proposition 2** *For intermediate synergy levels there exists a moderately discriminatory equilibrium in which both homogeneous teams and heterogeneous teams form. Formally,*

$$\kappa_3 < \kappa \leq \kappa_4 \implies \gamma_M = \frac{1}{2}p_e + \frac{H}{H+L}(1-p_e)$$

where

$$\kappa_3 = \frac{2H(1-p(1-p))}{H+L(1-2p(1-p))}, \quad \kappa_4 = \frac{2H(1-p(1-p))}{H(1-2p(1-p))+L}$$

and

$$p_e = \Pr\{\alpha = \beta \mid team\} = \frac{1-2p(1-p)}{1-p(1-p)}$$

is a discriminatory equilibrium in which realizations  $\langle \alpha, \beta \rangle \in \{\langle H, H \rangle, \langle H, L \rangle, \langle L, L \rangle\}$  form teams.

**Proof.** Let  $\gamma' = \frac{1}{2}p_e + \frac{H}{H+L}(1-p_e) = E\left[\frac{\alpha}{\alpha+\beta} \mid \langle \alpha, \beta \rangle \in \{\langle H, H \rangle, \langle H, L \rangle, \langle L, L \rangle\}\right]$ . Assume  $\gamma = \gamma'$ .  $(C_A)$  and  $(C_B)$  are satisfied for all  $\langle \alpha, \beta \rangle \in \{\langle H, H \rangle, \langle H, L \rangle, \langle L, L \rangle\}$  if and only if  $\kappa > \kappa_3$ .  $(C_B)$  is not satisfied for  $\langle \alpha, \beta \rangle = \langle L, H \rangle$  if and only if  $\kappa \leq \kappa_4$ . Thus,  $E\left[\frac{\alpha}{\alpha+\beta} \mid \text{team}\right] = \gamma'$ . ■

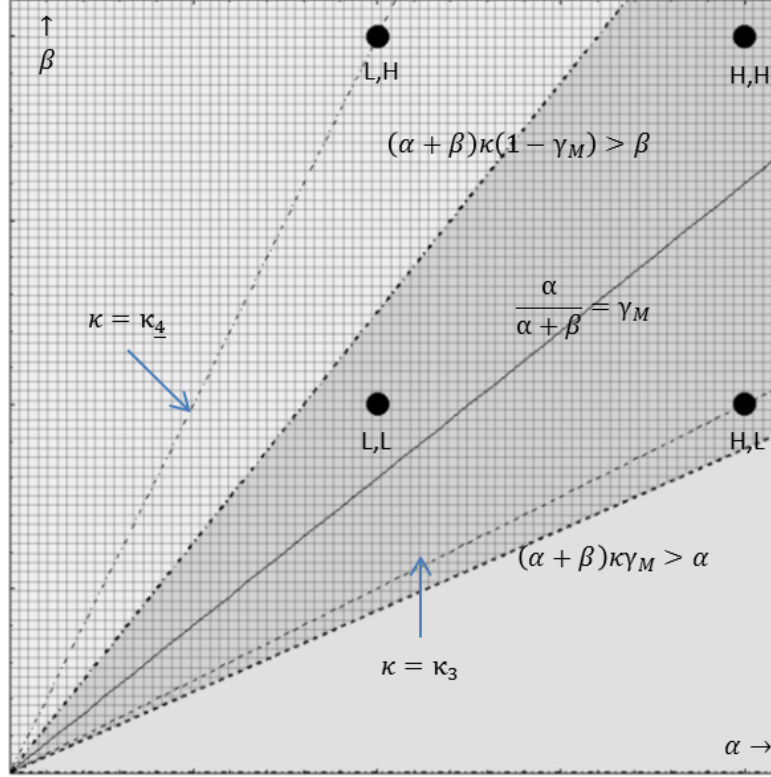


Figure 4: When synergy is moderate ( $\kappa_3 < \kappa \leq \kappa_4$ ) there exists a moderately discriminatory equilibrium, in which pairings  $\langle \alpha, \beta \rangle \in \{\langle H, H \rangle, \langle H, L \rangle, \langle L, L \rangle\}$  collaborate. If synergy increases to  $\kappa_4$  all pairings team up. If synergy falls below  $\kappa_3$  only homogenous teams form.

**Proposition 3** *If synergy is not extremely strong, then there exists a severely discriminatory equilibrium in which only heterogeneous teams form. Formally,*

$$\kappa \leq \kappa_2 \implies \gamma_s = \frac{H}{H+L}$$

where

$$\kappa_2 = \frac{H+L}{2L}$$

is a discriminatory equilibrium in which realizations  $\langle \alpha, \beta \rangle \in \{\langle H, L \rangle\}$  form teams.

**Proof.** Let  $\gamma' = \frac{H}{H+L} = E \left[ \frac{\alpha}{\alpha+\beta} \mid \langle \alpha, \beta \rangle = \langle H, L \rangle \right]$ . Assume  $\gamma = \gamma'$ .  $(C_A)$  and  $(C_B)$  are satisfied for  $\langle \alpha, \beta \rangle = \langle H, L \rangle$  if and only if  $\kappa > 1$ .  $(C_B)$  is not satisfied for  $\langle \alpha, \beta \rangle = \langle L, H \rangle$  if and only if  $\kappa \leq \frac{H}{L}$ .  $(C_B)$  is not satisfied for  $\langle \alpha, \beta \rangle \in \{\langle H, H \rangle, \langle L, L \rangle\}$  if and only if  $\kappa \leq \kappa_2 = \frac{H+L}{2L} < \frac{H}{L}$ . Thus,  $E \left[ \frac{\alpha}{\alpha+\beta} \mid team, \gamma' \right] = \gamma'$ . ■

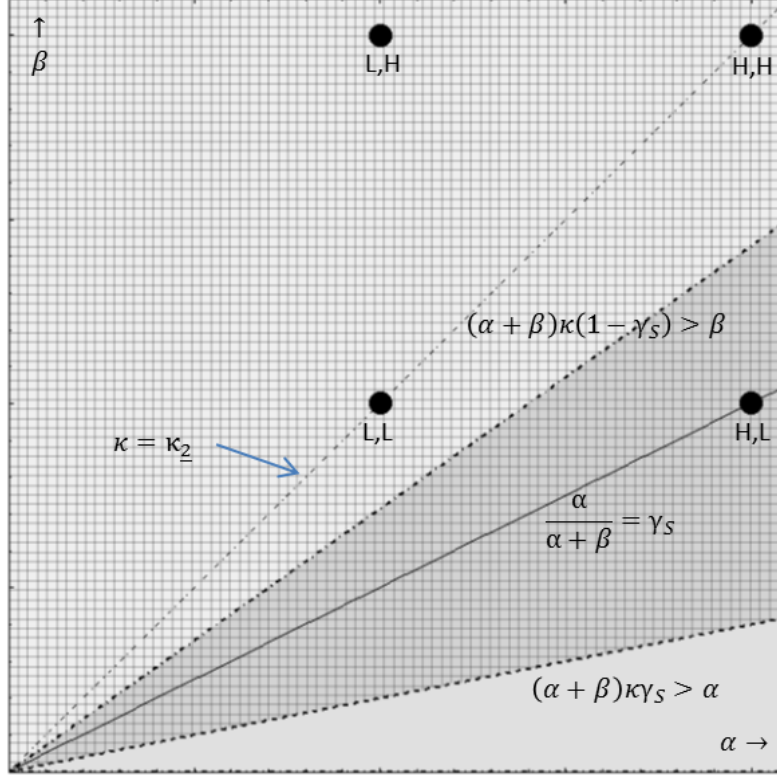


Figure 5: When synergy is very low ( $\kappa \leq \kappa_2$ ) and society believes discrimination is severe only pairings with discriminatory alignment = 1 will team up.

Propositions 1-3 say that if synergy is so strong that everyone chooses teamwork all the time, egalitarianism is the only equilibrium, but as it declines (1) discriminatory and egalitarian equilibria coexist (note that  $\kappa_3 < \kappa_4 < \kappa_4$  and  $\kappa_4 < \kappa_2$ ) and (2) adverse selection prevents efficient team formation under egalitarianism and discrimination alike.

Conventional wisdom holds that discriminating against anyone on an attribute that has no direct causal link to productivity cannot improve output and may very well be counterproductive. Indeed, since any pair working together produces more than the two working alone, in a first-best world all possible pairings would cooperate and egalitarianism would be the *only equilibrium*. But adverse selection creates a tension between social optimality and egalitarianism, because the severity of this adverse selection is not equal under both regimes—as  $\kappa$  falls below  $\kappa_4$  and until it falls below  $\kappa_3$  (always an open interval), more teamwork occurs under the discriminatory equilibrium of Proposition 2. In this case, conventional wisdom is specious:

**Proposition 4** (i) If synergy is moderate ( $\kappa_3 < \kappa \leq \kappa_4$ ) there exists a discriminatory equilibrium ( $\gamma = \frac{1}{2}p_e + \frac{H}{H+L}(1 - p_e)$ ) that is socially preferable to egalitarianism. (ii) If minorities gain more from additional teams formed under discrimination than they lose from discrimination in teams that exist under egalitarianism

$$(\kappa(H + L)(1 - \gamma) - L)p(1 - p) > \kappa(Hp^2 + L(1 - p)^2)(2\gamma - 1)$$

then both minorities and non-minorities are better off under the discriminatory equilibrium than egalitarianism.

**Proof.** Part (i): Since every team that forms under egalitarianism also forms under discrimination, and teams always outproduce their members working individually, part (i) is immediate.

Part (ii): Minorities and non-minorities as groups alike, prefer discrimination if and only if their expected returns under that regime are higher than under egalitarianism. Clearly, non-minorities always prefer discrimination—their payoff is strictly higher under discrimination when teams form (i.e.  $\langle \alpha, \beta \rangle \in \{\langle H, H \rangle, \langle H, L \rangle, \langle L, L \rangle\}$ ) and exactly the same when teams do not form under either regime (i.e.  $\langle \alpha, \beta \rangle \in \{\langle L, H \rangle\}$ ). On the other hand, minorities, as a group, prefer discrimination to egalitarianism iff

$$\begin{aligned} & \kappa(H + H)(1 - \gamma)p^2 + \kappa(H + L)(1 - \gamma)p(1 - p) \\ & + H(1 - p)p + \kappa(L + L)(1 - \gamma)(1 - p)^2 \\ & > \kappa(H + H)\frac{1}{2}p^2 + Lp(1 - p) + H(1 - p)p + \kappa(L + L)\frac{1}{2}(1 - p)^2 \end{aligned}$$

This simplifies to the form of the condition in part (ii) of the proposition. ■

The following simple numerical example verifies the existence of parameter sets which satisfy the conditions of Proposition 4 parts (i) and (ii):

**Example 1** If High ability is twice as potent as Low ability but equally common (i.e.  $H = 2, L = 1, p = \frac{1}{2}$ ) and synergy is moderate (i.e.  $\kappa = \frac{5}{4}$ ) society produces more under the discriminatory equilibrium (i.e.  $\gamma = \frac{5}{9}$ ) than the egalitarian one. Under egalitarianism, non-minorities and minorities both earn  $\frac{27}{16}$ , on average. Under discrimination, non-minorities earn  $\frac{29}{16}$  on average and minorities earn  $\frac{28}{16}$  on average.

Clearly discrimination harms many individuals—in the equilibrium of Proposition 4 minorities joining homogenous teams are harmed. By many moral frameworks, that alone justifies its eradication. If it also unequivocally harmed society’s overall productivity, policy aimed at ending discrimination could be justified on purely economic (utilitarian) grounds. Lamentably, Proposition 4 dispels such an unambiguous justification: *with respect to productivity, egalitarianism is not always socially preferable to discrimination; in fact, discrimination may be preferred by both minorities and non-minorities as groups.*<sup>14</sup> Proposition 4 highlights the potential tension facing policy makers between efficiency and equity.

<sup>14</sup>Lundberg and Startz’ (1983) conclude egalitarianism is always socially preferable. In their model, discrimination shifts training from individuals with lower costs for it to those with higher costs. In this one, discrimination may enable synergistic production when egalitarianism may not, and the increased productivity comes not from a change in the individual, but rather the choice of production technology.

What intuition lies behind this unsettling result? An increase in discrimination induces some new teams to form and some existing ones to break up. The new teams' increased output is a societal gain, but society loses output from those individuals formerly working on teams. Whether or not the gain exceeds the loss depends on the specific distribution of ability and team production function.

If synergy is very low only those teams near the central locus will form; the productivity difference between egalitarianism and discrimination (and individual work) is minimal. As synergy increases, the productivity difference can grow. Although beyond the scope of this model, in which the manager is constrained to be fair, these observations suggest that managers in moderately synergistic industries may have incentive to be discriminatory and *unfair*, as it may be profitable.

Despite the fact that the manager here cannot strategically *choose* to be discriminatory, both egalitarianism and discrimination are equilibria in the moderate synergy range ( $\kappa_3 < \kappa \leq \kappa_4$ ). The following evolutionary argument refines these equilibria. Suppose that the synergy of team production varies over a range of industries, each comprised of many competing firms. Some firms in each industry choose seniority based compensation (i.e. discriminatory) schemes while others compensate teammates equally. In industries with moderate ( $\kappa_3 < \kappa \leq \kappa_4$ ) synergy levels only seniority based firms survive due to the efficiency gains of discrimination, and, of course, seniority both reflects the relative contribution of teammates and is the right competitive “strategy” ex post. In industries with synergy outside this range, egalitarian firms dominate.

The productivity of society is the productivity of its members. The equilibrium definition describes the relative productivity of minorities and non-minorities on teams, but what about those working alone? And minorities versus non-minorities overall? Victims and beneficiaries remain statistically identical with respect to ability across the population at large, but not among those working on teams—this is precisely why a fair manager can discriminate after observing the teamwork decision.

**Proposition 5** *Among those working individually, discrimination victims outperform beneficiaries on average.*

**Proof.** The proposition can be formally written

$$E[\alpha \mid solo] < E[\beta \mid solo]$$

which can be verified under each discriminatory equilibrium.

Case  $\gamma = \frac{H}{H+L}$ :

$$\frac{Hp^2 + Lp(1-p) + L(1-p)^2}{1-p(1-p)} < \frac{Hp^2 + Hp(1-p) + L(1-p)^2}{1-p(1-p)}$$

Case  $\gamma = \frac{1}{2}p_e + \frac{H}{H+L}(1-p_e)$ :

$$L < H$$

■

The model predicts greater success for self-selected minority entrepreneurs. Very able discrimination victims have the lowest discriminatory alignment, especially when potential

partners are incompetent, and thus have the greatest incentive to work as individuals. Since a rejection of teamwork induces victim and beneficiary alike to work independently, victims have higher average ability in the solo working population. This intuition holds for general distributions and production functions (see the Appendix for a proof).

In the model presented here, a rejection by either teammate means both work alone. However, one of the teammates would have preferred teamwork. If either had another potential teamwork opportunity he might try again. Thus, in a market for teammates, the probability of rejection matters. The following two lemmas show that when teamwork is endogenous, adverse selection works causes two groups to eschew teamwork: (1) talented individuals and (2) discrimination victims.

**Lemma 1** *Talented individuals reject teamwork more often.*

**Proof.** Let  $\tilde{A}$  be the event that  $A$  rejects teamwork (i.e.  $g(\alpha, \beta)\gamma \leq \alpha$ ) and  $\tilde{B}$  be the event  $B$  rejects teamwork (i.e.  $g(\alpha, \beta)(1 - \gamma) \leq \beta$ ). Given that there is a rejection, the probability that the more able did it (recall that only one worker will reject due to synergy) can be written

$$\Pr\{\tilde{A} \mid \alpha > \beta\} + \Pr\{\tilde{B} \mid \alpha < \beta\} > \Pr\{\tilde{B} \mid \alpha > \beta\} + \Pr\{\tilde{A} \mid \alpha < \beta\}$$

where all probabilities are conditional on  $\tilde{A} \cup \tilde{B}$ . This holds iff

$$\begin{aligned} & \Pr\{\tilde{A} \mid \alpha > \beta\} + 1 - \Pr\{\tilde{A} \mid \alpha < \beta\} > 1 - \Pr\{\tilde{A} \mid \alpha > \beta\} + \Pr\{\tilde{A} \mid \alpha < \beta\} \\ \iff & \Pr\{\tilde{A} \mid \alpha > \beta\} > \Pr\{\tilde{A} \mid \alpha < \beta\} \\ \iff & \Pr\{g(\alpha, \beta)\gamma \leq \alpha \mid \alpha > \beta\} > \Pr\{g(\alpha, \beta)\gamma \leq \alpha \mid \alpha < \beta\} \end{aligned}$$

which is always true. ■

**Lemma 2** *Discrimination victims reject teamwork (with beneficiaries) more often.*

**Proof.** By symmetry,  $\gamma > \frac{1}{2} \iff \Pr\{g(\alpha, \beta)\gamma \leq \alpha\} < \Pr\{g(\alpha, \beta)(1 - \gamma) \leq \beta\}$  ■

This suggests that talented individuals and discrimination victims reject teamwork more overall, choosing different work than discrimination beneficiaries and those of lesser ability. This may explain why Russia's entrepreneurs are smart and short (see introduction). Likewise, as suggested by the occupational segregation in sports (also highlighted in the introduction), even among those traditionally employed, discrimination victims and the gifted will choose individually measurable occupations over synergistic ones.

The natural context in which to empirically measure discrimination is when minorities and non-minorities are working side by side, such as within firms. Since, job duties can be compared and management is consistent, it is the setting in which legal disputes over workplace discrimination are most easily waged. And indeed, discrimination in these team settings is precisely what the model captures, but minority and non-minority workers in teams do not represent the populations as a whole, because occupational choice is endogenous. Thus, this measure of discrimination does not reflect the overall adversity faced by minorities in the population. Since, by Proposition 5, discrimination victims outperform beneficiaries when working individually, the following is immediate:

**Proposition 6** *Discrimination victims receive more than  $1 - \gamma$  of total societal output on average.*

A high ability minority worker can opt out of discriminatory teams, say by choosing entrepreneurship or another occupation where individual contribution is more measurable. Thus, measuring discrimination as wage differences only within team settings overestimates the overall negative relative impact of discrimination on minorities—there is a selection bias due to the entrepreneurial choices of talented minorities. In fact, as the following example paradoxically shows, the total relative impact of discrimination on minorities need not be negative at all.

**Example 2** *If High ability is rare (i.e.  $p = \frac{1}{8}$ ), but very potent relative to Low ability (i.e.  $H = 20$  and  $L = 1$ ), and synergy is strong (i.e.  $\kappa = \frac{7}{4}$ ), then  $\gamma = \frac{5}{9}$  is a discriminatory equilibrium—non-minorities receive 125% (i.e.  $\frac{\gamma}{1-\gamma}$ ) what minorities do in teams. Despite the high synergy of teamwork, the presence of discrimination and the relative rarity of individual work (i.e.  $\frac{7}{64} \approx 11\%$  of the time), minorities receive over 127% of the credit that non-minorities receive overall.*

Proposition 5, Lemmas 1 and 2 as well as Proposition 6 hold under any discriminatory beliefs, even if those beliefs are not confirmed by a fair manager; that is,  $\gamma$  need not be a self-reinforcing BNE. For example, even if the manager has a preference for employees of one race over another (i.e. she is not fair) as is assumed in some other models of discrimination (e.g. Becker, 1957), talented minorities will *still strategically respond* by opting out of teams. We conclude the basic analysis by considering some comparative statics of the self reinforcing equilibrium of the model.

In one industry all workers may produce at similar levels, but in another the gap between highly productive workers and low productivity ones may be large. How does this production sensitivity to ability impact discrimination? Can different industries support different levels of statistical discrimination?

**Proposition 7** *As the ability gap between High and Low types increases, so does (a) discrimination (in any discriminatory equilibrium) and (b) the maximum synergy, for which discriminatory equilibria exist.*

**Proof.** (a)  $\frac{d\gamma}{dH} > 0$  and  $\frac{d\gamma}{dL} < 0$  for both discriminatory equilibria. (b)  $\frac{d\kappa_A}{dH} > 0$ ,  $\frac{d\kappa_A}{dL} < 0$ ,  $\frac{d\kappa_2}{dH} > 0$  and  $\frac{d\kappa_2}{dL} < 0$ . ■

Proposition 7 predicts that discrimination will be stronger in occupations, in which the (relevant) ability of workers exhibits higher variance. To see the intuition behind part (a) recall that discriminatory beliefs are an equilibrium, because on teams the expected type of beneficiaries is higher than victims’—either beneficiaries (on teams) are more likely to be High ability, less likely to be Low ability or both. Thus, if High increases or Low decreases, the expected ability gap increases and so does discrimination. The intuition behind part (b) is also simple. A High ability worker will work with a Low ability worker even if he believes he will be the victim of discrimination, *so long as synergy is high enough*. If this happens, a fair manager cannot discriminate (i.e. discrimination cannot be an equilibrium). But if the

ability gap between these two increases even more, then these two may not work together, and now a fair manager must discriminate.

The model provides a way to analyze discriminatory settings in which existing theory says little. Although applications of the model are varied, one familiar to many readers is academic coauthoring. Einav and Yariv (2006) show that the probability of receiving tenure at a top economics department declines significantly with the alphabetic ordering of one's surname initial, even when accounting for country of origin, ethnicity and religion. This discrimination is difficult to analyze with existing economic models of discrimination—it is hard to imagine that a taste for individuals with last names beginning with A exists, that their discourse is somehow different from those with last names beginning with B, or that their childhood environment has been so different that they have endogenously acquired different human capital. It is not farfetched, though, that economics researchers with surname initials at the end of the alphabet may choose coauthors (teamwork) strategically, given the discriminatory convention of alphabetic surname ordering on economics publications. By casting the body of academic peers in the role of a merit-fair manager (credit allocator) the coauthoring (team-formation) decision may be analyzed with the predictions of the model. Proposition 5 predicts that the solo work of authors with surname initials near the end of the alphabet are of higher quality than the solo work of authors near the beginning of the alphabet. If the variance in ability at a department increases with its rank, as one would expect if top departments are drawing from the thin right tail of the talent distribution, then Proposition 7 predicts discrimination will be strongest within the highest tiered departments.

## 5 Extensions

The simple model can be generally extended in several ways: (1) ability distributions and production functions can be made general, (2) a market for teammates can be added, (3) workers may have incomplete information about potential teammates' ability, (4) the credit split can be made contractible on the output, and (5) the sharing rule can be changed. In this section, I consider these extensions individually—discriminatory equilibria survive all of them.

### 5.1 General Ability Distributions and Production Functions

One might worry that the existence of discriminatory equilibria is an artifact of the two type model or a very specific team production function. The next two propositions reassure that they are not. One additional definition is required:

**Definition 1** *If an individual with no ability whatsoever joins a team and production is not improved (i.e.  $g(x, 0) = x$ ), and teamwork amplifies ability (i.e.  $\frac{d}{d\alpha}g(\alpha, \beta) > 1 \forall \alpha, \beta \geq 0$ ) then team production is regular.*

**Example 3**  $g(\alpha, \beta) = \alpha + \beta + \kappa\alpha\beta$  is a regular production function.

**Proposition 8** *If team production is regular, and ability is continuously distributed with support from 0, then at least one discriminatory equilibrium ( $\gamma \in (\frac{1}{2}, 1)$ ) exists in which teams form.*<sup>15</sup>

**Proof.** The proof in the Appendix has the following steps: (1)  $\lim_{\gamma \rightarrow 1} E \left[ \frac{\alpha}{\alpha + \beta} \mid team, \gamma \right] = 1$ , (2)  $\lim_{\gamma \rightarrow 1} \frac{d}{d\gamma} E \left[ \frac{\alpha}{\alpha + \beta} \mid team, \gamma \right] < 1$ , (3)  $\frac{d}{d\gamma} E \left[ \frac{\alpha}{\alpha + \beta} \mid team, \gamma \right] \big|_{\gamma=\frac{1}{2}} = 0 < 1$  and (4) this implies  $E \left[ \frac{\alpha}{\alpha + \beta} \mid team, \gamma \right]$  has a fixed point in  $(\frac{1}{2}, 1)$ . ■

Proposition 8 provides a sufficient but unnecessary condition for discriminatory equilibria to exist. There may be many such equilibria; Proposition 8 simply says that under reasonable conditions, *at least one* set of discriminatory beliefs exists such that workers will choose teamwork strategically such that a fair manager will confirm those beliefs. Regularity guarantees that the second step of the proof holds—many irregular production functions also satisfy the second step of the proof but must be handled on a case by case basis.

The concept of BNE, considered so far, is precise—an equilibrium exists whenever  $\gamma = E \left[ \frac{\alpha}{\alpha + \beta} \mid team, \gamma \right]$ . If private worker abilities can be uncovered, then empirical analysis can only tell us that  $\gamma$  is sufficiently close to  $E \left[ \frac{\alpha}{\alpha + \beta} \mid team, \gamma \right]$ . This, as the following proposition highlights, is a much looser condition than BNE and may hold for a very wide set of beliefs that are not, strictly speaking, equilibria.

**Proposition 9** *If ability is continuously distributed with support from 0 and synergy is low enough, the credit split of a fair manager will be arbitrarily close to confirming any beliefs. Formally, if synergy is measured by  $\kappa_{a\beta} = g(\alpha, \beta) - \alpha - \beta$ , then for all  $\varepsilon > 0, 0 < \kappa_{a\beta} \leq \varepsilon(\alpha + \beta) \implies \left| \gamma - E \left[ \frac{\alpha}{\alpha + \beta} \mid team, \gamma \right] \right| < \varepsilon$ .*

**Proof.**

$$\begin{aligned} & \left| \gamma - E \left[ \frac{\alpha}{\alpha + \beta} \mid team, \gamma \right] \right| \\ &= \left| \gamma - E \left[ \frac{\alpha}{\alpha + \beta} \mid g(\alpha, \beta)\gamma > \alpha, g(\alpha, \beta)(1 - \gamma) > \beta \right] \right| \\ &= \left| \gamma - E \left[ \frac{\alpha}{\alpha + \beta} \mid -\left( \frac{\kappa_{a\beta}}{\alpha + \beta} + 1 \right) \gamma < -\frac{\alpha}{\alpha + \beta} < \left( \frac{\kappa_{a\beta}}{\alpha + \beta} + 1 \right) (1 - \gamma) - 1 \right] \right| \\ &= \left| E \left[ \gamma - \frac{\alpha}{\alpha + \beta} \mid -\gamma \frac{\kappa_{a\beta}}{\alpha + \beta} < \gamma - \frac{\alpha}{\alpha + \beta} < (1 - \gamma) \frac{\kappa_{a\beta}}{\alpha + \beta} \right] \right| \end{aligned}$$

Thus, for all  $\kappa_{a\beta} \leq \varepsilon(\alpha + \beta)$  the above reduces to

$$= \left| E \left[ \gamma - \frac{\alpha}{\alpha + \beta} \mid -\gamma\varepsilon \leq -\gamma \frac{\kappa_{a\beta}}{\alpha + \beta} < \gamma - \frac{\alpha}{\alpha + \beta} < (1 - \gamma) \frac{\kappa_{a\beta}}{\alpha + \beta} \leq (1 - \gamma)\varepsilon \right] \right| < \varepsilon$$

■

Low synergy produces not only few teams but ones in which discriminatory beliefs reflect workers' respective actual, not just expected, abilities quite precisely. Thus, when synergy is very low, any discrimination level is close to an equilibrium.

<sup>15</sup>Obviously, beliefs  $\gamma \in \{0, 1\}$  are always discriminatory equilibria; however, since no teams form under these beliefs, they are of little interest by themselves.

This observation presents an empirical challenge. For example, the 1963 Equal Pay Act says that US employers must pay employees equally for equal work; however, the burden of establishing a prima facie case that different wages are paid to employees of the opposite sex and that the employees perform substantially equal work belongs to the employee. While US law prohibits even statistical discrimination, this burden of proof amounts to showing that the proportion of wages paid to men  $\gamma$  is statistically different from their proportional (expected) work  $E\left[\frac{\alpha}{\alpha+\beta} \mid team, \gamma\right]$ —an employee must show  $\left|\gamma - E\left[\frac{\alpha}{\alpha+\beta} \mid team, \gamma\right]\right| > \varepsilon$ , where  $\varepsilon$  is the measurement error. Proposition 9 implies that establishing that meritocracy is not functioning may be more difficult in low synergy industries, because the measurement error must be smaller.

## 5.2 Frictionless Market for Teammates

The basic model implicitly assumes no market for teammates; a rejection by either teammate means both work alone. Of course, in the real world, the outside option of an individual deciding whether or not to join a team, is not usually limited to working alone, but rather includes working on one of several different teams. Here I examine the extreme opposite situation, namely that the market for teammates is frictionless—every worker in the economy is a potential teammate. I will show that, even in this extreme case, discriminatory equilibria can still exist, and thus we should expect them in a more realistic market with frictions.

Suppose all workers who reject teamwork (or are rejected) randomly draw new potential teammates from the pool of individual workers until every worker (a) finds a teammate, (b) rejects or is rejected by all remaining individual workers. Without loss of generality, assume minorities and majorities each have an even number of individuals with each supported ability.

**Lemma 3** *In a frictionless market for teammates, no one works individually.*

**Proof.** Suppose someone chose to work individually. By symmetry another identical worker also did. These two could team up without facing discrimination and, because team production is synergistic, both be better off, a contradiction. ■

Can discrimination exist in a frictionless market for teammates? For simplicity, assume ability distributed as in (2) and that all workers assume discrimination exists. Clearly, High ability victims will always work together to avoid discrimination. Similarly Low ability beneficiaries will work together because no one else will work with them. Thus, if a heterogeneous team were to form, it could only be between a High ability beneficiary and a Low ability victim. A fair manager, seeing a team, would know this and divide credit accordingly:  $\gamma = \frac{H}{H+L}$ . These teams would form if and only if both parties prefer this heterogeneous team to working with their peers (i.e. those with identical discriminatory attribute and ability):

$$g(H, L) \frac{H}{H+L} > g(H, H) \frac{1}{2} \quad (M_A)$$

$$g(H, L) \frac{L}{H+L} > g(L, L) \frac{1}{2} \quad (M_B)$$

Thus, we have proved the following proposition:

**Proposition 10** *In a frictionless market for teammates, discrimination in which  $A$ 's and  $B$ 's cooperate can exist if and only if heterogeneous teams are sufficiently more productive than homogeneous ones (i.e.  $(M_A)$  and  $(M_B)$  are satisfied); otherwise discriminatory beliefs completely segregate society.*

**Example 4**  $g(\alpha, \beta) = \alpha + \beta + |\alpha - \beta|\kappa$  satisfies  $(M_A)$  and  $(M_B)$ .

As noted previously, Hamilton, *et al.* (2003) empirically find that heterogeneous teams produce more. So, one should not be surprised to find discriminatory compensation even if a perfect markets for teammates existed. Since, discriminatory equilibria exist both when the market for teammates does not exist and when it has no frictions, one can reasonably conclude that they exist in a more realistic imperfect market for teammates.

Lemma 2 suggested one cause of occupational segregation, namely that minorities will prefer occupations where individual contribution is more easily measured. Proposition 10 highlights a second possible cause of occupational segregation that exists even when there are no substantive differences between jobs—minorities may simply choose to team with other minorities to strategically eliminate the possibility of discrimination.

### 5.3 Incomplete Information

Although teammates almost certainly know each other's ability better than their manager, it could be difficult to know exactly how much a potential partner will contribute before production occurs. What if signals of a potential teammate's ability were noisy?

At the one extreme, workers may be able to communicate their types to each other almost perfectly. Suppose that there are finitely many ability types, and that with probability  $\sigma$  worker  $i$  observes  $j$ 's true ability and with probability  $1 - \sigma$  he observes a uniform draw from the type space instead. If the noise is small (i.e.  $\sigma$  is very near 1), then, since each worker type has a strict incentive to join a team (or not), the resulting team formation distribution will be arbitrarily close to the complete information specification. As a consequence, the manager's beliefs about the relative abilities of  $A$  and  $B$  workers will be arbitrarily close as well and all equilibria under complete information will persist in a model with slightly noisy signals.

At the other extreme, workers could observe nothing about each other's ability *ex ante*. In this extreme case, workers have the same information about the other worker as their manager. Here it is convenient to invoke the simple two type model again. The following lemma proves useful in analyzing this case:

**Lemma 4** *Suppose workers have no specific information about potential teammates' types. In all equilibria, untalented  $A$  workers always choose teamwork.*

The above lemma follows directly from the fact that all teamwork is synergistic and  $A$  will capture at least half of the product.

From the lemma it is immediately clear that a number of the equilibria identified in Section 4 no longer exist. The severely discriminatory equilibrium of Proposition 2 cannot survive—low ability  $A$  workers will sneak into teams too. Since low ability  $A$  workers will also sneak into teams with high ability  $B$ s in the moderately discriminatory equilibrium of

Proposition 3, this equilibrium also breaks. Given that both discriminatory equilibria from the complete information case no longer exist, one may doubt whether discrimination is possible when workers have no specific information about the ability of potential teammates. However, the following proposition shows that new discriminatory equilibria can arise when information is imperfect:

**Proposition 11** *When workers have no specific information about potential teammates' ability and synergy is linear ( $g(\alpha, \beta) = (\alpha + \beta)\kappa$ ) there always exists a non-empty synergy range*

$$\kappa_A = \frac{H}{(H+L)\gamma} < \kappa \leq \frac{H}{(2Hp + (H+L)(1-p))(1-\gamma)} = \kappa_{\bar{B}}$$

where

$$\gamma = \frac{H}{H+L}p + \frac{1}{2}(1-p)$$

is a discriminatory equilibrium, in which teams  $\langle \alpha, \beta \rangle \in \{\langle H, L \rangle, \langle L, L \rangle\}$  form.

**Proof.** The proposition describes a pure strategy equilibrium— $A$  always chooses teamwork and  $B$  chooses teamwork iff and only if his type is  $L$ . Therefore a team, if formed, will have composition

$$\langle \alpha, \beta \rangle = \begin{cases} \langle H, L \rangle & \text{with probability } p \\ \langle L, L \rangle & \text{with probability } 1-p \end{cases}$$

and the equilibrium (if it exists) will consist of the beliefs specified in the proposition. Now check the participation constraints of all types.

From Lemma 4 untalented  $A$  workers (regardless of production function) choose teamwork.

Now I will show that for any team production function exhibiting increasing differences, including when synergy is linear, untalented  $B$ s also choose teamwork. Formally,

$$(g(H, L)p + g(L, L)(1-p))(1-\gamma) > L \quad (3)$$

After substituting the equilibrium beliefs  $\gamma$ , the second derivative of the left hand side (LHS) with respect to  $p$  is

$$-2 \left( \frac{H}{H+L} - \frac{1}{2} \right) (g(H, H) - g(L, H))$$

which is strictly negative, because  $g$  exhibits increasing differences. This concavity implies that the LHS of (3) has a minimum at  $p \in \{0, 1\}$ . When  $p = 0$  the LHS of (3) reduces to  $\frac{1}{2}g(L, L)$ , which is strictly greater than the right hand side  $L$ . Similarly, when  $p = 1$  the LHS of (3) reduces to  $L \frac{g(H, L)}{H+L}$ , which is also strictly greater than the right hand side  $L$ . Thus (3) always holds—untalented  $B$ s never wish to deviate.

With linear synergy talented  $A$ s choose teamwork iff

$$(H+L)\kappa\gamma > H$$

which reduces to the lower bound of the synergy range specified by the proposition.

Talented  $B$ s choose individualistic work (i.e. they cannot deviate) iff

$$((H + H)p + (L + H)(1 - p))\kappa(1 - \gamma) \leq H$$

which reduces to the upper bound of the synergy range.

Finally, the synergy range of the lemma is non-empty if and only if the lower boundary is strictly less than the upper. Cross multiplying yields

$$\frac{2Hp + (H + L)(1 - p)}{H + L} < \frac{\gamma}{1 - \gamma} = \frac{2Hp + (H + L)(1 - p)}{2Lp + (H + L)(1 - p)}$$

which always holds. ■

Note that the parameters of Example 1 also lead to a discriminatory equilibrium when workers cannot communicate information about their ability, but discrimination is stronger ( $\gamma = \frac{7}{12}$ ) now, because homogenous high ability teams no longer form—incomplete information increases the potential for adverse selection. This is intuitive, since talented minorities cannot afford the risk that their non-minority teammate may not be as gifted.

Thus, discriminatory equilibria may exist whether the signal noise is arbitrarily small or arbitrarily large, although the possible equilibria may, in fact, change with signal quality. More fundamentally, discrimination does not arise just because the workers are communicating something to each other that the manager cannot observe. Rather the opportunity for discrimination comes from the fact that the workers cannot credibly reveal information to the manager—not being able to reveal that information to teammates only make the potential for adverse selection and discrimination worse. Recognizing this fact, the implicit assumption that potential teammates cannot transfer utility to each other does not seem artificially limiting—when teammates cannot credibly communicate their type *ex ante*, offering a side payment for cooperation (to offset discrimination) is infeasible.

Incomplete information also increases adverse selection under egalitarian beliefs. Notice that Lemma 4 also implies that even under egalitarian beliefs high ability workers cannot guarantee that their potential team is similarly skilled. So, if synergy is not strong enough to induce teams of heterogenous ability ( $\kappa \leq \frac{2H}{H+L} = \kappa_A$ ), high ability workers (both  $A$  and  $B$ ) will eschew teamwork—their potential teammates may not be competent enough to justify splitting credit with them. Thus, without high synergy, only untalented workers will team up together under egalitarian beliefs and incomplete information.

Furthermore, it is always true that  $\kappa_A < \kappa_4 < \kappa_B$ . So, there always a non-empty synergy interval where the following two equilibria co-exist: (1) under egalitarian beliefs only untalented workers cooperate, and (2) under discriminatory beliefs both untalented workers cooperate and talented non-minorities cooperate with untalented minorities. The set of teams formed under egalitarianism is a proper subset of those formed under discrimination. So, the following version of Proposition 4 is immediate:

**Proposition 4 (Incomplete Information)** *When workers have no specific information about potential teammates' ability and synergy is linear ( $g(\alpha, \beta) = (\alpha + \beta)\kappa$ ), if  $\kappa_A < \kappa \leq \kappa_4$ , then society produces more and both minorities as well as non-minorities are better off under the discriminatory equilibrium than egalitarianism.*

Although discriminatory equilibria may still exist and Proposition 4 even sharpens when workers have no *ex ante* information about their teammates' abilities, notice that if synergy

is low enough, discriminatory equilibria disappear altogether. Why? Intuitively, it is because the lowest ability workers always have the greatest incentives to join teams—although this is especially true of beneficiaries of discrimination, it is also true of untalented victims. Talented workers know this and, when informed about potential teammates’ abilities, can cooperate selectively. Without this information, though, talented workers take a risk on the abilities of their teammates, a risk that can be offset by synergy; however, with very little synergy, only the lowest ability workers can afford the risk of blind cooperation. Thus, due to the symmetry of the model, only egalitarianism survives.

Of course, the manager may also get some signal of her employees’ abilities. In this model, output itself is a strong signal of worker abilities. In the next section, I consider the impact of such a signal on equilibria.

## 5.4 Equilibria with Contractible Output

Previous analysis assumes that the fractional credit split did not depend on the realized output. The system of offering a salary to join a team and a proportional bonus based on company profitability fits this setting. The total bonus amount is tied to team output, but the fraction relative to one’s peers is not. Similarly, corporate shares and options are typically divvied up before their exercisable worth is ever known; an output contractible split is impossible. Some compensation schemes, though, do recognize team output when splitting the reward. For example, Senior team member bonuses may more closely tied to team output than Junior members’.

Could the existence of discriminatory equilibria stem from the manager’s inability to contract on the realized output? After all, the manager learns a great deal about her employees’ abilities from the team’s output. This subsection shows that discriminatory equilibria can exist even when the manager can contract on team output.

This requires that the credit split be a function of team output,  $\gamma(Q)$ , where  $Q = g(\alpha, \beta)$ . Theoretically, very little changes. The definition of equilibrium beliefs changes to

$$\gamma(Q) = E \left[ \frac{\alpha}{\alpha + \beta} \mid g(\alpha, \beta)\gamma(Q) > \alpha, g(\alpha, \beta)(1 - \gamma(Q)) > \beta \right]$$

This means the belief set is much more complex; workers must have beliefs for each possible output level. Without additional restrictions imposed on equilibria, workers may rationally believe that the manager severely discriminates if she observes low output, moderately discriminates if she observes typical output and does not discriminate at all for exceptional output. It is not difficult to see that, in general, describing even a single complete set of beliefs could be extremely cumbersome (not just as a researcher, but also as a manager or worker). Nevertheless, a few examples reveal that discriminatory equilibria may exist, even when the manager can contract on the extra information contained in the output itself.

**Example 5** *Assume abilities are distributed  $H > M = \frac{H+L}{2} > L > 0$  each arising with equal probability and linear synergy,  $g(\alpha, \beta) = (\alpha + \beta)\kappa$ . If the manager sees a team produce  $Q = (H + L)\kappa = 2M\kappa$  then she does not know exactly what each worker contributed. It can be shown that if  $\frac{2(H+L)}{H+3L} < \kappa \leq \frac{4H}{H+3L}$ , then  $\gamma(2M\kappa) = \frac{1}{2} \frac{H}{H+L} + \frac{1}{4}$  is an equilibrium belief,*

which forms a team if and only if  $\langle \alpha, \beta \rangle \in \{\langle H, L \rangle, \langle M, M \rangle\}$ .<sup>16</sup>

This example illustrates that although the manager may gain some information from output, she cannot, in general, completely resolve employee contributions, and thus the opportunity for discrimination persists. Furthermore, while it is clear that the above example is constructed to make this point, a manager would have even greater difficulty resolving contribution if there were many types or a continuum of types, from which many possible teams could produce identical output.

But perhaps surprisingly, even when output completely reveals the contribution of individual workers, discrimination can persist. Consider the severely discriminatory equilibrium of Proposition 2. In this case, the manager knows exactly what each teammate contributes before production occurs. Thus, observing the output adds no information above and beyond what discrimination tells her—the equilibrium is identical whether output is contractible or not. Of course, if beliefs were egalitarian and an (off-equilibrium) heterogeneous team formed, then the manager would not know which worker was high ability and which was low before or after production.

Thus, despite the increased complexity of calculating complete belief sets contingent on output, versions of the previous propositions still hold with similar proofs. Also, although I have not explicitly modeled a separate signal of worker abilities available to the manager, the exercise here gives strong intuition that so long as the manager cannot perfectly observe worker types *without discriminating*, the potential for discrimination exists.

## 5.5 Shapley Values

In the basic model, a manager is fair if she divides team produce according to average ability. From the perspective that (in the model) ability is the only parameter an individual brings to the team this seems appropriate; however, if one is willing include parameters not associated with the individual alone, say by combining the firm's team production function with the mix of individual member abilities, then other sharing rules are possible. For example, by combining the possible ability levels of all team members together with information about the production function the manager may be able to calculate the average marginal contribution of each member and compensate according to that measure. In this subsection, I will show that discriminatory equilibria may still exist under such an allocation rule.

The most common way to fairly allocate cooperative gains is by using Shapley values (Shapley 1953)—they use the marginal contributions of members as inputs. Since a Shapley value represents a total allocation due a player in a coalition game, rather than a proportional measure like  $\gamma$ , they do not scale with output. Thus, using Shapley values, which completely distribute all surplus, requires that the level of output be fixed. Therefore, I restrict attention to settings where compensation is contractible on observed team output.

---

<sup>16</sup> Although the example illustrates the persistence of discriminatory equilibria with familiar linearly synergistic team production ( $g(\alpha, \beta) = (\alpha + \beta)\kappa$ ), there is nothing special about that form. When the same ability distribution holds, but team production has constant synergy ( $g(\alpha, \beta) = \alpha + \beta + \kappa$ ) then when synergy satisfies  $\frac{H^2 - L^2}{H + 3L} \leq \kappa \leq 3\frac{H^2 - L^2}{H + 3L}$ ,  $\gamma(2M + \kappa) = \frac{1}{2}\frac{H}{H + L} + \frac{1}{4}$  is an equilibrium belief, which forms the same teams.

However, as was illustrated in Section 5.4, output alone is not enough to reveal the contributions of team members and is, thus, insufficient to generally determine team members' marginal contributions. Therefore, a manager is fair if she assigns each teammate his expected Shapley value for the observed level of output. It is a self-reinforcing equilibrium if, for a given level of team output, workers believe they will receive their expected Shapley value. Formally, if workers  $A$  and  $B$  believe that they will respectively receive  $\nu_A(Q)$  and  $\nu_B(Q)$  when jointly producing  $Q$ , a BNE exists whenever

$$\nu_A(Q) = E[\phi_A(\alpha, \beta) \mid team, Q] \text{ AND } \nu_B(Q) = E[\phi_B(\alpha, \beta) \mid team, Q]$$

where  $\phi_A(\alpha, \beta)$  and  $\phi_B(\alpha, \beta)$  are the Shapley values for  $A$  and  $B$  of abilities  $\alpha$  and  $\beta$  respectively.

For simplicity, again assume the team production function and type distribution of Example 5. I will show that discrimination is an equilibrium when the manager sees output  $Q = 2M\kappa$ . For any given ability realization  $\langle \alpha, \beta \rangle$  the  $A$ 's and  $B$ 's respective Shapley values may be calculated

$$\begin{aligned} \phi_A(\alpha, \beta) &= \frac{1}{2}((\alpha + \beta)\kappa - \beta) + \frac{1}{2}\alpha = \frac{1}{2}((\alpha + \beta)\kappa + \alpha - \beta) \\ \phi_B(\alpha, \beta) &= \frac{1}{2}((\alpha + \beta)\kappa - \alpha) + \frac{1}{2}\beta = \frac{1}{2}((\alpha + \beta)\kappa - \alpha + \beta) \end{aligned}$$

The Shapley values associated with team  $\langle \alpha, \beta \rangle = \langle H, L \rangle$  are

$$\begin{aligned} \phi_A(H, L) &= \frac{1}{2}((H + L)\kappa + H - L) \\ \phi_B(H, L) &= \frac{1}{2}((H + L)\kappa - H + L) \end{aligned}$$

The Shapley values associated with team  $\langle \alpha, \beta \rangle = \langle M, M \rangle$  can be simplified to

$$\phi_A(M, M) = \phi_B(M, M) = \frac{H + L}{2}\kappa$$

The manager, seeing output  $Q = 2M\kappa$ , know that the team is either  $\langle H, L \rangle$  or  $\langle M, M \rangle$  with equal probability, Therefore, the expected Shapley values (i.e. expectation over the possible teams that could have formed, given that a manager sees output  $Q = 2M\kappa$ ) are

$$\begin{aligned} E[\phi_A \mid team, Q = 2M\kappa] &= \frac{1}{2} \left( \frac{1}{2}((H + L)\kappa + H - L) \right) + \frac{1}{2}M\kappa = \frac{2(H + L)\kappa + H - L}{4} \\ E[\phi_B \mid team, Q = 2M\kappa] &= \frac{1}{2} \left( \frac{1}{2}((H + L)\kappa - H + L) \right) + \frac{1}{2}M\kappa = \frac{2(H + L)\kappa - H + L}{4} \end{aligned}$$

These discriminatory payments are self-reinforcing if and only if beliefs that they will be paid induce teams to form in the assumed way. Formally, teams  $\langle H, L \rangle$  form

$$(E[\phi_A \mid team, Q = 2M\kappa] > H) \text{ AND } (E[\phi_B \mid team, Q = 2M\kappa] > L)$$

teams  $\langle M, M \rangle$  form

$$(E[\phi_A \mid team, Q = 2M\kappa] > M) \text{ AND } (E[\phi_B \mid team, Q = 2M\kappa] > M)$$

and teams  $\langle L, H \rangle$  do not form

$$(E[\phi_A \mid team, Q = 2M\kappa] \leq L) \text{ OR } (E[\phi_B \mid team, Q = 2M\kappa] \leq H)$$

Since  $E[\phi_A \mid team, Q = 2M\kappa] > E[\phi_B \mid team, Q = 2M\kappa]$  and  $H > M > L$ , showing the that the following subset of the above conditions hold suffices to guarantee the existence of a discriminatory equilibrium:

$$\begin{aligned} E[\phi_A \mid team, Q = 2M\kappa] &= \frac{2(H+L)\kappa + H - L}{4} > H \\ E[\phi_B \mid team, Q = 2M\kappa] &= \frac{2(H+L)\kappa - H + L}{4} > \frac{H+L}{2} = M \\ E[\phi_B \mid team, Q = 2M\kappa] &= \frac{2(H+L)\kappa - H + L}{4} \leq H \end{aligned}$$

These readily simplify to

$$\frac{3H+L}{2(H+L)} < \kappa \leq \frac{5H-L}{2(H+L)}$$

Thus, for moderate synergy (i.e.  $\frac{3H+L}{2(H+L)} < \kappa \leq \frac{5H-L}{2(H+L)}$ ), there exists a discriminatory equilibrium for output level  $Q = 2M\kappa$ , in which teams  $\langle \alpha, \beta \rangle \in \{\langle H, L \rangle, \langle M, M \rangle\}$  form—the existence of discriminatory equilibria is robust to expected Shapley value allocations.

Although changing the allocation rule to expected Shapley values would alter the details of the proofs related to the other results, the basic intuition that *talented minorities have the greatest incentive to eschew teamwork* remains, and so one may be confident that analogous proofs exist. Likewise, the basic consequence of this intuition is that discrimination puts pressure on teams to form in ways that mimic consensus beliefs. So, while there are many alternative allocation rules, of which Shapley values are but one, that a person could analyze, most of them can be expected to exhibit the feature that an average measure of individual contributions in teams resembles beliefs—when the resemblance is exact, it is a Bayesian Nash Equilibrium, and the beliefs self-reinforce.

## 6 Conclusion

Career choice is a fundamental life decision. The model highlights how discriminatory expectations can shape these choices. While minorities are free to choose either teamwork or entrepreneurship in the model, i.e., they face no “closed doors,” they may worry about the allocation of credit in team environments where individual contributions cannot be readily measured. When talented minorities expect to receive too little credit, they opt out of team-based careers in favor of entrepreneurship. In contrast, less talented minorities opt in since they enjoy productive gains from teamwork and receive reasonably fair credit for their contributions. As a result, expectations about minority contributions in teams are self-fulfilling.

Importantly, the model implies that measures of discrimination based on wage differentials in firms overstate the economic effects of discrimination. The bias in the estimates stems from selection—talented minorities fight discrimination by opting out of the system

and pursuing entrepreneurship. The “dual” to this implication is that minorities should outperform beneficiaries when working individually—a fact which is broadly consistent with a number of studies.

The model also reveals that meritocracy does not eliminate discrimination *per se*. Managers in the model fairly allocate credit based on their information. Indeed, in a severely discriminatory equilibrium, credit is being correctly allocated, even *ex post*. Thus, meritorious individuals enjoy the credit they deserve, yet, based on selection expectations, the result is still discriminatory.

In other models of statistical discrimination, leveling the playing field between victims and beneficiaries may remedy the situation. For instance, if the problem is that the discourse system of minorities leads to noisier signals of ability, then the appropriate policy solutions involve either educating majorities to better understand minority discourse or, more realistically, training minorities to communicate in ways that majorities can understand. If the problem is underinvestment in human capital, then subsidy schemes, such as minority-targeted scholarships, can remedy the problem. In my setting, minorities and majorities are equally skilled and equally able to convey this information at the time of employment. The apparent economic policy solution implied by the model—constrain the occupational choices of individuals so that talented minorities can no longer eschew teamwork—harms minorities even further in the near term. This may be seen as negative, but given that populations of minorities and non-minorities in the model are statistically identical at all times, a change in beliefs suffices to break the discriminatory equilibrium, without enhancing the current generation of minorities’ abilities. Thus, the model may suggest cultural rather than economic policy remedies.

The model presented here explains some instances of discrimination that are outside the domain of other models. For instance, the alphabetical discrimination in the market for academic economists highlighted by Einav and Yariv is hard to explain using standard models of discrimination. It seems unlikely that individuals whose last names begin later in the alphabet systematically underinvest in human capital or use a different dialect than those whose last names come earlier. My model, however, offers an expectational rationale for this phenomenon. Moreover, it is not simply a “just so story”—the model offers sharp out of sample predictions as well.

Alchian and Demsetz (1972) observed that the fundamental incentive structure within teams changes, because individual actions are unobservable. That work spawned a substantial theoretical investigation of moral hazard in exogenously formed teams. By endogenizing the teamwork decision, the model here uniquely exposes an adverse selection problem created by the same unobservability of individual contribution in teams.

This model captures one force among many potentially operating in teams (and outside). A great deal of complexity could be added to the model, but Section 5 illustrates that the fundamental force survives an array of extensions. Its simplicity facilitates incorporation into models with richer institutional details, and indeed, studying this force in a specific setting may dictate adding such intricacies, even potentially at a loss of clarity or tractability. This paper’s aims are more general.

Like other discrimination models it is static. Future work will examine teamwork decisions in a dynamic setting—when future potential teammates may share the attribute of discrimination or not, and ability may be revealed over time.

## 7 Appendix

Throughout the appendix, the following notational definition is useful:

**Definition 2**  $\psi(\gamma) = E \left[ \frac{\alpha}{\alpha+\beta} \mid team, \gamma \right]$

**Proposition 1 (General)** (a) *Egalitarianism (i.e.  $\gamma = \frac{1}{2}$ ) is always a team forming equilibrium.* (b) *Under egalitarianism, a team will form iff the synergy of production is greater than the difference in worker abilities.*

**Proof.** (a) Since  $g(\alpha, \beta) > \alpha + \beta$ , a team forms whenever  $A$  and  $B$  have identical ability. Thus, equation (1) must hold:

$$E \left[ \frac{\alpha}{\alpha+\beta} \mid g(\alpha, \beta) \frac{1}{2} > \alpha, g(\alpha, \beta) \left(1 - \frac{1}{2}\right) > \beta \right] = \frac{1}{2}$$

where the last equality results because  $\alpha$  and  $\beta$  are iid and  $g$  is symmetric.

(b) Let synergy be measured by  $\kappa_{a\beta} = g(\alpha, \beta) - \alpha - \beta > 0$ . Then under egalitarianism, a team forms iff  $\alpha + \beta + \kappa_{a\beta} > 2\alpha$  and  $\alpha + \beta + \kappa_{a\beta} > 2\beta$ . This can be rewritten  $\kappa_{a\beta} > \alpha - \beta$  and  $\kappa_{a\beta} > \beta - \alpha$ , which reduces to  $\kappa_{a\beta} > |\alpha - \beta|$ . ■

**Proposition 5 (General)** *Discrimination victims produce better average solo work than beneficiaries.*

**Proof.** Abbreviate  $g(\alpha, \beta)$  as  $g$  and  $1 - \gamma$  as  $\bar{\gamma}$  for notational simplicity. When no team forms, exactly one worker objects to teamwork because  $g > \alpha + \beta$ . Therefore, the expectation of a random variable  $x$  over the solo sample space can be partitioned as follows:

$$E[x \mid Solo] = E[x \mid g\gamma \leq \alpha] \Pr\{g\gamma \leq \alpha\} + E[x \mid g\bar{\gamma} \leq \beta] \Pr\{g\bar{\gamma} \leq \beta\}$$

The second term can be further partitioned

$$\begin{aligned} E[x \mid Solo] &= E[x \mid g\gamma \leq \alpha] \Pr\{g\gamma \leq \alpha\} + E[x \mid g\gamma \leq \beta, g\bar{\gamma} \leq \beta] \Pr\{g\gamma \leq \beta, g\bar{\gamma} \leq \beta\} \\ &\quad + E[x \mid g\gamma > \beta, g\bar{\gamma} > \alpha, g\bar{\gamma} \leq \beta] \Pr\{g\gamma > \beta, g\bar{\gamma} > \alpha, g\bar{\gamma} \leq \beta\} \\ &\quad + E[x \mid g\gamma > \beta, g\bar{\gamma} \leq \alpha, g\bar{\gamma} \leq \beta] \Pr\{g\gamma > \beta, g\bar{\gamma} \leq \alpha, g\bar{\gamma} \leq \beta\} \end{aligned}$$

Observe (1)  $\gamma > \frac{1}{2}$  and  $g\gamma \leq \beta$  imply  $g\bar{\gamma} \leq \beta$  and (2)  $g > \alpha + \beta$  and  $g\bar{\gamma} \leq \alpha$  imply  $g\gamma > \beta$ . Thus, the conditional expected abilities can be simplified as follows:

$$\begin{aligned} E[x \mid Solo] &= E[x \mid g\gamma \leq \alpha] \Pr\{g\gamma \leq \alpha\} + E[x \mid g\gamma \leq \beta] \Pr\{g\gamma \leq \beta\} \\ &\quad + E[x \mid \alpha < g\bar{\gamma} \leq \beta < g\gamma] \Pr\{\alpha < g\bar{\gamma} \leq \beta < g\gamma\} \\ &\quad + E[x \mid g\bar{\gamma} \leq \alpha, g\bar{\gamma} \leq \beta] \Pr\{g\bar{\gamma} \leq \alpha, g\bar{\gamma} \leq \beta\} \end{aligned}$$

Because  $\alpha$  and  $\beta$  are iid and  $g$  is symmetric with respect to  $\alpha$  and  $\beta$  the difference in the expected ability of  $B$ s who work alone from the expected ability of  $A$ s who work alone is

$$E[\alpha \mid Solo] - E[\beta \mid Solo] = E[\alpha - \beta \mid \alpha < g\bar{\gamma} \leq \beta < g\gamma] \Pr\{\alpha < g\bar{\gamma} \leq \beta < g\gamma\} < 0$$

■

**Definition 3** Given  $\alpha$  and  $\gamma$ , the lowest type  $B$  who will (be permitted by  $A$  to) join a team is defined by  $L(\alpha, \gamma)$  satisfying  $g(\alpha, L(\alpha, \gamma))\gamma = \alpha$ . Similarly, the highest type  $B$  who will (willingly) join a team is defined by  $H(\alpha, \gamma)$  satisfying  $g(\alpha, H(\alpha, \gamma))(1 - \gamma) = H(\alpha, \gamma)$ .

**Remark 1** Observe that as  $\gamma$  approaches 1, any  $A$  type will permit any  $B$  type to join the team, although none but the lowest  $B$  types will be willing to do so. Formally,

$$\lim_{\gamma \rightarrow 1} H(\alpha, \gamma) = \lim_{\gamma \rightarrow 1} L(\alpha, \gamma) = 0 \quad (4)$$

**Remark 2** Applying the Implicit Function Theorem to the definitions of  $H(\alpha, \gamma)$  and  $L(\alpha, \gamma)$  yields

$$\begin{aligned} H_\gamma(\alpha, \gamma) &= -\frac{\frac{\partial}{\partial \gamma}(g(\alpha, \beta)(1 - \gamma) - \beta)}{\frac{\partial}{\partial \beta}(g(\alpha, \beta)(1 - \gamma) - \beta)} \Big|_{\beta=H(\alpha, \gamma)} = \frac{g(\alpha, H(\alpha, \gamma))}{g_\beta(\alpha, H(\alpha, \gamma))(1 - \gamma) - 1} \\ L_\gamma(\alpha, \gamma) &= -\frac{\frac{\partial}{\partial \gamma}(g(\alpha, \beta)\gamma - \alpha)}{\frac{\partial}{\partial \beta}(g(\alpha, \beta)\gamma - \alpha)} \Big|_{\beta=L(\alpha, \gamma)} = -\frac{g(\alpha, L(\alpha, \gamma))}{g_\beta(\alpha, L(\alpha, \gamma))\gamma} \end{aligned}$$

**Definition 4** Define the expectation of a random variable  $\zeta(\alpha, \beta)$  conditional on a team forming given  $A$ 's ability  $\alpha$  and beliefs about discrimination  $\gamma$

$$Z(\alpha, \gamma) = E_\beta[\zeta(\alpha, \beta) \mid L(\alpha, \gamma) < \beta < H(\alpha, \gamma)] = \frac{\int_{L(\alpha, \gamma)}^{H(\alpha, \gamma)} \zeta(\alpha, \beta) dF(\beta)}{\int_{L(\alpha, \gamma)}^{H(\alpha, \gamma)} dF(\beta)} \quad (5)$$

where  $F$  is distribution of  $(\alpha \text{ and}) \beta$ . Then by the Quotient Rule

$$Z_\gamma(\alpha, \gamma) = \frac{\left(\int_{L(\alpha, \gamma)}^{H(\alpha, \gamma)} dF(\beta)\right)\left(\frac{d}{d\gamma} \int_{L(\alpha, \gamma)}^{H(\alpha, \gamma)} \zeta(\alpha, \beta) dF(\beta)\right) - \left(\int_{L(\alpha, \gamma)}^{H(\alpha, \gamma)} \zeta(\alpha, \beta) dF(\beta)\right)\left(\frac{d}{d\gamma} \int_{L(\alpha, \gamma)}^{H(\alpha, \gamma)} dF(\beta)\right)}{\left(\int_{L(\alpha, \gamma)}^{H(\alpha, \gamma)} dF(\beta)\right)^2}$$

For fixed  $\alpha$  and  $0 < \gamma < 1$  Leibniz Rule may be applied

$$Z_\gamma(\alpha, \gamma) = \frac{(\zeta(\alpha, H(\alpha, \gamma)) - Z(\alpha, \gamma))H_\gamma(\alpha, \gamma)F'(H(\alpha, \gamma)) - (\zeta(\alpha, L(\alpha, \gamma)) - Z(\alpha, \gamma))L_\gamma(\alpha, \gamma)F'(L(\alpha, \gamma))}{F(H(\alpha, \gamma)) - F(L(\alpha, \gamma))} \quad (6)$$

**Lemma 5** If  $Z(\alpha, \gamma)$  is defined as in (5) then as  $\gamma$  approaches unity  $Z(\alpha, \gamma)$  converges pointwise

$$\lim_{\gamma \rightarrow 1} Z(\alpha, \gamma) = \zeta(\alpha, 0)$$

**Proof.** Since from (5) both numerator and denominator of  $Z(\alpha, \gamma)$  approach 0, apply L'Hôpital's Rule once

$$\lim_{\gamma \rightarrow 1} Z(\alpha, \gamma) = \lim_{\gamma \rightarrow 1} \frac{\zeta(\alpha, H(\alpha, \gamma))H_\gamma(\alpha, \gamma)F'(H(\alpha, \gamma)) - \zeta(\alpha, L(\alpha, \gamma))L_\gamma(\alpha, \gamma)F'(L(\alpha, \gamma))}{H_\gamma(\alpha, \gamma)F'(H(\alpha, \gamma)) - L_\gamma(\alpha, \gamma)F'(L(\alpha, \gamma))}$$

From (4)  $\lim_{\gamma \rightarrow 1} \zeta(\alpha, H(\alpha, \gamma)) = \lim_{\gamma \rightarrow 1} \zeta(\alpha, L(\alpha, \gamma)) = \zeta(\alpha, 0)$ :

$$\lim_{\gamma \rightarrow 1} Z(\alpha, \gamma) = \zeta(\alpha, 0) \lim_{\gamma \rightarrow 1} \frac{H_\gamma(\alpha, \gamma)F'(H(\alpha, \gamma)) - L_\gamma(\alpha, \gamma)F'(L(\alpha, \gamma))}{H_\gamma(\alpha, \gamma)F'(H(\alpha, \gamma)) - L_\gamma(\alpha, \gamma)F'(L(\alpha, \gamma))} = \zeta(\alpha, 0)$$

■

**Lemma 6** *If  $Z(\alpha, \gamma)$  is defined as in (5) then as  $\gamma$  approaches unity  $Z_\gamma(\alpha, \gamma)$  converges pointwise*

$$\lim_{\gamma \rightarrow 1} Z_\gamma(\alpha, \gamma) = \frac{H_\gamma(\alpha, 1) + L_\gamma(\alpha, 1)}{2} \zeta_\gamma(\alpha, 0)$$

**Proof.** Observe from (4) and Lemma 5 that the numerator and denominator of (6) both go to 0 as  $\gamma$  approaches 1. Apply L'Hôpital's Rule once. The derivative of the first term of the numerator with respect to  $\gamma$

$$\begin{aligned} & \frac{d}{d\gamma} (\zeta(\alpha, H(\alpha, \gamma)) - Z(\alpha, \gamma) H_\gamma(\alpha, \gamma) F'(H(\alpha, \gamma))) \\ = & H_\gamma(\alpha, \gamma) F'(H(\alpha, \gamma)) \frac{d}{d\gamma} (\zeta(\alpha, H(\alpha, \gamma)) - Z(\alpha, \gamma)) \\ & + (\zeta(\alpha, H(\alpha, \gamma)) - Z(\alpha, \gamma)) \frac{d}{d\gamma} H_\gamma(\alpha, \gamma) F'(H(\alpha, \gamma)) \\ = & H_\gamma(\alpha, \gamma) F'(H(\alpha, \gamma)) (H_\gamma(\alpha, \gamma) \zeta_\gamma(\alpha, H(\alpha, \gamma)) - Z_\gamma(\alpha, \gamma)) \\ & + (\zeta(\alpha, H(\alpha, \gamma)) - Z(\alpha, \gamma)) (H_{\gamma\gamma}(\alpha, \gamma) F'(H(\alpha, \gamma)) + H_\gamma(\alpha, \gamma)^2 F''(H(\alpha, \gamma))) \end{aligned}$$

Take the limit as  $\gamma$  approaches 1 and simplify using (4) and Lemma 5

$$\begin{aligned} & \lim_{\gamma \rightarrow 1} \frac{d}{d\gamma} (\zeta(\alpha, H(\alpha, \gamma)) - Z(\alpha, \gamma) H_\gamma(\alpha, \gamma) F'(H(\alpha, \gamma))) \\ = & H_\gamma(\alpha, 1) F'(0) \left( H_\gamma(\alpha, 1) \zeta_\gamma(\alpha, 0) - \lim_{\gamma \rightarrow 1} Z_\gamma(\alpha, \gamma) \right) \end{aligned}$$

Similarly, the derivative of the numerator's second term with respect to  $\gamma$  as  $\gamma$  approaches 1

$$\begin{aligned} & \lim_{\gamma \rightarrow 1} \frac{d}{d\gamma} (\zeta(\alpha, L(\alpha, \gamma)) - Z(\alpha, \gamma) L_\gamma(\alpha, \gamma) F'(L(\alpha, \gamma))) \\ = & L_\gamma(\alpha, 1) F'(0) \left( L_\gamma(\alpha, 1) \zeta_\gamma(\alpha, 0) - \lim_{\gamma \rightarrow 1} Z_\gamma(\alpha, \gamma) \right) \end{aligned}$$

The derivative of the denominator with respect to  $\gamma$  as  $\gamma$  approaches 1

$$\lim_{\gamma \rightarrow 1} \frac{d}{d\gamma} (F(H(\alpha, \gamma)) - F(L(\alpha, \gamma))) = H_\gamma(\alpha, 1) F'(0) - L_\gamma(\alpha, 1) F'(0)$$

Thus,

$$\begin{aligned} \lim_{\gamma \rightarrow 1} Z_\gamma(\alpha, \gamma) &= \frac{H_\gamma(\alpha, 1) (H_\gamma(\alpha, 1) \zeta_\gamma(\alpha, 0) - \lim_{\gamma \rightarrow 1} Z_\gamma(\alpha, \gamma)) - L_\gamma(\alpha, 1) (L_\gamma(\alpha, 1) \zeta_\gamma(\alpha, 0) - \lim_{\gamma \rightarrow 1} Z_\gamma(\alpha, \gamma))}{H_\gamma(\alpha, 1) - L_\gamma(\alpha, 1)} \\ &= \frac{H_\gamma(\alpha, 1) H_\gamma(\alpha, 1) - L_\gamma(\alpha, 1) L_\gamma(\alpha, 1)}{H_\gamma(\alpha, 1) - L_\gamma(\alpha, 1)} \zeta_\gamma(\alpha, 0) - \frac{H_\gamma(\alpha, 1) - L_\gamma(\alpha, 1)}{H_\gamma(\alpha, 1) - L_\gamma(\alpha, 1)} \lim_{\gamma \rightarrow 1} Z_\gamma(\alpha, \gamma) \\ &= \frac{H_\gamma(\alpha, 1) + L_\gamma(\alpha, 1)}{2} \zeta_\gamma(\alpha, 0) \end{aligned}$$

■

**Remark 3** Since  $g_\beta(\alpha, \beta) > 1$  and  $H_\gamma(\alpha, \gamma) < 0$  for all  $\gamma$  satisfying  $g_\beta(\alpha, H(\alpha, \gamma))(1 - \gamma) < 1$ , there exists some  $\gamma^\varepsilon$  for all  $\varepsilon > 0$  such that for all  $\gamma^\varepsilon \leq \gamma \leq 1$  the following holds:  $g_\beta(\alpha, H(\alpha, \gamma))(1 - \gamma) < \varepsilon$ .

**Remark 4** Since  $F$  has finite variance,  $H(\alpha, \gamma) > L(\alpha, \gamma) > 0$  and  $\lim_{\gamma \rightarrow 1} H(\alpha, \gamma) = \lim_{\gamma \rightarrow 1} L(\alpha, \gamma) = 0$ , there exists some  $\gamma^\varepsilon$  for all  $\varepsilon > 0$  such that for all  $\gamma^\varepsilon \leq \gamma \leq 1$  the following holds:  $\overline{F}'(\gamma) - \underline{F}'(\gamma) < \varepsilon$ , where

$$\begin{aligned}\overline{F}'(\gamma) &= \max\{F'(x) : x \in (0, H(\alpha, \gamma))\} \\ \underline{F}'(\gamma) &= \min\{F'(x) : x \in (0, H(\alpha, \gamma))\}\end{aligned}$$

**Definition 5** Define  $\hat{\gamma}$  such that for all  $\gamma > \hat{\gamma}$  (1)  $g_\beta(\alpha, H(\alpha, \gamma))(1 - \gamma) < \frac{1}{2}$  and (2)  $\frac{\overline{F}'(\hat{\gamma})}{\underline{F}'(\hat{\gamma})} < 2$ . From Remarks 3 and 4 such a  $\hat{\gamma}$  always exists.

**Lemma 7** If  $Z(\alpha, \gamma)$  is defined as in (5),  $\zeta_\alpha(\alpha, \beta) > 0$  and  $\zeta_\alpha(\alpha, \beta) > 0$  then for all  $\gamma > \hat{\gamma}$ ,  $Z_\gamma(\alpha, \gamma)$  is bounded as follows:

$$0 < Z_\gamma(\alpha, \gamma) \leq \frac{\zeta(\alpha, L(\alpha, \gamma)) - \zeta(\alpha, H(\alpha, \gamma))}{H(\alpha, \gamma) - L(\alpha, \gamma)} (-H_\gamma(\alpha, \gamma) - L_\gamma(\alpha, \gamma)) \frac{\overline{F}'(\hat{\gamma})}{\underline{F}'(\hat{\gamma})} \quad (7)$$

**Proof.** From (6)

$$Z_\gamma(\alpha, \gamma) = \frac{(Z(\alpha, \gamma) - \zeta(\alpha, H(\alpha, \gamma)))(-H_\gamma(\alpha, \gamma))F'(H(\alpha, \gamma)) + (\zeta(\alpha, L(\alpha, \gamma)) - Z(\alpha, \gamma))(-L_\gamma(\alpha, \gamma))F'(L(\alpha, \gamma))}{F(H(\alpha, \gamma)) - F(L(\alpha, \gamma))} > 0$$

Observe that  $\zeta(\alpha, H(\alpha, \gamma)) \leq Z(\alpha, \gamma) \leq \zeta(\alpha, L(\alpha, \gamma))$  and every factor in the numerator and the denominator are always positive for all  $\gamma > \hat{\gamma}$ . Thus,

$$Z_\gamma(\alpha, \gamma) \leq \frac{\zeta(\alpha, L(\alpha, \gamma)) - \zeta(\alpha, H(\alpha, \gamma))}{F(H(\alpha, \gamma)) - F(L(\alpha, \gamma))} (-H_\gamma(\alpha, \gamma)F'(H(\alpha, \gamma)) - L_\gamma(\alpha, \gamma)F'(L(\alpha, \gamma)))$$

The form of the lemma results from applying the Mean Value Theorem to the denominator and bounding the  $F'$  terms in both numerator and denominator. ■

**Corollary 1** If  $Z(\alpha, \gamma)$  is defined as in (5) and  $\zeta(\alpha, \beta) = \frac{\alpha}{\alpha + \beta}$ , then for all  $\gamma > \hat{\gamma}$ ,  $Z_\gamma(\alpha, \gamma)$  is bounded by the following Lebesgue integrable function:

$$|Z_\gamma(\alpha, \gamma)| \leq \frac{1}{\alpha} \left( 2g(\alpha, H(\alpha, \hat{\gamma})) + \frac{g(\alpha, L(\alpha, \hat{\gamma}))}{\hat{\gamma}} \right) \frac{\overline{F}'(\hat{\gamma})}{\underline{F}'(\hat{\gamma})} = \Theta(\alpha) \quad (8)$$

**Proof.** Substitute  $\zeta(\alpha, \beta) = \frac{\alpha}{\alpha + \beta}$ ,  $H_\gamma(\alpha, \gamma)$  and  $L_\gamma(\alpha, \gamma)$  from Lemma 2

$$Z_\gamma(\alpha, \gamma) \leq \frac{\frac{\alpha}{\alpha + L(\alpha, \gamma)} - \frac{\alpha}{\alpha + H(\alpha, \gamma)}}{H(\alpha, \gamma) - L(\alpha, \gamma)} \left( \frac{g(\alpha, H(\alpha, \gamma))}{1 - g_\beta(\alpha, H(\alpha, \gamma))(1 - \gamma)} + \frac{g(\alpha, L(\alpha, \gamma))}{g_\beta(\alpha, L(\alpha, \gamma))\gamma} \right) \frac{\overline{F}'(\hat{\gamma})}{\underline{F}'(\hat{\gamma})}$$

Simplifying the first factor and then using the facts that  $H(\alpha, \gamma) > L(\alpha, \gamma) > 0$ ,  $1 - g_\beta(\alpha, H(\alpha, \gamma))(1 - \gamma) \leq \frac{1}{2}$ ,  $g_\beta(\alpha, \beta) > 1$  to bound each factor yields the form of the corollary. ■

**Lemma 8** *If ability is continuously distributed with support from 0, then  $\gamma$*

$$\lim_{\gamma \rightarrow 1} \psi(\gamma) = 1$$

**Proof.** Define  $Z(\alpha, \gamma)$  as in (5) where  $\zeta(\alpha, \beta) = \frac{\alpha}{\alpha + \beta}$ . Then

$$\lim_{\gamma \rightarrow 1} \psi(\gamma) = \lim_{\gamma \rightarrow 1} \int_{-\infty}^{\infty} Z(\alpha, \gamma) dF(\alpha)$$

From Lemma 5  $Z(\alpha, \gamma)$  converges pointwise to  $\frac{\alpha}{\alpha + 0} = 1$  for all  $\alpha$ , and  $Z(\alpha, \gamma)$  is dominated by 1 (i.e.  $|Z(\alpha, \gamma)| \leq 1$ ). Thus, by Lebesgue's Dominated Convergence Theorem

$$\lim_{\gamma \rightarrow 1} \psi(\gamma) = \int_{-\infty}^{\infty} 1 dF(\alpha) = 1$$

■

**Lemma 9** *If team production is regular and ability is continuously distributed with support from 0, then*

$$\lim_{\gamma \rightarrow 1} \psi'(\gamma) < 1$$

**Proof.** Define  $Z(\alpha, \gamma)$  as in (5) where  $\zeta(\alpha, \beta) = \frac{\alpha}{\alpha + \beta}$ . Then (1)  $Z(\alpha, \gamma)$  is a Lebesgue integrable function for all  $\gamma \in (\hat{\gamma}, 1)$ , (2) for almost all  $\alpha$ ,  $Z_\gamma(\alpha, \gamma)$  exists for all  $\gamma \in (\hat{\gamma}, 1)$  and (3) by Lemma 1  $Z_\gamma(\alpha, \gamma)$  is dominated by  $\Theta(\alpha)$  as defined in (8) for all  $\gamma \in (\hat{\gamma}, 1)$ . Thus, by Leibniz' Rule (see Folland 1999, Theorem 2.27.b for the measure theory version)

$$\lim_{\gamma \rightarrow 1} \psi'(\gamma) = \lim_{\gamma \rightarrow 1} \int_{-\infty}^{\infty} Z_\gamma(\alpha, \gamma) dF(\alpha)$$

From Lemma 6  $Z_\gamma(\alpha, \gamma)$  converges pointwise to

$$-\frac{H_\gamma(\alpha, 1) + L_\gamma(\alpha, 1)}{2\alpha}$$

for all  $\alpha$ , and from Corollary 1  $Z_\gamma(\alpha, \gamma)$  is dominated by  $\frac{1}{\alpha} \left( 2g(\alpha, H(\alpha, \hat{\gamma})) + \frac{g(\alpha, L(\alpha, \hat{\gamma}))}{\hat{\gamma}} \right) \frac{\bar{F}'(\hat{\gamma})}{\underline{F}'(\hat{\gamma})}$  for all  $\gamma > \hat{\gamma}$ . Thus, by Lebesgue's Dominated Convergence Theorem

$$\lim_{\gamma \rightarrow 1} \psi'(\gamma) = - \int_{-\infty}^{\infty} \frac{H_\gamma(\alpha, 1) + L_\gamma(\alpha, 1)}{2\alpha} dF(\alpha) \quad (9)$$

From Remark 2  $H_\gamma(\alpha, 1) = -g(\alpha, 0)$  whenever  $H(\alpha, \gamma)$  is interior. Observe  $H(\alpha, \gamma)$  is always interior when  $\gamma$  is near unity, since  $g\left(\alpha, \alpha \frac{1-\gamma}{\gamma}\right) (1-\gamma) \geq \left(\alpha + \alpha \frac{1-\gamma}{\gamma}\right) (1-\gamma) = \alpha \frac{1-\gamma}{\gamma}$ . Similarly  $L_\gamma(\alpha, 1) = -\frac{g(\alpha, 0)}{g_\beta(\alpha, 0)}$  whenever  $L(\alpha, \gamma)$  is interior.

Case  $L(\alpha, 1)$  is interior: Simplify (9)

$$\lim_{\gamma \rightarrow 1} \psi'(\gamma) = - \int_{-\infty}^{\infty} \frac{-g(\alpha, 0) + -\frac{g(\alpha, 0)}{g_\beta(\alpha, 0)}}{2\alpha} dF(\alpha) = \frac{1}{2} \int_{-\infty}^{\infty} \left( 1 + \frac{1}{g_\beta(\alpha, 0)} \right) dF(\alpha) < 1$$

where the second equality follows because  $g(\alpha, 0) = \alpha$  by the regularity assumption and the inequality follows because  $g_\beta(\alpha, \beta) > 1$  for all  $\alpha$  and  $\beta$ .

Case  $L(\alpha, 1)$  is not interior: Simplify (9) using  $H_\gamma(\alpha, 1) = -g(\alpha, 0)$  and  $L_\gamma(\alpha, 1) = 0$  (because  $L(\alpha, 1)$  is not interior).

$$\lim_{\gamma \rightarrow 1} \psi'(\gamma) = - \int_{-\infty}^{\infty} \frac{-g(\alpha, 0)}{2\alpha} dF(\alpha) = \frac{1}{2} \int_{-\infty}^{\infty} dF(\alpha) = \frac{1}{2} < 1$$

where the last equality follows because  $g(\alpha, 0) = \alpha$  by the regularity assumption. ■

**Lemma 10**

$$\psi' \left( \frac{1}{2} \right) = 0$$

**Proof.** Rotate the ability sample space  $\Omega$  by angle  $-\frac{\pi}{4}$ :

$$\begin{aligned} \tilde{\alpha} &= \alpha \cos \left( -\frac{\pi}{4} \right) - \beta \sin \left( -\frac{\pi}{4} \right) = \frac{\alpha + \beta}{\sqrt{2}} \\ \tilde{\beta} &= \alpha \sin \left( -\frac{\pi}{4} \right) + \beta \cos \left( -\frac{\pi}{4} \right) = \frac{-\alpha + \beta}{\sqrt{2}} \end{aligned}$$

This yields  $\alpha = \frac{\tilde{\alpha} - \tilde{\beta}}{\sqrt{2}}$ ,  $\beta = \frac{\tilde{\alpha} + \tilde{\beta}}{\sqrt{2}}$  and  $\tilde{\zeta}(\tilde{\alpha}, \tilde{\beta}) = \frac{\tilde{\alpha} - \tilde{\beta}}{2\tilde{\alpha}} = \frac{\alpha}{\alpha + \beta}$ . Thus  $\tilde{Z}(\alpha, \frac{1}{2}) = \frac{1}{2}$ ,  $\tilde{\zeta}(\tilde{\alpha}, \tilde{\beta}) - \tilde{Z}(\alpha, \frac{1}{2}) = \frac{-\tilde{\beta}}{2\tilde{\alpha}}$  and from (6)

$$\tilde{Z}_\gamma \left( \alpha, \frac{1}{2} \right) = \frac{\frac{-\tilde{H}(\tilde{\alpha}, \frac{1}{2})}{2\tilde{\alpha}} \tilde{H}_\gamma(\tilde{\alpha}, \frac{1}{2}) \tilde{F}' \left( \tilde{H}(\tilde{\alpha}, \frac{1}{2}) \right) - \frac{-\tilde{L}(\tilde{\alpha}, \frac{1}{2})}{2\tilde{\alpha}} \tilde{L}_\gamma(\tilde{\alpha}, \frac{1}{2}) \tilde{F}' \left( \tilde{L}(\tilde{\alpha}, \frac{1}{2}) \right)}{\tilde{F} \left( \tilde{H}(\tilde{\alpha}, \frac{1}{2}) \right) - \tilde{F} \left( \tilde{L}(\tilde{\alpha}, \frac{1}{2}) \right)}$$

Observe that when  $\gamma = \frac{1}{2}$  the team forming region (i.e.  $\Omega \ni g(\tilde{\alpha}, \tilde{\beta}) \gamma \geq \tilde{\alpha}$  and  $g(\tilde{\alpha}, \tilde{\beta})(1 - \gamma) \geq \tilde{\beta}$ ) is symmetric about the  $\tilde{\alpha}$ -axis. Thus  $-\tilde{L}(\tilde{\alpha}, \frac{1}{2}) = \tilde{H}(\tilde{\alpha}, \frac{1}{2})$ ,  $\tilde{f}(\tilde{\alpha}, \tilde{L}(\tilde{\alpha}, \frac{1}{2})) = \tilde{f}(\tilde{\alpha}, \tilde{H}(\tilde{\alpha}, \frac{1}{2}))$  and  $-\tilde{L}_\gamma(\tilde{\alpha}, \frac{1}{2}) = \tilde{H}_\gamma(\tilde{\alpha}, \frac{1}{2})$ . Thus,  $\tilde{Z}_\gamma(\tilde{\alpha}, \frac{1}{2}) = 0$ . By Leibniz' Rule, then

$$\psi' \left( \frac{1}{2} \right) = \int_{-\infty}^{\infty} \tilde{Z}_\gamma \left( \tilde{\alpha}, \frac{1}{2} \right) dF(\tilde{\alpha}) = 0$$

■

**Theorem 1 (Fixed Point)** *If  $\psi$  is continuous and differentiable at distinct fixed points  $a$  and  $c$ , and  $\text{sign}(1 - \psi'(a)) = \text{sign}(1 - \psi'(c))$  then there exists another fixed point  $b$  strictly between  $a$  and  $c$ .*

**Proof.** Define  $\chi(\gamma) = \gamma - \psi(\gamma)$ . Then  $\chi(\gamma) = 0 \iff \gamma = \psi(\gamma)$ .  $\exists \delta > 0 \ni \forall 0 < \varepsilon < \delta, \text{sign}(\chi(a + \varepsilon)) = \text{sign}(1 - \psi'(c)), \text{sign}(\chi(c - \varepsilon)) = -\text{sign}(1 - \psi'(c))$ . Thus if  $\text{sign}(1 - \psi'(a)) = \text{sign}(1 - \psi'(c))$ , then 0 lies between  $\chi(a + \varepsilon)$  and  $\chi(c - \varepsilon)$ . Then by the Intermediate Value Theorem there exists  $b \in (a + \varepsilon, c - \varepsilon)$  such that  $\chi(b) = 0$ . ■

**Proposition 8** *If team production is regular, continuous and ability is continuously distributed with support from 0, then at least one discriminatory equilibrium ( $\gamma \in (\frac{1}{2}, 1)$ ) exists in which teams form.*

**Proof.**  $\gamma = \frac{1}{2}$  is always an equilibrium by Proposition 1 (General).  $\lim_{\gamma \rightarrow 1} \psi(\gamma) = 1$  by Lemma 8.  $\lim_{\gamma \rightarrow 1} \psi'(\gamma) < 1$  by Lemma 9.  $\psi'(\frac{1}{2}) = 0 < 1$  by Lemma 10. Thus,  $\text{sign}(1 - \psi'(\frac{1}{2})) = "-" = \text{sign}(1 - \psi'(1))$ . Theorem 1 implies  $\psi(\gamma)$  has a fixed point in  $(\frac{1}{2}, 1)$ . ■

## References

- [1] Alchian, A. A., and Demsetz, H. "Production, Information Costs, and Economic Organization." *The American Economic Review*, 62 (1972): 777-95.
- [2] Arrow, K. J., "The Theory of Discrimination." In O. Ashenfelter and A. Rees, eds. *Discrimination in Labor Markets*. Princeton University Press, 1973. 3-33.
- [3] Becker, G., *The Economics of Discrimination*. University of Chicago Press, 1957.
- [4] Clark, K., and Drinkwater, S., "Pushed Out or Pulled In? Self-employment among Ethnic Minorities in England and Wales." *Labour Economics*, 7 (2000): 603-28.
- [5] Coate, S., and Loury, G. C., "Will Affirmative-Action Policies Eliminate Negative Stereotypes?" *The American Economic Review*, 83 (1993): 1220-1240.
- [6] Djankov, S., and Miguel, E., and Qian, Y. and Roland, G., and Zhuravskaya, E., "Who are Russia's Entrepreneurs?" *Journal of the European Economic Association* 3 (2005): 1-11.
- [7] Einav, L., and Yariv, L., "What's in a Surname? The Effects of Surname Initials on Academic Success." *The Journal of Economic Perspectives*, 20 (2006): 175-187.
- [8] Folland, G. B. . *Real Analysis: Modern Techniques and Their Applications*, second ed. Wiley-Interscience, 1999.
- [9] Hamilton, B. H., and Nickerson, J. A., and Owan, H., "Team Incentives and Worker Heterogeneity: An Empirical Analysis of the Impact of Teams on Productivity and Participation." *The Journal of Political Economy*, 111 (2003): 465-497.
- [10] Holmström, B., "Moral Hazard in Teams." *The Bell Journal of Economics*, 13 (1982): 324-340.
- [11] Judge, T. A., and Cable, D. M., "The Effect of Physical Height on Workplace Success and Income: Preliminary Test of a Theoretical Model." *Journal of Applied Psychology*, 89 (2004): 428-441.
- [12] Kahn, L. M., "Discrimination in Sports: A Survey of the Literature." *Industrial and Labor Relations Review*, 44 (1991): 395-418.
- [13] Lavoie, M., Grenier G., Coulombe, S., *Canadian Public Policy*, 13 (1987): 407-22.
- [14] Legros, P., Matthews, S. A., "Efficient and Nearly-Efficient Partnerships." *The Review of Economic Studies*, 60 (1993): 599-611.
- [15] Lempert, R. O., Chambers, D. L., Adams, T. K., "Michigan's Minority Graduates in Practice: The River Runs through Law School." *Law and Social Inquiry*, 25 (2000): 395-505.

- [16] Loy, J. W., and Elvogue, J. F., “Racial Segregation in American Sport.” *International Review for the Sociology of Sport*, 5 (1970): 5-24.
- [17] Lundberg, S. J., and Startz, R., “Private Discrimination and Social Intervention in Competitive Labor Markets.” *The American Economic Review*, 73 (1983): 340-347.
- [18] McAfee, P. R., and McMillan, J., “Optimal Contracts for Teams.” *International Economic Review*, 32 (1991): 561-577.
- [19] National Association for Law Placement, Press Release: *Salaries at Largest Firms Peak in 2009*.
- [20] Phelps, E. S., “The Statistical Theory of Sexism and Racism.” *American Economic Review*, 62 (1972): 659-61.
- [21] Shapley, L. S., “A Value for  $n$  Person Games.” In *Contributions to the Theory of Games*, volume II, by H.W. Kuhn and A.W. Tucker, eds. *Annals of Mathematical Studies* v. 28. Princeton University Press, 1953: 307–317.
- [22] Shane, S. A., *The Illusions of Entrepreneurship*. Yale University Press, 2008.

# Social Responsibility of Firms beyond Profits

## 1 Introduction

Firms spend a lot of money on Corporate Social Responsibility (CSR), be it factoring environmental concerns into their manufacturing processes, sponsoring employee volunteering in the community, or outright giving of products and cash. A survey of just 155 US firms reported corporate philanthropy of this last type totaling \$11.5 billion in 2007.<sup>1</sup> Is this too much? Too little? Or just right?

In *The Social Responsibility of Business is to Increase Profits* (1970), Milton Friedman implies that it is way too much:

- “The manager is the agent of the individuals who own the corporation... and his primary responsibility is to them.”
- “Insofar as his actions in accord with his ‘social responsibility’ reduce returns to stockholders, he is spending their money.”
- “The stockholders... could separately spend their own money on the particular action if they wished to do so. The executive is exercising a distinct ‘social responsibility,’ rather than serving as an agent of the stockholders... only if he spends the money in a different way than they would have spent it.”

Friedman’s model of costly ‘social responsibility’ acknowledges shareholders may value both profits *and* ‘social goods,’ but he concludes shareholders themselves provision the latter more efficiently than the firm. Friedman suggests that socially responsible actions by a firm (beyond legal requirements) reflect only one of two distinct things: either (1) the firm is engaging in sophisticated profit maximization, or (2) managerial incentives are misaligned with shareholder interests. After all, if incentives were optimally aligned, there would be no gain to delegating social responsibilities to the manager—shareholders could just as effectively achieve their ends by contributing on their own.

The so-called *Friedman Doctrine* (Friedman 1962, 1970) has profoundly influenced the CSR literature. Much of this literature suggests that corporate giving is really just indirect profit maximization. For example, Porter and Kramer (2002) as well as Besley and Ghatak (2007) argue that it is a differentiation strategy, and so observed levels are “just right.”

---

<sup>1</sup>Committee Encouraging Corporate Philanthropy, “Giving in Numbers: 2008 Edition.”

Some economists claim shareholders of socially responsible firms feel a behavioral “warm-glow” similar to that associated with personal giving to social causes. For example Zivin and Small (2005) show it is optimal for some firms to be socially responsible because some citizens, specifically those who buy shares of socially responsible firms, prefer corporate philanthropy to personal giving on a unit basis, say to avoid taxation of corporate profits. In other words, if firms can provide “warm-glow” to shareholders more cheaply than individuals can purchase it from the market, then firms should provide it. Regardless of whether managers are using CSR to maximize profits in a sophisticated way or that the “warm-glow” felt by shareholders of firms practicing CSR allows shareholders to offset their own personal giving, the net effect is the same—shareholders end up with more money in their pockets.

On the other hand, the manager might, as Friedman suggests, be a rogue who does not maximize shareholders’ welfare. For example, he may discharge his own social responsibility through the firm using profits due to shareholders. Baron (2007), though, argues that such CSR harms shareholders only if it is an imperfect substitute for personal giving, and if shareholders are surprised by such philanthropy, as shareholders who do not benefit from such giving will divest. Alternatively, many social scientists outside economics see no dilemma in misaligned managerial and shareholder incentives—firm management should not work just for shareholders but for society at large (see Garriga and Mele 2004 for a survey).

Thus, the literature takes the view that either (1) a manager can serve the interests of shareholders by using CSR to increase their wealth or (2) CSR represents an agency problem—managers do not act in shareholder interests.

We show that neither view is necessary for the manager to have a positive role in the provision of public goods. In a model where transaction frictions, such as taxes and agency problems, as well as behavioral factors, such as warm glow, are absent, we show that a manager, acting on behalf of shareholders, will optimally undertake CSR that leaves shareholders with less money. How can this be? The key feature of the model is that shareholders care both about consumption and their *personal gains* from the public good; that is, we adopt the familiar pure altruism framework widely used in public economics.<sup>2</sup> Thus, there is scope for the manager to provide public goods if he can do so more efficiently than shareholders.

Empirical evidence suggests that the social behavior of a firm depends on the extent to which its owners and managers suffer harm or derive benefit. For example, Grant, Jones and Trautner (2010) find that absentee managed plants in the US emit more toxins, on average, than other plants.

Friedman’s claim that shareholders can efficiently discharge their social responsibilities in a decentralized fashion by contributing on their own ignores a key commitment role the manager could play on shareholders’ behalf. After all, shareholders recognize they face a prisoners’ dilemma when it comes to decentralized contributions to some public good—every shareholder would benefit if all contributed to the public good, but if other shareholders contribute, each has the individual incentive to shirk. The manager, however, can eliminate shirking by provisioning public goods centrally. Our first result shows that incenting manager behavior to reflect shareholders’ interest results in: (1) greater provision of the public

---

<sup>2</sup>We use the term *pure altruism* not in the vernacular sense of “selfless concern for the welfare of others,” but rather as economists typically do: individuals have preferences over private consumption and total supply public goods but not over how public goods are funded *per se*.

good than shareholders would undertake when decentralized, and (2) higher shareholder welfare.

Furthermore, the manager can influence shareholder payoffs by another lever: firm production could create externalities that affect shareholder welfare. For instance, to the extent that shareholders care about global warming, a plant that produces greenhouse gases also affects their welfare. Now, shareholders might simply incent the manager to maximize profits and then undo the environmental damage themselves through decentralized contributions to sequestration, carbon offsetting, and the like. And, indeed, Friedman implicitly argues that doing so would be optimal. Our second result is that this is never the case: shareholder welfare always increases by incenting the manager to produce less than the profit maximizing output. To see why, consider the benefits of the last unit of production. The increase in profits is negligible while the reduction in welfare owing to the externality is not. While shareholders can spend profits to reverse this, it would clearly be more efficient to direct the manager not to produce the output in the first place.

Exactly how much will production be abated? Suppose that a social planner ran the firm for the benefit of all citizens rather than just the firm's shareholders, selecting both the amount of production and the disposition of profits. The socially optimal output would be such that marginal profit equals the marginal cost of negating the damage. Our third result shows that if, at the socially optimal production level, shareholders would benefit from any contribution to the public good at all, then a manager maximizing shareholder interests produces exactly the socially optimal quantity without any intervention by a social planner.

Our fourth result shows that if this same condition holds, a neutrality result emerges: decreasing the marginal production cost of a firm is equivalent to decreasing the marginal negative externality of production in terms of overall public goods provision. Thus, investing in technology to make products cheaper may generate cleaner air for shareholders and society than investment in clean production technologies, if the former is less expensive.

To summarize, when managerial incentives reflect shareholder preferences, the firm plays a positive role in ameliorating the familiar free-rider problem among shareholders. More strikingly, the firm also plays a positive role for society at large. Under mild conditions, we show that its output corresponds with the social optimum even though the manager is only serving the interests of shareholders.

The remainder of the paper proceeds as follows: Section 2 describes the model. Section 3 derives the four key results described above where shareholders are homogeneous. In section 4, we relax this and several other simplifying assumptions allowing for, among other things, heterogeneous shareholders. Section 5 concludes. We relegate more technical proofs to an appendix.

## 2 Model

A firm produces and sells an amount  $q$  of a product. Production generates  $\pi(q)$  profits, where  $\pi(\cdot)$  is concave and single-peaked. Thus, there exists a unique profit maximizing quantity  $\hat{q}$  (i.e.  $\pi'(\hat{q}) = 0$ ). Production, however, also depletes a public good. The replacement cost of this public good is  $\psi(q)$ , which is strictly increasing and convex. By producing nothing, a firm earns no profits, but it also does not deplete the public good (i.e.  $\pi(0) = \psi(0) = 0$ );

however, the first unit of production generates more profit than the replacement cost of the public good (i.e.  $\pi'(0) > \psi'(0)$ ).

The firm is owned by  $S$  identical shareholders, each with strictly convex preferences represented by the utility function  $u(c, g)$ , increasing in both private consumption  $c$  and public goods quantity  $g$ . Later we will relax the assumption that shareholders are identical. Although passive in the model, we also assume there are  $N$  *heterogeneous* non-shareholding citizens. To isolate the effects of the firm's actions on welfare, we assume that these citizens have no wealth nor do they receive dividends from the firm. They do, however, benefit from the public good—non-shareholding citizen  $n$  has utility  $v^n(g)$ , increasing and strictly concave in its argument.

We consider a two stage game. First, the manager simultaneously chooses the production quantity  $q$  and an amount  $\alpha$  to contribute to the public good. The remaining profits are distributed equally among the shareholders. In the second stage, each shareholder simultaneously contributes an amount,  $\beta_i$ , to the public good. Thus, the level of public goods provided is

$$g = -\psi(q) + \alpha + \sum_{j=1}^S \beta_j$$

Because  $\psi$  captures depletion of the public good in monetary units, features, such as increasing cost to provision the public good as damage increases, are implicitly included. After contributing to the public goods, all remaining cash is consumed by the shareholder. Since shareholders are identical, we restrict attention to symmetric equilibria of the second stage subgame. We can write each shareholder's utility as function of  $q$ ,  $\alpha$ , and  $\beta_i$

$$u\left(\frac{\pi(q) - \alpha}{S} - \beta_i, -\psi(q) + \alpha + \sum_{j=1}^S \beta_j\right) \quad (1)$$

Citizen  $n$ 's utility can be similarly stated

$$v^n\left(-\psi(q) + \alpha + \sum_{j=1}^S \beta_j\right) \quad (2)$$

What determines the manager's payoffs? In the spirit of Friedman, we suppose that the manager's incentives align his payoffs with those of shareholders—the manager simultaneously chooses  $q$  and  $\alpha$  to maximize the utility of the principal, a representative shareholder

$$\max_{0 \leq q, 0 \leq \alpha \leq \pi(q)} u\left(\frac{\pi(q) - \alpha}{S} - \beta_i, -\psi(q) + \alpha + \sum_{j=1}^S \beta_j\right)$$

Formally, shareholders specify a forcing contract dictating  $q$  and  $\alpha$ . The remainder of the analysis examines the properties of such contracts.

### 3 Analysis

We begin by studying public goods contributions on the part of the manager and shareholders. Suppose shareholders provide strictly positive amounts of the public good (i.e.  $\beta_i > 0$

for all  $i$ ). Would the shareholders benefit by delegating public goods contributions to the manager? The following lemma suggests that answer is no.

**Lemma 1** *When shareholder contributions  $\beta_i$  are interior, manager contributions per shareholder  $\alpha_i$  (where  $\alpha_i = \alpha/S$ ) crowd out private contributions at a one for one rate. That is,*

$$\frac{d\beta_i}{d\alpha_i} = -1$$

The proof of the lemma follows directly from Bergstrom, Blume, and Varian 1986, Theorem 6, part (i), p. 42.

The lemma suggests that there is no benefit to having the manager contribute to the public good: firm contributions are exactly offset by reductions from shareholders. The result is a familiar one in public economics. Similar “neutrality” results have been shown to hold under a wide array of policy interventions (see, e.g. Warr, 1983; Kemp; and Bergstrom, Blume and Varian, 1986). While Friedman’s essay predates this literature, a similar intuition probably informed his view that public goods provision might just as well be left to individual shareholders rather than performed by firms.

The next result, however, shows that this intuition is incorrect when the manager’s incentives are aligned with those of shareholders.

**Proposition 1** *(i) Shareholders delegate all public goods contributions to the manager. (ii) Overall public goods provisioning and shareholder welfare are higher relative to the case where shareholders contribute individually.*

**Proof.** Suppose to the contrary that each shareholder contributes an amount  $\beta_i > 0$  to the public good while the manager optimally contributes  $\alpha' \geq 0$ . We will show that the manager can profitably deviate by increasing public goods provisioning and shareholder welfare such that shareholders optimally delegate all contributions to the manager. Let  $c(q, \alpha', \beta'_i)$  and  $g(q, \alpha', \beta'_i)$  be the levels of consumption and public goods enjoyed by each shareholder respectively. If instead, the manager contributed  $\alpha'' = \alpha' + S \times \beta'_i$  (i.e. an additional  $\beta'_i$  per shareholder), then by Lemma 1, shareholders would optimally respond by contributing nothing and the overall level of the public good would be unchanged; that is,  $c(q, \alpha'', 0) = c(q, \alpha', \beta'_i)$  and  $g(q, \alpha'', 0) = g(q, \alpha', \beta'_i)$ . Now suppose that the manager increased  $\alpha''$  slightly. Since individual contributions are at a corner solution, Lemma 1 no longer applies. Instead, each shareholder would experience a decrease in utility of  $u_c(c(q, \alpha', \beta'_i))$  and an increase of  $S \times u_g(g(q, \alpha', \beta'_i))$  from increased public goods provision. But since  $\beta'_i$  was optimal originally, then  $u_c(c(q, \alpha', \beta'_i)) = u_g(g(q, \alpha', \beta'_i))$  and hence  $u_c(c(q, \alpha', \beta'_i)) < S \times u_g(g(q, \alpha', \beta'_i))$ . Thus, the manager’s deviation increases public goods provisioning and shareholder welfare, but this contradicts the notion that the original contract was optimal. ■

Why does centralization help? The reason is that the manager can act as a commitment device on the part of shareholders. Indeed, the manager is able to perfectly solve the free-rider problem from the perspective of shareholders. Under the optimal contract, the manager fully internalizes the benefits to all shareholders of increased giving to the public good and sets output and contributions accordingly. This obviously relies on the assumption that

shareholders are identical; however, as we show in Section 4.1, the manager continues to play a useful role in solving the collective action problem (albeit imperfectly) even when shareholders are heterogeneous.

The intuition that centralized contribution mitigates free-riding may seem equally applicable to charitable non-profits. There is, however, an important difference between a charity and a firm. Management completely controls firm profits until distributed to the shareholders while a charity relies on voluntary contributions from individuals to fund the public good. Of course, these contributions are subject to the free-rider problem and hence the charity cannot replicate the commitment function of the firm. Thus, a charity is less effective in this centralization role than is the firm.

Next we turn to the quantity decision of the manager, one for which an analog outside the firm is more difficult.

**Proposition 2** *When incentives are fully aligned, the manager will produce less than the profit maximizing quantity.*

**Proof.** Suppose a firm produced the profit maximizing quantity  $\hat{q}$ . A slight production decrease would create a first order gain in shareholder welfare due to increased public good (i.e.  $\psi'(\hat{q}) > 0$ ), but no first order loss in profits (i.e.  $\pi'(\hat{q}) = 0$ ). Thus, some  $q < \hat{q}$  is optimal. ■

Friedman argued that a manager acting in the interests of shareholders would maximize profits and distribute the proceeds for shareholders to do with as they please. Propositions 1 and 2 show that the shareholders incent the manager to do neither—optimal production is below profit maximizing levels and optimal public goods provision is performed by the firm rather than shareholders.

Propositions 1 and 2 do not imply that, from a societal perspective, the free-rider problem is solved. Notice that the manager's incentives account for the positive externality among shareholders, but does not account for the positive externality accruing to non-shareholders. Indeed, it follows immediately from Proposition 1 that public goods would be underprovided were society to rely only on the firm. One might suspect that a similar argument could be made about production. The manager accounts for the negative externality of production on shareholders but takes no account of the externality on non-shareholders. Thus, one would expect the firm to overproduce from a societal perspective.

Before exploring this intuition, consider the following benchmark setting: Suppose that a social planner were given *full control of the firm and its profits*. How much would she optimally produce for the benefit of *all citizens*? By reasoning as in Proposition 1, we conclude that shareholders will make no private contributions to the public good. A utilitarian planner would maximize the aggregate not only of shareholder welfare but also that of non-shareholding citizens. That is, the planner will solve

$$\max_{0 \leq q, 0 \leq \alpha \leq \pi(q)} Su \left( \frac{\pi(q) - \alpha}{S}, -\psi(q) + \alpha \right) + \sum_{n=1}^N v^n(-\psi(q) + \alpha) \quad (3)$$

To make the problem interesting, we assume that the population on non-shareholding citizens,  $N$ , is sufficiently large that the planner wants to contribute something to the public

good. The following lemma describes the socially optimal production quantity. The proof, which is routine but tedious, is relegated to the appendix.

**Lemma 2** *The socially optimal production level,  $q^*$ , is the unique value of  $q$  solving  $\pi'(q) = \psi'(q)$ .*

Lemma 2 is intuitive. It says that the planner produces up to the point where marginal profit equals the marginal cost of repairing the damage to the public good. When choosing the production quantity, the planner simply asks “Will producing another unit generate more profits than it costs to clean up the resultant damage to the public good?” If the answer is ‘yes,’ then producing the unit and paying to completely negate the damage always makes society better off, regardless of how the planner decides to use the leftover profits from the additional unit. On the other hand, if the answer is ‘no,’ and the planner would spend any money at all, from any source, on the public good, then regardless of what other decisions the planner may make, the planner can save money and maintain public goods levels by not producing the additional unit. This intuition readily extends to a richer model where the planner also controls factors beyond those directly related to the firm, such as the ability to tax and redistribute income from citizens.

Lemma 2 shows that the planner’s problem may be decomposed into separate production and allocation decisions. Production quantity is selected to maximize the size of the “pie,” accounting for the costs of repairing the public good. The allocation decision determines the fraction of the pie going to consumption versus public goods provision.

With this benchmark in mind, we now turn to production when the firm is under the control of the manager. The following condition is the managerial analog to the “large  $N$ ” condition for the social planner’s problem. It describes circumstances in which the manager wants to contribute positive amounts to the public good.

**Condition 1 (Fundability)** *We say the public good is fundable iff shareholders prefer the manager to contribute something to the public good when production is optimally abated. Formally,*

$$u_c \left( \frac{\pi(q^*)}{S}, -\psi(q^*) \right) \leq Su_g \left( \frac{\pi(q^*)}{S}, -\psi(q^*) \right) \quad (4)$$

*Otherwise we say the public good is unfundable.*

We now come to the main result of the paper. It says that if the fundability condition holds, then the manager and the social planner make *exactly the same* production decision. Formally,

**Proposition 3** *(i) The manager chooses the socially optimal quantity  $q^*$  iff the public good is fundable; otherwise the firm overproduces (i.e.  $q \in (q^*, \hat{q})$ ). (ii) Furthermore, the manager provisions strictly positive amounts of the public good iff the inequality in equation (4) is strict.*

**Proof.** Step 1: First, we will show that the manager chooses the socially optimal quantity  $q^*$  if the public good is *fundable*.

Step 1.a: We may use Proposition 1 to simplify the manager's problem to

$$\max_{0 \leq q, 0 \leq \alpha \leq \pi(q)} u \left( \frac{\pi(q) - \alpha}{S}, -\psi(q) + \alpha \right) \quad (5)$$

Let  $q'$  and  $\alpha'$  be the manager's optimal production quantity and public goods contribution decisions respectively. The (unconstrained) first order condition of the manager's problem (5) for  $\alpha$  is

$$u_c = S u_g \quad (6)$$

and the (unconstrained) first order condition of the manager's problem for  $q$  is

$$\pi'(q') u_c = \psi'(q') S u_g \quad (7)$$

Together, equations (6) and (7) imply that, if an interior solution exists, the manager chooses production such that  $\pi'(q) = \psi'(q)$ ; that is, he chooses the socially optimal production quantity,  $q^*$ . We now consider possible corners. There are three constraints:  $q' \geq 0$ ,  $\alpha' \geq 0$ , and  $\alpha' \leq \pi(q')$ .

Step 1.b: We will first establish that  $q$  is never cornered by showing that  $q' \geq q^* > 0$ . Suppose to the contrary that  $q' < q^*$ . This implies  $\pi'(q') > \psi'(q')$ . The manager could increase production by a sufficiently small  $\varepsilon$ , increase  $\alpha$  by  $\varepsilon \times \psi'(q')$  to completely offset the additional production externality, and increase the total dividends to shareholders by  $\varepsilon \times (\pi'(q') - \psi'(q'))$ . Since this deviation leaves shareholders strictly better off, it contradicts the optimality of  $q'$ . Furthermore, since  $\pi'(0) > \psi'(0)$ ,  $\pi(\cdot)$  is strictly concave and  $\psi(\cdot)$  is strictly convex, we know  $q^* > 0$ . Thus,  $q$  is never cornered.

Step 1.c: We will show that if condition (4) is satisfied, then  $\alpha$  is not cornered below. Observe that since  $\frac{\partial u_c}{\partial q} < 0$  and  $\frac{\partial u_g}{\partial q} > 0$  condition (4) implies

$$u_c \left( \frac{\pi(q')}{S}, -\psi(q') \right) \leq S u_g \left( \frac{\pi(q')}{S}, -\psi(q') \right) \quad (8)$$

for all  $q' \geq q^*$ . Furthermore, since  $\frac{\partial u_c}{\partial \alpha} > 0$  and  $\frac{\partial u_g}{\partial \alpha} < 0$ , if condition (4) holds, there is always some  $\alpha \geq 0$  large enough such that (6) will hold for any  $q' \geq q^*$ . Thus, if that  $\alpha$  is not more than profits ( $\alpha \leq \pi(q')$ ), then the solution is interior and by Step 1.a  $q' = q^*$ .

Step 1.d: We will show that when  $\alpha$  is cornered above ( $\alpha' = \pi(q')$ ), then  $q' = q^*$ . When the constraint  $\alpha \leq \pi(q)$  binds ( $\alpha = \pi(q)$ ), the manager's problem becomes

$$\arg \max_q u(0, -\psi(q) + \pi(q)) \quad (9)$$

with the first order condition for  $q$

$$\pi'(q') u_g = \psi'(q') u_g$$

In this case, it is clear that  $q' = q^*$ . Thus, in Steps 1.a-1.d, we have shown that the manager chooses the socially optimal quantity  $q^*$  if the public good is *fundable*.

Step 2: Now we will show that if the manager chooses  $q^*$ , the public good is *fundable*. We do this by proving its contrapositive, namely, if the public good is *unfundable*, then  $q' > q^*$ . Suppose to the contrary that  $q' \leq q^*$ . From Step 1.b, it can only be the case that  $q' = q^*$ .

Step 2.a. We will show a contradiction when  $\alpha$  is interior. In this case, the manager's first order condition for  $\alpha$  must be met at  $q' = q^*$ :

$$u_c \left( \frac{\pi(q^*) - \alpha'}{S}, -\psi(q^*) + \alpha' \right) = Su_g \left( \frac{\pi(q^*) - \alpha'}{S}, -\psi(q^*) + \alpha' \right) \quad (10)$$

However, *unfundability* implies

$$\begin{aligned} u_c \left( \frac{\pi(q^*) - \alpha'}{S}, -\psi(q^*) + \alpha' \right) &> u_c \left( \frac{\pi(q^*)}{S}, -\psi(q^*) \right) \\ &> Su_g \left( \frac{\pi(q^*)}{S}, -\psi(q^*) \right) > Su_g \left( \frac{\pi(q^*) - \alpha'}{S}, -\psi(q^*) + \alpha' \right) \end{aligned}$$

where the outer inequalities follow because  $\frac{\partial u_c}{\partial \alpha} > 0$  and  $\frac{\partial u_g}{\partial \alpha} < 0$ , and this contradicts the manager's first order condition for  $\alpha$ .

Step 2. b. We will show a contradiction when  $\alpha$  is cornered below. In this case, the manager's first order condition cannot be met, because  $u_c > Su_g$  for all  $\alpha' \geq 0$ . But then the manager's first order condition for  $q$  (eqn. (7)) cannot be met except at  $q' > q^*$ , a contradiction.

Step 2.c. We will show a contradiction when  $\alpha$  is cornered above. In this case, the manager's first order cannot be met, because  $u_c < Su_g$  for all  $\alpha' \leq \pi(q^*)$ , but *unfundability* means  $u_c > Su_g$  for  $\alpha' = 0$ , a contradiction. Thus, in steps 2.a-2.c we have shown if the manager chooses  $q^*$ , the public good is *fundable*.

Step 3: Now we will show the manager provisions strictly positive amounts of the public good if the inequality in equation (4) is strict. A strict inequality in equation (4) implies *fundability*. From Step 1  $q' = q^*$  and either the manager's first order condition for  $\alpha$  holds or  $\alpha$  is bounded above. If  $\alpha$  is bounded above we are done. Suppose contrary to  $\alpha$  being interior, that  $\alpha = 0$ . Then the manager's first order condition for  $\alpha$  implies

$$u_c \left( \frac{\pi(q^*)}{S}, -\psi(q^*) \right) \geq Su_g \left( \frac{\pi(q^*)}{S}, -\psi(q^*) \right)$$

but this contradicts the strict inequality in equation (4).

Step 4: Finally, we will show that if the manager provisions strictly positive amounts of the public good, the inequality in equation (4) is strict. To do this we first argue that  $\alpha' > 0$  implies that  $q' = q^*$ . From Step 1.a, it is sufficient to establish a contradiction when  $q' > q^*$ . Recall that this implies  $\pi'(q') < \psi'(q')$ . In that case, it is more efficient to reduce production than to pay for offsetting public goods—the manager could decrease production  $q$  by a sufficiently small  $\varepsilon$ , and because  $\alpha > 0$ , reduce  $\alpha$  by  $\varepsilon \times \psi'(q')$  resulting no net decrease in public goods, but increasing total dividends paid to shareholders by  $\varepsilon \times (\psi'(q') - \pi'(q'))$ , which contradicts the optimality of  $q'$ . Since optimal production occurs when  $q = q^*$ , equation (10) represents the manager's first order condition. But since  $\frac{\partial u_c}{\partial \alpha} > 0$  and  $\frac{\partial u_g}{\partial \alpha} < 0$  the following must hold if  $\alpha$  were reduced to 0 :

$$u_c \left( \frac{\pi(q^*)}{S}, -\psi(q^*) \right) < Su_g \left( \frac{\pi(q^*)}{S}, -\psi(q^*) \right)$$

This is equation (4) where the inequality is strict. ■

Proposition 3 offers tight conditions in which the manager produces the socially optimal level of output. If, at this level of output, shareholders would have the manager contribute anything at all to the public good, then the incentives of the manager are perfectly aligned with societal incentives in terms of output. The intuition is as follows: While the shareholders do not desire the same overall level of the public good as does society at large, they do desire that the public good be provisioned as efficiently as possible by the manager. When the fundability condition holds, shareholders will direct the manager to divert a portion of profits to the public good for any production level above the social optimum. When there is overproduction, the marginal depletion of the public good exceeds the marginal profit. As a consequence, the manager can reduce production and increase dividends while still maintaining the same level of the public good. The stopping point occurs when the two margins are equalized—exactly the social planner’s optimality condition. In short, when the fundability condition holds, government intervention is no longer necessary to solve the “missing market” problem of the production externality.

How restrictive is the fundability condition? There are several reasons to believe that it is likely to be satisfied in most practical applications. First, if, in the absence of any production, shareholders view the public good as sufficiently important that they would contribute positive amounts, then the fundability condition is automatically satisfied. Second, if the decentralized provision of the public good under output  $q \leq q^*$  produces any contributions whatsoever, then the fundability condition is also satisfied. Finally, for a fixed dividend per shareholder, there exists a large enough shareholder base  $S$  such that the fundability condition is always satisfied.

Proposition 3 suggests that government intervention over production quantity cannot improve production quantity when the fundability condition holds. Nonetheless, governments do take considerable interest in externality mitigating technology—mandating that firms develop or implement technology to reduce externalities like pollution or subsidizing such research directly.

Suppose that the government faces the choice of subsidizing technology to make production cheaper or to make it cleaner. Obviously, a government concerned with production externalities would opt for the latter. Indeed, it would seem that subsidizing cheaper production would only exacerbate the problem of polluting output by inducing the firm to increase output. This, however, ignores the effects of changing technology on the contract offered by shareholders. The following proposition shows that, when the fundability condition holds, the two investment strategies are *neutral* with respect to public goods provision. Put differently, society may be better off investing in technology which makes production cheaper rather than cleaner, if developing the former technology is less expensive.

Before proceeding, we need to be precise about the technology changes we have in mind. Suppose that under the *cleaner* technology, we replace  $\psi(q)$  with  $\hat{\psi}(q)$  with the property that, for all  $q$ ,  $\psi'(q) > \hat{\psi}'(q)$ . Suppose that under a *cheaper* technology, we replace  $\pi(q)$  with  $\hat{\pi}(q)$ , with the property that, for all  $q$ ,  $\hat{\pi}'(q) > \pi'(q)$ . Other than this,  $\hat{\psi}(q)$  and  $\hat{\pi}(q)$  have the usual properties of profit and externality functions described in Section 2. Finally, to make the two technology improvements comparable in their effectiveness, suppose that, for all  $q$ ,

$$\psi'(q) - \hat{\psi}'(q) = \hat{\pi}'(q) - \pi'(q) \quad (11)$$

That is, for a given level of output, the cost effectiveness of the cleaner technology is identical to the cost savings from the cheaper technology.

To illustrate this, consider the following example of profit and damage repair functions:

$$\begin{aligned}\pi(q) &= \frac{\frac{1}{a} - a \left(\frac{1}{a} - q\right)^2}{2} \\ \psi(q) &= \frac{bq^2}{2}\end{aligned}$$

where  $a$  parameterizes the cheapness of the production technology and  $b$  parameterizes its cleanliness. The derivatives associated with these functions are

$$\begin{aligned}\pi'(q) &= 1 - aq \\ \psi'(q) &= bq\end{aligned}$$

Now, if we substitute  $\hat{a}$  for  $a$  to obtain  $\hat{\pi}(q)$  and  $\hat{b}$  for  $b$  to obtain  $\hat{\psi}(q)$ , then the technology improvements are comparable whenever  $b - \hat{b} = a - \hat{a}$ .

Our next result establishes the neutrality of comparable technological changes.

**Proposition 4** *Suppose the fundability condition holds. Then firm output is identical under the cleaner or cheaper technology. Furthermore, total public goods are identical under the two technology improvements.*

**Proof.** Since fundability holds, marginal profits equals marginal externality. With the cleaner technology, there is a unique  $q$  solving

$$\hat{\psi}'(q) = \pi'(q) \tag{12}$$

while with the cheaper technology, there is a unique  $q'$  solving

$$\psi'(q') = \hat{\pi}'(q') \tag{13}$$

We will show that  $q = q'$ . Rewriting equation (11), we have

$$\pi'(q) - \hat{\psi}'(q) = \hat{\pi}'(q) - \psi'(q)$$

Next, notice from equation (12) that  $\pi'(q) - \hat{\psi}'(q) = 0$ ; therefore, for this same value of  $q$ , it must be that  $\hat{\pi}'(q) - \psi'(q) = 0$ , which is the solution to equation (13). Hence, we may conclude that  $q' = q$ .

Next, notice that following the production decision, the manager uses  $\alpha$  to balance consumption,  $c$ , and public goods provisioning,  $g$ . One can think of this as the manager's budget set. The trade-off between these is unaffected by the technology, so the slope of the manager's budget set is constant and identical under the two technology improvements.

Next, we will show that the budget sets themselves are identical. To see this, we will show that the two technology improvements lead to budget sets that share a common point. Specifically, notice that the maximum total public goods under the cleaner technology is

$\pi(q^*) - \hat{\psi}(q^*)$  while the maximum under the cheaper technology is  $\hat{\pi}(q^*) - \psi(q^*)$ , where  $q^*$  solve equations (12) and (13). We claim that

$$\pi(q^*) - \hat{\psi}(q^*) = \hat{\pi}(q^*) - \psi(q^*)$$

Recall that

$$\pi(q^*) - \hat{\psi}(q^*) = \int_0^{q^*} \pi'(q) - \hat{\psi}'(q) dq$$

while

$$\hat{\pi}(q^*) - \psi(q^*) = \int_0^{q^*} \hat{\pi}'(q) - \psi'(q) dq$$

Differencing the two expressions, we obtain

$$\int_0^{q^*} \hat{\pi}'(q) - \pi'(q) - (\psi'(q) - \hat{\psi}'(q)) dq = 0$$

where the equality follows from equation (11). Since the budget sets are identical under the two technology improvements, the optimal choice must likewise be identical. Hence, total public goods are *identical* under the two technology improvements. ■

The fundability condition ensures that marginal profit equals the marginal externality, i.e.  $\pi' = \psi'$  under the optimal output. Thus, the manager's problem is equivalent to choosing  $q$  to maximize  $\pi(q) - \psi(q)$ . It is helpful to think of this as a familiar firm maximization problem where  $\pi(q)$  is a revenue function and  $\psi(q)$  is a cost function. Under this view, the cleaner technology is equivalent to a reduction in marginal costs while the cheaper technology is equivalent to an increase in marginal revenues of the same amount. Since the manager only cares about the net of revenues and costs, each of these changes has the *same* effect—a price increase or a marginal cost decrease of \$1 produce the same effect on profits and hence output. Following production, the manager's job is simply to choose between consumption and public goods provision along the budget curve induced by the output decision. Since the relative price, and, indeed, the budget set itself is unaffected by the technological change, the final choice of consumption and public goods provision is also unchanged.

### 3.1 Testable Implications of the Model

The model, in principle, is testable. Specifically, a firm undertakes CSR because the manager can provide public goods more efficiently than shareholders can on their own. Notice that, as the firm becomes more widely held (i.e.  $S$  increases), the free-rider problem grows and, as a consequence, the scope for efficiency increases. Thus, the model predicts that, all else equal, more widely held firms will (optimally) engage in greater CSR than more closely held firms. One could test this using cross-sectional data with controls for firm size and dividend payouts exploiting differences in the breadth of shareholdings. Alternatively, buyouts and privatizations offer natural experiments in which the breadth of the shareholder base shrinks. Mergers and public offerings increase the breadth of the shareholder base.

If the ratio of the marginal utilities of shareholders' personal gains from the public good to marginal utilities of consumption  $u_g/u_c$  increases, so should CSR activities of a firm. While preferences themselves are not directly observable, it is not unreasonable to infer that

Socially Responsible Investment (SRI) funds care more about public welfare than their average peers. Similarly, the investment activities of insiders are publicly registered, and in many cases their private philanthropy documented. Investment (divestiture) by individuals or organizations revealing stronger (weaker) preferences for public welfare, one may expect more (less) CSR.<sup>3</sup> The model assumes that managers' contracts reflect shareholder preferences. Thus, the contract will reduce the power of managerial incentives tied to profits as shareholder preferences for public goods grow, *ceteris paribus*. The size and form of executive compensation is available for many large firms. Clearly, this model along with several alternatives predicts firm provision of public goods will increase in more profitable times (i.e. as  $\pi'$  increases).

## 4 Robustness

To illustrate the main economic intuitions of the model in the simplest possible setting, we assumed that shareholders were identical, stock holdings were exogenous, and that the firm was, in effect, a monopolist. In this section, we relax each of these assumptions in turn.

### 4.1 Heterogeneous Shareholders

In this section, we show that the main results of the model continue to hold when shareholders are not identical. The manager continues to play a positive role in provisioning public goods and, with suitable modification of the fundability condition, it remains the case that manager's output choice coincides with the social optimum.

When shareholders are identical, determining the manager's objective function absent agency problems is straightforward. However, when shareholders differ and have multidimensional utilities, this is no longer the case. One possibility is that shareholders select a utilitarian contract for the manager. In that case, the manager would choose  $q$  and  $\alpha$  to maximize the sum of shareholder utilities perhaps weighted by their ownership shares. Alternatively, one might imagine a proposal process along the lines of Baron and Ferejohn (1989). A simple version of this process (finite stages, closed rule) would result in a welfare function giving weight to the proposer's utility subject to the constraint that the forcing contract is sufficient to induce a minimal winning coalition to join the proposer. Finally, one might postulate a pure voting process possibly leading to a contract whereby the manager is asked to maximize the utility of the *median* shareholder.<sup>4</sup> We abstract away from the details determining the manager's contract in favor of a general, flexible form that nests the above approaches. Suppose that shareholder  $i$  is entitled to a fraction  $\lambda_i$  (where  $\sum \lambda_i \leq 1$ ) of net profits and that  $f$  is an increasing and concave function of shareholder utilities. Then, a variety of shareholder negotiating processes for determining the manager's contract will result in the following objective function for the manager:

$$\max_{0 \leq q, 0 \leq \alpha \leq \pi(q)} f\left(u^1\left(c^1(q, \alpha), g(q, \alpha)\right), u^2\left(c^2(q, \alpha), g(q, \alpha)\right), \dots, u^S\left(c^S(q, \alpha), g(q, \alpha)\right)\right) \quad (14)$$

<sup>3</sup>Since the investment decision is probably endogenous, one would need a suitable instrument to establish causation.

<sup>4</sup>It is well-known that the existence of a uniquely defined median shareholder is problematic. See, e.g., McKelvey 1976

where

$$\begin{aligned} c^i(q, \alpha) &= \lambda_i(\pi(q) - \alpha) - \beta^{i*}(q, \alpha) \\ g(q, \alpha) &= -\psi(q) + \alpha + \sum_{j=1}^S \beta^{j*}(q, \alpha) \end{aligned}$$

Here,  $\beta^{i*}(q, \alpha)$  is the equilibrium individual contribution of shareholder  $i$  in the second stage game given that the manager produces  $q$  and contributes  $\alpha$  and all other shareholders make equilibrium contributions given  $q$  and  $\alpha$ .

Analogous to the case where shareholders are identical, we assume that, in the absence of any contributions from the manager, the public good is sufficiently desirable that all shareholders would make non-zero contributions in the second stage game. That is,  $\beta_i > 0$  for all  $i$ . When shareholders are identical, we showed that they optimally delegated *all* public goods provisioning to the manager. When shareholders differ, the result is weakened; however the broader intuition that the firm plays an important delegation role remains intact. Consistent with the identical shareholder case, the manager optimally increases the overall provisioning of the public good and leaves all shareholders better off than when they contribute only individually. Formally,

**Proposition 5** (i) *At least one shareholder delegates all public goods contributions to the manager.* (ii) *Overall public goods provisioning and shareholder welfare are higher relative to the case where shareholders contribute only individually.*

**Proof.** Suppose that the manager optimally chooses production quantity  $q'$  and contributes  $\alpha'$ . Let  $\beta'_i$  be each shareholder's individual contribution to the public good, and let shareholder  $m$  be one individually *contributing the least*. Suppose contrary to the proposition that  $\beta'_m > 0$  (i.e. the lowest contributor does not fully delegate). We will show that the manager can profitably deviate by increasing public goods provisioning and shareholder welfare such that shareholder  $m$  will optimally delegate all contributions to the manager. Let  $c(q, \alpha', \beta'_i)$  and  $g(q, \alpha', \beta'_i)$  be the levels of consumption and public goods respectively enjoyed by shareholder  $i$ . Suppose that the manager deviates by contributing  $\alpha'' = \alpha' + S \times \beta'_m$  (i.e. an additional  $\beta'_m$  per shareholder) to the public good, then by Lemma 1, all shareholders would optimally respond by contributing  $\beta'_i - \beta'_m$ , and the overall level of the public good would be unchanged; that is,  $c(q, \alpha'', \beta'_i - \beta'_m) = c(q, \alpha', \beta'_i)$  and  $g(q, \alpha'', \beta'_i - \beta'_m) = g(q, \alpha', \beta'_i)$ . Now suppose that the manager increased  $\alpha''$  slightly. Shareholder  $m$  is now at a corner solution; hence Lemma 1 no longer applies. Each shareholder would experience a decrease in utility of  $u_c^i(c(q, \alpha', \beta'_i))$  and an increase of  $S \times u_g^i(g(q, \alpha', \beta'_i))$  from increased public goods provision. But since each  $\beta'_i$  was optimal originally, then  $u_c^i(c(q, \alpha', \beta'_i)) = u_g^i(g(q, \alpha', \beta'_i))$ , and hence  $u_c^i(c(q, \alpha', \beta'_i)) < S \times u_g^i(g(q, \alpha', \beta'_i))$ . Thus, the manager's deviation increases the provisioning of the public good and the utility of every shareholder. Hence, it also increases the value of the manager's objective function, but this contradicts the notion that the original contract was optimal. ■

Limited delegation is a consequence of imperfect alignment between the manager's objectives and those of an *individual* shareholder. While the manager optimizes for some expression of collective preferences, an individual may care sufficiently about the public good

that she continues to contribute privately. To completely resolve the free-riding problem for shareholders, a manager would have to be able to choose the amount of each shareholder's contribution to the public good from his individual share of profits, an unlikely possibility. It is important to recognize that this same force is present even if a utilitarian social planner were to run the firm.

We now turn to the question of production quantities. Since the arguments in Proposition 2 did not rely on shareholders being identical, it follows immediately that:

**Remark 1** *With heterogeneous shareholders, the firm produces strictly less than the profit maximizing quantity.*

But how much production does the firm undertake? It is intuitive (and may be readily verified) that the addition of shareholder heterogeneity leaves the socially optimal production level unchanged; thus, Lemma 2 continues to hold. We previously showed that the firm optimally chose the socially optimal level of production provided that the fundability condition held. Here, we amend the fundability condition to account for shareholder heterogeneity and show that it remains the case that the firm produces at the socially optimal level. Before proceeding, it is useful to offer the following technical lemma (proved in the Appendix):

**Lemma 3** *If shareholders prefer the manager to contribute something at production level  $q' \geq q^*$ , then shareholders prefer the manager to contribute more for all greater production levels ( $q'' > q'$ ).*

Accordingly, we can again define *fundability* as the condition that manager contribution is not cornered at zero for the single production level  $q^*$ :

**Condition 2 (Fundability)** *We say the public good is fundable iff shareholders prefer the manager to contribute something to the public good when production is optimally abated. Formally,*

$$\sum_{i=1}^S (\lambda_i + \beta_\alpha^{i*}) u_c^i f_i \leq \left(1 + \sum_{i=1}^S \beta_\alpha^{i*}\right) \sum_{i=1}^S u_g^i f_i \quad (15)$$

where  $f_i$ ,  $u_c^i$ ,  $u_g^i$  and  $\beta_\alpha^{i*}$  are evaluated at  $\langle q, \alpha \rangle = \langle q^*, 0 \rangle$  for all  $i$ . Otherwise we say the public good is unfundable.

We now extend Proposition 3, which is proved in the Appendix, to allow for heterogeneous shareholders:

**Proposition 6** *When shareholders are heterogeneous, the manager chooses the socially optimal quantity  $q^*$  iff the public good is fundable (in the sense of Condition 2) otherwise the firm overproduces (i.e.  $q \in (q^*, \widehat{q})$ ). Furthermore, the manager provisions strictly positive amounts of the public good iff the inequality in equation (15) is strict.*

Like Proposition 2, Proposition 4 also made no use of the fact that shareholders were identical. Thus, it too immediately extends to the heterogeneous case. We formalize this observation in the following remark.

**Remark 2** *Suppose that Condition 2 holds. Then with heterogeneous shareholders, firm output is identical under the cleaner or cheaper technology. Furthermore, total public goods are identical under the two technology improvements.*

## 4.2 Endogenous Shareholder Assignment

In the initial analysis we assumed that shareholders were exogenously assigned to firms. Of course, investors adjust their holdings regularly. One may worry that when shareholders are free to move, they will automatically flee to profit maximizing firms. This section shows that they do not, and that our primary results continue to hold.

Suppose shareholders are atomic—each shareholder is too insignificant to alter the per shareholder dividend, production quantity, or public goods provision by a manager if she sells her share and buys an outside investment. A shareholder may sell her firm holdings and buy another, equally priced, investment, which pays a dividend,  $\Pi$ , on the same schedule as the firm. Assume an individual will pay the same amount for two investments which generate identical utility. Clearly, the proofs of Lemma 1 through Proposition 4 still hold, but now the number of shareholders,  $S$ , is endogenous.

**Proposition 7** *The firm pays the same dividend as an identically priced quantity of the outside investment (i.e.  $\frac{\pi - \alpha}{S} = \Pi$ ).*

**Proof.** An atomic shareholder cannot change total public goods (e.g. by exchanging investments) except by her private contribution. By moving to an investment with a higher dividend, a shareholder could increase her private consumption, and thus would contribute at least as much to the public good (though possibly still 0 if her personal marginal utility for private consumption remains greater than her marginal utility for the public good). This is true for all shareholders of the firm as well as those holding the outside investment. In equilibrium, no owner of the firm or the outside investment can have incentive to move to the other. ■

**Corollary 1** *All firms pay the same dividend.*

**Corollary 2** *There is no price premium (or discount) for shareholder conscious firms.*

The fact that shareholders are not willing to pay more for a firm run by a manager, who maximizes their total welfare (as opposed to one, who only cares about profits), comes from the fact that in equilibrium, no individual shareholder of such a firm is better off than a person who holds the alternative investment—price adjusted dividends are identical and public goods, wherever they come from, are non-excludable.<sup>5</sup>

## 4.3 Competitive Market

If one interprets the profit function  $\pi(q)$  and externality function  $\psi(q)$  as the residual profit and externality functions for firm  $n$  operating in, say, a Cournot oligopoly, then the proofs of the main propositions are unchanged. However,  $q_n^*$  is no longer the socially optimal quantity.  $q_n^*$  is the production quantity where firm  $n$ 's marginal profit equals marginal cost of offsetting its production externality, given the production decisions of competitors, but it does not account for the inframarginal impacts of firm  $n$ 's production on each other firm's profit

---

<sup>5</sup>This should not be confused with unwillingness to pay for “warm-glow” utility from owning shares of a firm, which improves society, but the shareholders here do not care which investment they hold *per se*.

and externality. Thus, if production by firm  $n$  decreases marginal profit and increases the marginal externality for all other firms, the industry will overproduce relative to the societal optimal but less than a pure profit maximizing industry. The amount of overproduction is exactly the same as if a tax authority could only charge a profit maximizing firm for its own externality.

## 5 Conclusion

One might think that the more inward-looking the firm, the worse its actions for society at large. Put differently, the better shareholders can solve the agency problem and induce the manager to act in their interests, the worse it is for the much larger non-shareholding public. We have shown that, when the interests of shareholders and society at large correlate at all, precisely the opposite is true—a firm that solves the agency problem optimally regulates its output and engages in costly CSR activities that benefit society at large. Specifically, when the manager acts purely on behalf of shareholders: (1) firms will provide more public goods than shareholders would on their own, and (2) if production generates externalities felt by shareholders, firms will produce less than the profit maximizing quantity. Thus, although shareholders will have less money, they will be better off. Broader society benefits too, though not by any design of the firm.

Remarkably, if shareholders care enough about the public good that they are willing to fund some of it on their own, they will direct the firm to produce the *socially optimal quantity*. Finally, under these same conditions, a neutrality result emerges: introducing profit enhancing technology has the same impact on the supply of the public good as a technology that reduces the damage from firm output. The reason is that the firm itself internalizes the trade-off between profit gains and damage caused by its output.

The key to these results is recognizing that shareholders, like other citizens, care about public goods as well as money (although perhaps not with the same rates of substitution). Shareholders recognize the free-rider problems endemic to the private provision of public goods and, quite rightly, see the firm as offering an efficient avenue for ameliorating these problems. Thus, when shareholders direct managers to act in their interests, CSR emerges not as an undesirable consequence of behavioral motives or agency problems on the part of the manager, but rather in the course of discharging his duties faithfully to maximize shareholder welfare.

This is not to say that the firm perfectly solves the public goods problem. The need for governmental remedies remains; however, the amount of the public good increases compared to the case where firms engage in pure profit maximization and thus the scope for governmental intervention is lessened. Put differently, making managers more accountable to shareholders confers a *social* benefit.

In terms of the broader literature, we offer a new rationale for CSR. It is not simply a disguised form of profit maximization or an unfortunate consequence of behavioral motives or agency problems. Rather, CSR arises specifically at the direction of shareholders, not in spite of their wishes.

Viewed through this lens, several new implications emerge. For instance, our model suggests that widely held firms will exhibit more social responsibility than closely held firms, a

prediction that seems consistent with casual empiricism. It also has implications for policy makers evaluating foreign direct investment. Socially responsible behavior by firms is driven by shareholders' *personal gains from the public good*. The manager's choices do not comprehend impacts to the public good not felt by shareholders. So, if the negative externalities of firm production are geographically localized, such as with some forms of pollution or labor practices, then firms operating nearer to influential shareholders can be expected to behave better. Policy makers do well to consider the incentives of shareholders to outsource and then do evil abroad, while still provisioning public goods where shareholders benefit most, at home. Of course, this implies that foreign held companies are less likely to behave nicely in the US (from the perspective of US citizens) than locally held firms.

On the flipside, when shareholders feel the externalities of production and remote consumers do not, those consumers will (at least partially) pay for the externalities because the supply reductions implied by Proposition 2 will increase the market clearing price. For example, if a US factory produces less pesticide because its US shareholders breathe the production exhaust, the reduced supply of pesticide will raise its cost. For consumers breathing the same air as shareholders, this trade-off may justify the additional price, but those a continent away will only lose consumer surplus.

Proposition 3 cautions against regulating production quantities—in the case of a widely held monopoly (such that fundability holds), regulators can only do harm. In effect, there is no longer a need for Pigovian taxes to induce the firm to internalize production externalities—a useful thing given the difficulty of obtaining the information required to implement such taxes (Baumol, 1972). Moreover, even when firms are (imperfectly) competitive, they still internalize private information regarding the profits and harm that they directly generate.

Although the model does not lead to Friedman's ideal of shareholders of profit maximizing firms, who individually spend their dividends on social goods, Proposition 4 says that when fundability holds, improving firms' profitability helps society as much as reducing its negative externality, a result that, although stemming from another mechanism, is reminiscent of Friedman's original thesis that making more profits is what helps society.

## 6 Appendix

**Lemma 2** *The socially optimal production level,  $q^*$ , is the unique value of  $q$  solving  $\pi'(q^*) = \psi'(q^*)$ .*

**Proof.** First, consider the case where there is an interior solution for both  $q$  and  $\alpha$ . In that case, the first order condition of the planner's problem (3) for  $\alpha$  is

$$u_c = Su_g + \sum_{n=1}^N v_g^n \quad (16)$$

where  $v_g^n$  denotes the derivative with respect to its argument. The first order condition of the planner's problem for  $q$  is

$$\pi'(q) u_c = \psi'(q) \left( Su_g + \sum_{n=1}^N v_g^n \right) \quad (17)$$

Together, equations (16) and (17) imply that the socially optimal production quantity,  $q^*$ , satisfies  $\pi'(q) = \psi'(q)$ .

Next, we consider possible corner solutions. First, consider the case where  $q = 0$ . In that case, the constraint on  $\alpha$  is binding and hence  $\alpha = 0$ . This is never optimal for the planner. If, instead, the planner produced an arbitrarily small amount,  $q = \varepsilon$ , and used the entire proceeds for the public good, i.e.  $\alpha = \pi(\varepsilon)$  then welfare would be

$$Su(0, -\psi(\varepsilon) + \pi(\varepsilon)) + \sum_{n=1}^N v^n(-\psi(\varepsilon) + \pi(\varepsilon)) > Su(0, 0) + \sum_{n=1}^N v^n(0)$$

where the inequality follows from the fact that  $\pi'(0) > \psi'(0)$ . The right-hand side of the above inequality is welfare under zero production; thus,  $q = 0$  is never optimal, and equation (17) always holds with equality.

Finally, consider the case where  $\alpha = \pi(q)$ . The planner's problem then becomes

$$\max_q Su(0, -\psi(q) + \pi(q)) + \sum_{n=1}^N v^n(-\psi(q) + \pi(q))$$

yielding the following first order condition for  $q$

$$(-\psi'(q) + \pi'(q)) \left( Su_g + \sum_{n=1}^N v^n \right) = 0$$

Hence, the socially optimal production quantity satisfies  $\pi'(q) = \psi'(q)$ . Strict concavity of  $\pi(\cdot)$  and strict convexity of  $\psi(\cdot)$  imply that this solution is unique. ■

**Lemma 3** *If shareholders prefer the manager to contribute something at production level  $q' \geq q^*$ , then shareholders prefer the manager to contribute more for all greater production levels ( $q'' > q'$ ).*

**Proof.** Given production  $q$ , let  $\alpha > 0$  be the optimal managerial contribution,  $c^i(q, \alpha, \beta^i) = \lambda_i(\pi(q) - \alpha) - \beta^i$  be shareholder  $i$ 's private consumption and  $g(q, \alpha, \beta) = -\psi(q) + \alpha + \sum_{j=1}^S \beta^j$  be total public goods. Suppose that the manager increased production to  $q'' = q' + \varepsilon$ , where  $\varepsilon > 0$  is sufficiently small. Holding managerial and private contribution fixed, all shareholders will consume more and enjoy less public goods. Since

$$\frac{u_g^i(c^i(q', \alpha', \beta^{i'}) , g(q', \alpha', \beta'))}{u_c^i(c^i(q', \alpha', \beta^{i'}) , g(q', \alpha', \beta'))} < \frac{u_g^i(c^i(q'', \alpha', \beta^{i'}) , g(q'', \alpha', \beta'))}{u_c^i(c^i(q'', \alpha', \beta^{i'}) , g(q'', \alpha', \beta'))}$$

for all  $i$  and positive contribution was optimal at  $q'$ , more total contribution, either centralized or decentralized, is optimal at  $q''$ . Define  $B(q, \alpha)$  to be the equilibrium set of shareholders who privately contribute or are precisely indifferent to contributing when the manager chooses production level  $q$  and public goods contribution  $\alpha$

$$B(q, \alpha) = \{i : u_c^i(c^i(q, \alpha, \beta^i), g(q, \alpha, \beta)) = u_g^i(c^i(q, \alpha, \beta^i), g(q, \alpha, \beta))\}$$

If  $B(q', \alpha') = \emptyset$ , the additional contribution must come from the manager, because no individual shareholder will contribute. So we restrict our attention to the remaining case where at least some shareholders privately contribute.

Consider contributors first: Each shareholder  $i \in B(q', \alpha')$  would contribute more if no other shareholder  $j \in B(q', \alpha')$  did, but since  $\frac{d\beta^i}{d\beta^j} > -1$  every shareholder  $i \in B(q', \alpha')$  will contribute more. So, all shareholders  $i \in B(q', \alpha')$  would benefit from small increase above  $\alpha'$ .

Now consider non-contributors: Even if all shareholders  $i \in B(q', \alpha')$  spent all of their additional dividend on the public good (i.e.  $\beta^{i''} = \lambda_i(\pi(q'') - \pi(q')) + \beta^{i'}$  for all  $i \in B(q', \alpha')$  and  $\beta^{i''} = \beta^{i'} = 0$  for all  $i \notin B(q', \alpha')$ ), they could not recover the public good destroyed by the additional production externality because  $\pi'(q'') < \psi'(q'')$ . Since consumption would be identical (i.e.  $c^i(q'', \alpha', \beta^{i''}) = c^i(q', \alpha', \beta^{i'})$ ) and public goods reduced (i.e.  $g(q'', \alpha', \beta^{i''}) < g(q', \alpha', \beta^{i'})$ ) all contributing shareholders  $i \in B(q', \alpha')$  are at a lower budget set. Thus, regardless of how contributing shareholders  $i \in B(q', \alpha')$  (with convex preferences) increase their contribution, public goods decrease. Since it was optimal for the manager to contribute public goods at  $q'$ , it must be optimal for the manager to contribute more to the public good now that public goods have decreased and the private consumption of all non-contributing shareholders  $i \notin B(q', \alpha')$  has increased. ■

The following Lemmas prove useful in proving Proposition 6.

**Lemma 4** *The relationship between output, individual, and managerial contributions to the public good satisfies*

$$\begin{aligned} \pi'(q) \beta_\alpha^i(q, \alpha) &< -\beta_q^i(q, \alpha) < \psi'(q) \beta_\alpha^i(q, \alpha) \iff q < q^* \\ \pi'(q) \beta_\alpha^i(q, \alpha) &= -\beta_q^i(q, \alpha) = \psi'(q) \beta_\alpha^i(q, \alpha) \iff q = q^* \\ \pi'(q) \beta_\alpha^i(q, \alpha) &> -\beta_q^i(q, \alpha) > \psi'(q) \beta_\alpha^i(q, \alpha) \iff q > q^* \end{aligned}$$

**Proof.** Given that the manager produces  $q$  and contributes  $\alpha$  to the public good and that other shareholders contribute  $\beta_{i-}$ , shareholder  $i$ 's optimality condition balances her marginal utilities of consumption and public good

$$F_i \equiv -u_c^i \left( \lambda_i(\pi(q) - \alpha) - \beta^i, -\psi(q) + \alpha + \sum_{j=1}^S \beta^j \right) + u_g^i \left( \lambda_i(\pi(q) - \alpha) - \beta^i, -\psi(q) + \alpha + \sum_{j=1}^S \beta^j \right) = 0$$

From the Implicit Function Theorem

$$\beta_q^i(q, \alpha) = -(D_\beta F^{-1})_i \cdot D_q F \quad (18)$$

$$\beta_\alpha^i(q, \alpha) = -(D_\beta F^{-1})_i \cdot D_\alpha F \quad (19)$$

where the  $i^{\text{th}}$  coordinate of the column vectors  $D_q F$  and  $D_\alpha F$  respectively are

$$(D_q F)_i = \frac{dF_i}{dq} = -(\pi'(q) \lambda_i(u_{cc}^i - u_{cg}^i) + \psi'(q)(u_{gg}^i - u_{cg}^i)) \quad (20)$$

$$(D_\alpha F)_i = \frac{dF_i}{d\alpha} = \lambda_i(u_{cc}^i - u_{cg}^i) + (u_{gg}^i - u_{cg}^i) \quad (21)$$

Diminishing MRS implies the following:

$$\begin{aligned} \frac{d}{dc} MRS_{cg} &= \frac{d}{dc} \frac{u_c}{u_g} = \frac{u_{cc}u_g - u_c u_{cg}}{u_g^2} < 0 \iff u_{cc} - u_{cg} < 0 \\ \frac{d}{dg} MRS_{gc} &= \frac{d}{dg} \frac{u_g}{u_c} = \frac{u_{gg}u_c - u_g u_{cg}}{u_c^2} < 0 \iff u_{gg} - u_{cg} < 0 \end{aligned}$$

where “ $\Longleftrightarrow$ ” follows because the optimality condition for an individual shareholder’s private contribution to the public good implies  $u_c = u_g$ ,  $u_c > 0$  and  $u_g > 0$ . Note that  $\frac{\partial F_i}{\partial \beta_i} = u_{cc}^i - u_{cg}^i + u_{gg}^i - u_{cg}^i$  and  $\frac{\partial F_i}{\partial \beta_j} = u_{gg}^i - u_{cg}^i$  when  $i \neq j$ . Since  $u_{cc}^i - u_{cg}^i < 0$  and  $u_{gg}^i - u_{cg}^i < 0$ , the rows of  $D_\beta F$  are linearly independent. Thus,  $D_\beta F$  is invertible. From (18)-(21)

$$\begin{aligned} -\beta_q^i(q, \alpha) &> \psi'(q) \beta_\alpha^i(q, \alpha) \\ \Longleftrightarrow \pi'(q) \lambda_i(u_{cc}^i - u_{cg}^i) + \psi'(q)(u_{gg}^i - u_{cg}^i) &> \psi'(q)(\lambda_i(u_{cc}^i - u_{cg}^i) + (u_{gg}^i - u_{cg}^i)) \\ \Longleftrightarrow \pi'(q) < \psi'(q) \\ \Longleftrightarrow q > q^* \end{aligned}$$

and similarly

$$\begin{aligned} \pi'(q) \beta_\alpha^i(q, \alpha) &> -\beta_q^i(q, \alpha) \\ \Longleftrightarrow \pi'(q)(\lambda_i(u_{cc}^i - u_{cg}^i) + (u_{gg}^i - u_{cg}^i)) &> \pi'(q) \lambda_i(u_{cc}^i - u_{cg}^i) + \psi'(q)(u_{gg}^i - u_{cg}^i) \\ \Longleftrightarrow \pi'(q) < \psi'(q) \\ \Longleftrightarrow q > q^* \end{aligned}$$

■

**Proposition 6** *The manager chooses the socially optimal quantity  $q^*$  iff the public good is fundable; otherwise the firm overproduces (i.e.  $q \in (q^*, \hat{q})$ ). Furthermore, the manager provisions strictly positive amounts of the public good iff the inequality in equation (15) is strict.*

**Proof.** Step 1: First, we will show that the manager chooses the socially optimal quantity  $q^*$  if the public good is *fundable*.

Step 1.a: Let  $q'$  and  $\alpha'$  be the manager’s optimal production quantity and public goods contribution decisions respectively. The (unconstrained) first order condition of the manager’s problem (14) for  $\alpha$  is

$$\sum_{i=1}^S (\lambda_i + \beta_\alpha^{i*}(q', \alpha')) u_c^i f_i = \left(1 + \sum_{j=1}^S \beta_\alpha^{j*}(q', \alpha')\right) \sum_{i=1}^S u_g^i f_i \quad (22)$$

and the (unconstrained) first order condition of the manager’s problem for  $q$  is

$$\sum_{i=1}^S (\lambda_i \pi'(q') - \beta_q^{i*}(q', \alpha')) u_c^i f_i = \left(\psi'(q') - \sum_{j=1}^S \beta_q^{j*}(q', \alpha')\right) \sum_{i=1}^S u_g^i f_i \quad (23)$$

From Lemma 4, and (23) we know

$$\begin{aligned} \pi'(q') \sum_{i=1}^S (\lambda_i + \beta_\alpha^{i*}(q', \alpha')) u_c^i f_i &< \psi'(q') \left(1 + \sum_{j=1}^S \beta_\alpha^{j*}(q', \alpha')\right) \sum_{i=1}^S u_g^i f_i \Longleftrightarrow q' < q^* \\ \pi'(q') \sum_{i=1}^S (\lambda_i + \beta_\alpha^{i*}(q', \alpha')) u_c^i f_i &= \psi'(q') \left(1 + \sum_{j=1}^S \beta_\alpha^{j*}(q', \alpha')\right) \sum_{i=1}^S u_g^i f_i \Longleftrightarrow q' = q^* \\ \pi'(q') \sum_{i=1}^S (\lambda_i + \beta_\alpha^{i*}(q', \alpha')) u_c^i f_i &> \psi'(q') \left(1 + \sum_{j=1}^S \beta_\alpha^{j*}(q', \alpha')\right) \sum_{i=1}^S u_g^i f_i \Longleftrightarrow q' > q^* \end{aligned}$$

Substituting (22) into the above implies that one or more of the following must hold at the optimal  $q$  :

$$\begin{aligned}\pi'(q') &< \psi'(q') \iff q' < q^* \\ \pi'(q') &= \psi'(q') \iff q' = q^* \\ \pi'(q') &> \psi'(q') \iff q' > q^*\end{aligned}$$

The first and last statements are false. Thus, if an interior solution exists, it can only be at  $q' = q^*$ . We now consider possible corners. There are three constraints:  $q' \geq 0$ ,  $\alpha' \geq 0$ , and  $\alpha' \leq \pi(q')$ .

Step 1.b: We will first establish that  $q$  is never cornered by showing that  $q' \geq q^* > 0$ . Suppose to the contrary that  $q' < q^*$ . This implies  $\pi'(q') > \psi'(q')$ . The manager could increase production by a sufficiently small positive  $\varepsilon$ , increase  $\alpha$  by  $\varepsilon \times \psi'(q')$  to completely offset the additional production externality, and increase the total dividends to shareholders by  $\varepsilon \times (\pi'(q') - \psi'(q'))$ . Since this deviation leaves all shareholders better off, it contradicts the optimality of  $q'$ . Furthermore, since  $\pi'(0) > \psi'(0)$ ,  $\pi(\cdot)$  is strictly concave and  $\psi(\cdot)$  is strictly convex, we know  $q^* > 0$ . Thus,  $q$  is never cornered.

Step 1.c. We will show that if the condition (15) is satisfied, then  $\alpha$  is not cornered below. If the condition (15) is satisfied and the manager were to chose production level  $q^*$ , shareholders would wish the manager to contribute something to the public good. In turn, then from Lemma 3 we know that the shareholders would like the manager to contribute something for all  $q' \geq q^*$ —in other words, the manager's first order condition for  $\alpha$  (6) can only be satisfied by a sufficiently large nonnegative  $\alpha$ . Thus, if this  $\alpha$  is not more than profits ( $\alpha \leq \pi(q')$ ), then the solution is interior and by Step 1.a.  $q' = q^*$ .

Step 1.d. We will show that when  $\alpha$  is cornered above ( $\alpha' = \pi(q')$ ,  $\beta^{i*}(q', \pi(q')) = 0$ ), then  $q' = q^*$ . When the constraint  $\alpha \leq \pi(q)$  binds ( $\alpha = \pi(q)$ ) the manager's problem becomes

$$\max_{0 \leq q} f(u^1(0, -\psi(q) + \pi(q)), u^2(0, -\psi(q) + \pi(q)), \dots, u^S(0, -\psi(q) + \pi(q))) \quad (24)$$

with the first order condition for  $q$

$$\pi'(q) \sum_{i=1}^S f_i u_g^i = \psi'(q) \sum_{i=1}^S f_i u_g^i$$

In this case, it is clear that  $q' = q^*$ . Thus, in Steps 1.a - 1.d, we have shown that the manager chooses the socially optimal quantity  $q^*$  if the public good is *fundable*.

Step 2: Now we will show that if the manager chooses  $q^*$ , the public good is *fundable*. We do this by proving its contrapositive, namely, if the public good is *unfundable*, then  $q' > q^*$ . Suppose to the contrary that  $q' \leq q^*$ . From Step 1.b, it can only be that the case that  $q' = q^*$ .

Step 2.a: We will show a contradiction when  $\alpha$  is interior. Since  $q^*$  is optimal the manager's first order condition for  $q$  (eqn. 23) must hold at  $q^*$  and optimal provisioning  $\alpha'$

$$\sum_{i=1}^S (\lambda_i \pi'(q^*) - \beta_q^{i*}(q^*, \alpha')) u_c^i f_i = \left( \psi'(q^*) - \sum_{j=1}^S \beta_q^{j*}(q^*, \alpha') \right) \sum_{i=1}^S u_g^i f_i$$

From Lemma 4 this can be rewritten

$$\pi'(q^*) \sum_{i=1}^S (\lambda_i + \beta_\alpha^i(q^*, \alpha')) u_c^i f_i = \psi'(q^*) \left( 1 + \sum_{j=1}^S \beta_\alpha^{j*}(q, \alpha) \right) \sum_{i=1}^S u_g^i f_i$$

where  $\pi'(q^*) = \psi'(q^*)$ . However, *unfundability* implies that for all  $\alpha' \geq 0$

$$\sum_{i=1}^S (\lambda_i + \beta_\alpha^{i*}(q^*, \alpha')) u_c^i f_i > \left( 1 + \sum_{j=1}^S \beta_\alpha^{j*}(q^*, \alpha') \right) \sum_{i=1}^S u_g^i f_i$$

which is a contradiction.

Step 2.b: We will show a contradiction when  $\alpha$  is cornered below. In this case, the manager's first order condition for  $\alpha$  cannot be met, because

$$\sum_{i=1}^S (\lambda_i + \beta_\alpha^{i*}(q^*, \alpha')) u_c^i f_i > \left( 1 + \sum_{j=1}^S \beta_\alpha^{j*}(q^*, \alpha') \right) \sum_{i=1}^S u_g^i f_i \quad (25)$$

for all  $\alpha' \geq 0$ . Since  $q^*$  is optimal, the manager's first order condition for  $q$  must be satisfied. Using Lemma 1 it can be written

$$\pi'(q^*) \sum_{i=1}^S (\lambda_i + \beta_\alpha^{i*}(q^*, \alpha')) u_c^i f_i = \psi'(q^*) \left( 1 + \sum_{j=1}^S \beta_\alpha^{j*}(q^*, \alpha') \right) \sum_{i=1}^S u_g^i f_i \quad (26)$$

But from (25) this cannot be met except at  $q' > q^*$ , a contradiction.

Step 2.c. We will show a contradiction when  $\alpha$  is cornered above. In this case, the manager's first order condition cannot be met, because

$$\sum_{i=1}^S (\lambda_i + \beta_\alpha^{i*}(q^*, \alpha')) u_c^i f_i < \left( 1 + \sum_{j=1}^S \beta_\alpha^{j*}(q^*, \alpha') \right) \sum_{i=1}^S u_g^i f_i$$

for all  $\alpha' \leq \pi(q^*)$ . but *unfundability* means

$$\sum_{i=1}^S (\lambda_i + \beta_\alpha^{i*}(q^*, 0)) u_c^i f_i > \left( 1 + \sum_{j=1}^S \beta_\alpha^{j*}(q^*, 0) \right) \sum_{i=1}^S u_g^i f_i$$

for  $\alpha' = 0$ , a contradiction. Thus, in Steps 2.a - 2.c we have shown that if the manager chooses  $q^*$ , the public good is fundable.

Step 3: Now we will show the manager provisions strictly positive amounts of the public good if the inequality in equation (15) is strict. A strict inequality in equation (15) implies fundability. From Step 1  $q' = q^*$  and either the manager's first order condition for  $\alpha$  holds or  $\alpha$  is bounded above. If  $\alpha$  is bounded above we are done. Suppose contrary to being interior, that  $\alpha = 0$ . Then the manager's first order condition for  $\alpha$  implies

$$\sum_{i=1}^S (\lambda_i + \beta_\alpha^{i*}(q^*, \alpha')) u_c^i f_i \geq \left( 1 + \sum_{j=1}^S \beta_\alpha^{j*}(q^*, \alpha') \right) \sum_{i=1}^S u_g^i f_i$$

but this contradicts the strict inequality of (15).

Step 4: Finally, we show that if the manager provisions strictly positive amounts of the public good, the inequality in equation (15) is strict. To do this first observe that  $\alpha' > 0$  means that the manager's first order condition for  $\alpha$  is met (i.e.  $\alpha$  is interior) or  $\alpha$  is bounded above. From the arguments of Step 1 we know we that  $q' = q^*$ . Having established that optimal production occurs when  $q = q^*$ , we will show a contradiction when  $\alpha' > 0$  and the inequality in (15) is not strict. Suppose, contrary to the proposition, that the fundability condition is tight (recall that the case where the equality in the above is "greater than" ( $>$ ) has already been ruled out in Step 2).

$$\sum_{i=1}^S (\lambda_i + \beta_{\alpha}^{i*}(q^*, 0)) u_c^i f_i = \sum_{i=1}^S \left( 1 + \sum_{j=1}^S \beta_{\alpha}^{j*}(q^*, 0) \right) u_g^i f_i \quad (27)$$

This is precisely the manager's first order condition for  $\alpha$  when  $\alpha' = 0$ , but this contradicts the predicate that optimal  $\alpha' > 0$ . ■

## References

- [1] Baron, David P., "Corporate Social Responsibility and Social Entrepreneurship," *Journal of Economics & Management Strategy*, 2007 (16) pp. 683-717.
- [2] Baumol, William J., "On Taxation and the Control of the Externalities," *The American Economic Review*, 1972 (62) pp.307-322.
- [3] Bergstrom, Theodore, Blume, Lawrence, and Varian, Hal, "On the Private Provision of Public Goods," *Journal of Public Economics*, 1986 (29) pp. 25-49.
- [4] Besley, Timothy and Ghatak, Maitreesh, "Retailing Public Goods: The Economics of Corporate Social Responsibility," *Journal of Public Economics*, 2007 (91) pp. 1645-1663.
- [5] Friedman, Milton, "The Social Responsibility of Business is to Increase its Profits," *New York Times Magazine*, 1970.
- [6] Friedman, Milton, *Capitalism and Friedman*, University of Chicago Press, 1962.
- [7] Garriga, Elisabet, and Mele, Domenec, "Corporate Social Responsibility Theories: Mapping the Territory," *Journal of Business Ethics*, 2004 (53) pp. 51-71.
- [8] Graff Zivin, Joshua, and Small, Arthur, "A Modigliani-Miller Theory of Altruistic Corporate Social Responsibility," *Topics in Economic Analysis & Policy*, 2005 (5) pp. 1-19.
- [9] Grant, Don, and Jones, Andrew W., and Trautner, Mary N., "Do Facilities with Distant Headquarters Pollute More? How Civic Engagement Conditions the Environmental Performance of Absentee Managed Plants," working paper, 2010.
- [10] Kemp, Murray C., "A Note on the Theory of International Transfers," *Economic Letters*, 1984 (14) pp.259-262.

- [11] McKelvey, Richard D., “Intransitivities in Multidimensional Voting Models and Some Implications for Agenda Control,” *Journal of Economic Theory*, 1976 (12) pp 472-482.
- [12] Pigou, Arthur C., *The Economics of Welfare*, 4th ed. (London: Macmillan & Co. 1938).
- [13] Porter, M. E. and Kramer, M. R., “The Competitive Advantage of Corporate Philanthropy,” *Harvard Business Review* 2002 (80) pp. 56-59.
- [14] Warr, Peter, “The Private Provision of a Public Good is Independent of the Distribution of Income,” *Economic Letters*, 1983 (13) pp. 207-211.

# **Can Birds of a Feather *Fly* Together?**

## **Evidence for the Economic Payoffs of Ethnic Homophily<sup>1</sup>**

### **1. Introduction**

In 2004, Vinod Khosla, Indian billionaire and co-founder of Sun Microsystems opened Khosla Ventures. By 2011 the Silicon Valley based venture capital firm's portfolio contained US companies (co-)founded by Ramesh Chandra (MokaFive), Srinu Devadas (Verayo), Nick Ganju (ZocDoc), Yogi Goswami (Sunborne), Sandeep Gulati (Zyomed), Siraj Khaliq (WeatherBill), Ramu Krishnan (Ramu Inc.), Ashok Krishnamurthi (Xsigo), Hosain Rahman (Aliph), Anil Rao (Sea Micro), Mulpuri Rao (Soladigm), Bindu Reddy (MyLikes), Mohit Singh (Seeo), Arvind Sundararajan (MyLikes) and Adya Tripathi (Tula). If one added the names of CEOs and Directors, the list of executives with Indian heritage in Khosla's portfolio of companies would grow longer still. Khosla Ventures does not explicitly advertise a preference for funding the companies of ethnic Indians, yet casual observation suggests it has one. Does ethnicity influence the formation of business partnerships? Do certain ethnicities work more with their own than others? How does ethnicity-based investing affect business performance? This paper takes up these questions in the context of the US venture capital industry.

More broadly, our study of ethnic associations is motivated by a growing literature in social science that links trust, relationships, and social norms within groups, collectively called "social capital," to economic outcomes (from Granovetter 1973 through Grief 1996, and beyond). According to Putnam (1993): "dilemmas of collective action hamper attempts to cooperate for mutual benefit...Third-party enforcement is an inadequate solution to this problem...Norms of generalized reciprocity and networks of civic engagement encourage social trust and cooperation because they reduce incentives to defect, reduce uncertainty, and provide models for future cooperation." Thus, social capital replaces the costly or imperfect structures otherwise necessary for sustaining cooperation and facilitates business transactions.<sup>2</sup>

Ethnicity influences the stock and flow of individuals' social capital. Ethnic communities provide members with strong reciprocal norms, sanctions for violations and access to large networks of individuals who share the community's rules. Ethnicity-based networks appear widespread in

---

<sup>1</sup> This work is joint with Deepak Hegde.

<sup>2</sup> This insight was originally expressed by Arrow (1972, p 357): "Virtually every commercial transaction has within itself an element of trust, certainly any transaction conducted over a period of time. It can be plausibly argued that much of the economic backwardness in the world can be explained by the lack of mutual confidence."

business, and several studies have highlighted the success of individual ethnic groups in overcoming the information barriers associated with financial transactions (Grief 1989, 1993; Weidenbaum and Hughes 1996).<sup>3</sup> Yet, few large-sample studies investigate the effect of ethnicity-based social capital on the conduct and performance of financial transactions, in settings that involve transactions among different ethnic groups.<sup>4</sup>

This gap is significant because the characteristics of an individual ethnic group may be correlated with both the social associations of its members and economic outcomes. For example, *Migration News* (April 2000) reported that there are a million Indian-Americans in the US, but they are not uniformly distributed across the US or its industries—some 300,000 of them reside in the Silicon Valley, and about that same number are employed in the software industry. Given this, one may wonder whether Khosla Venture’s investments simply reflect the sorting of Indian venture capitalists (VCs) and entrepreneurs into the IT sector or the Silicon Valley, rather than the strength of the Indian community’s co-ethnic networks. Hence, estimating the real effects of ethnicity-based social capital requires disentangling it from firms’ characteristics like industry and location preferences, which could be correlated to the ethnicity of its personnel.

Another unresolved issue is whether transactions within co-ethnic networks perform better than those outside. Although the social capital literature implies superior performance through the reduction of information costs, it is also plausible that ethnically-colored transactions reflect the taste-based bias of investors towards members of their own ethnicity. To the extent that this bias discriminates against superior opportunities outside co-ethnic networks, it can result in inferior economic performance. Hence, evaluating the relationship between ethnicity-based social capital and performance requires an analysis of the mechanisms of influence and alternative investment opportunities – a task that begs multiple observations of actual and counterfactual transactions.

---

<sup>3</sup> Maghribi traders of the 11th century Mediterranean developed informal contract-enforcement mechanisms based on their Judaeo-Muslim beliefs which allowed them to overcome commitment problems while dealing with overseas agents (Grief 1989, 1993). In more recent times, Japan’s general trading companies called “Sogo shosha” have managed extensive networks of Japanese businesses both internally and overseas, accounting for more than half of the country’s global economic trade (Yoshino and Libson 1986). Ethnic Chinese merchants who fled the mainland after the Communist takeover in 1948 are known for their “bamboo networks” of successful family-owned businesses throughout Southeast Asia (Weidenbaum and Hughes 1996).

<sup>4</sup> A recent exception, Bengtsson & Hsu (2010), estimates the effect of individual attributes, including previous educational background and ethnicity on matching individual VC partners to company founders. B&H use a sample (of 955 startups and 283 VC firms) in which the most common ethnicities are Chinese and Indian and estimate the probability of investment at the individual level, conditional on ethnic match. Their analysis finds that VC partners are more likely to match with founders of the same ethnicity but that such matches do not impact performance. Our analysis uses a broader notion of firm-level ethnic distance between VC’s and companies, which is based on the complete ethnicity profiles of VCs and start-up companies (24 ethnic origins, of over 100,000 personnel belonging to 2,687 VC’s and 13,119 startups and representative of the population of US venture investments). This allows us to isolate the effect of ethnic distance on firm decisions in a manner different from B&H. Our analysis also allows us to uniquely address differences across the 24 ethnic groups, potential sample selection issues, and control for company-, VC-, and pair-specific attributes correlated with ethnic investments.

Our large-sample study of U.S. venture investments addresses the above issues by investigating the following questions:

- Does “ethnic distance” between a venture capital firm and a start-up company influence the probability that the VC invests in the company, after accounting for the geographic and industry preferences of the pair?
- What characteristics of investments and ethnic groups influence the strength of the relationship between ethnic distance and venture investments?
- Conditioned on the investment decision, does the ethnic distance between VCs and companies affect the economic performance of the companies?

Several features of the VC industry make it an ideal setting to investigate ethnicity’s influence on the selection and performance of investments. The agency relationship between VCs and the startup companies they invest in is conducted under tremendous imperfect information. Although carefully designed contracts minimize the mutual information costs of this agency relationship, writing and enforcing such contracts can be expensive. These transaction costs may be reduced if VCs and entrepreneurs share common norms of communication, reciprocity and cooperation. Hence, we can investigate whether VC partners, when they encounter company executives of similar ethnic background, are more likely to select the company for investment, *ceteris paribus*. Next, to the extent that the pair’s shared norms improve selection quality and reduce monitoring costs, we can test whether ethnic similarity improves the venture’s financial performance as measured by the company’s successful exit through IPO. Finally, since VCs and entrepreneurs face the greatest informational barriers early in a start-up company’s development, we can also test whether the influence of ethnicity-based social capital is greater in the initial financing rounds.

The economic significance of the VC industry also motivates its study. The National Venture Capital Association (NVCA) reports: “In 2008, [US] venture capital-backed companies employed more than 12 million people and generated nearly \$3 trillion in revenue. Respectively, these figures accounted for 11 percent of [US] private sector employment and the equivalent of 21 percent of US GDP during that same year.” The NVCA also reports that on average, just one in a hundred business plans sent to a VC is funded, and of the companies funded, 40% fail, 40% grow large enough to generate moderate returns, and 20% produce high returns—this last, relatively small group of companies become the purveyors of technological change, the engines of economic growth, and are ultimately responsible for the VC industry’s striking economic impact. This high-risk, high-reward nature of the industry suggests that if ethnicity influences the probability that a start-up company is funded, or survives to a subsequent funding round, then the potential economic impact of ethnicity-based social capital could be significant.

We assemble the names of each VC partner and startup executive from the personnel rosters of 2,687 US based VCs and 13,119 of the startup companies they funded between 1991 and 2010. We use information in the given and family names of each partner and executive to classify them into one of 24 ethnic groups defined by a combination of national, linguistic and religious denominations.<sup>5</sup> Then, for each possible actual and counterfactual VC and startup company pair, we

---

<sup>5</sup> We infer the Cultural Ethnic Language Groups (CELGs) of individuals from a database constructed and maintained by Messrs Richard Webber of OriginsInfo.Ltd.

compute a measure of “ethnic distance”—if a large proportion of VC partners and company executives belong to the same ethnic group, then the pairing has a small ethnic distance and a high level of ethnicity-based social capital. This primary independent variable explains both the VC’s decision to invest in the company and the investment’s performance. As controls, we compute measures of geographic and industry distance for each pair. Thus, we identify the impact of co-ethnicity on the probability and conditional performance of VC investment in isolation from the impacts of colocation and industry specialization.

After controlling for the agglomeration of ethnic communities in industry- and geographic- areas and a host of VC and company characteristics, we find that a 1% increase in ethnic similarity for the VC-company pair increases the probability of investment by 0.05%. The evidence for ethnicity-based investing is particularly strong within “collectivist” cultures (such as Japanese, Korean and Chinese) and for early-stage investments in startup companies. Conditional on investment, ethnic proximity also increases the probability of advancing to successive rounds, especially early ones. Finally, a 1% increase in ethnic closeness increases a portfolio company’s probability of IPO by 0.6-1.2%. This translates to an *ex ante* increase in IRR for the VC between 7% and 15%. This result is robust to the inclusion of VC-fixed effects, suggesting that even within a given VC’s portfolio, companies that are ethnically closest to the VC perform the best. As a further basis to understand the extent of ethnicity’s influence, we compare it to the effects of geographic distance – a variable widely acknowledged as indicative of VCs’ monitoring costs and a strong influence on both the selection and performance of VC investments (Lerner 1995; Sorenson and Stuart 2005). We find that co-ethnicity predicts VC investment about as strongly as geographic proximity, but surprisingly, it predicts performance better. In summary then, our study establishes the importance of co-ethnic associations in the VC industry.

This study contributes to the broader literature on social capital in three ways. First, previous research has explored the influences of various social associations, including networks and membership of professional and social institutions, on economic performance. But this research has been hampered by the fact that individuals cultivate particular social associations, because of the economic impact they expect to reap. This makes determining the true effect of social capital on performance difficult. We examine the role of ethnicity—at birth each of us is, by chance, assigned to a powerful, yet distinct, set of cultural norms and a well-defined network of individuals who share them. Hence, we identify systematic relationships between exogenously determined social distance and economic performance. Second, ours is one of the first studies to reveal the mechanisms through which social influence actually works, by testing its effect on partnerships and performance as information costs vary. Finally, we use the most comprehensive classifications of ethnic origins (known to us) to date, to identify the attributes of ethnic groups that determine the strength of associations among its members and quantify these effects on economic outcomes.

Section-2 explains the VC-company relationship, why we expect ethnicity-based social capital to affect the relationship, and how we propose to empirically test our expectations about matching and performance. Section-3 describes the sample and the variables used in our estimation. Section 4 presents results on factors affecting the probability of match. Section 5 turns to the performance implications of ethnicity based matching. Section 6 concludes.

## 2. How *can* ethnicity affect the VC-company relationship?

### 2.1 The VC-Company relationship: selection and performance

Transforming an idea into an enterprise that provides new products and services, thousands of jobs and substantial profits, all while the brief window of market opportunity is open, can require tremendous capital and management expertise. Many entrepreneurs lack these factors and the venture capital industry supplies this need. VC partners are typically experienced businessmen and women, including many successful entrepreneurs, who invest in fledgling companies and guide them through the growth process as directors of the company's governing board. VCs raise the funds required for investment in their "portfolio" companies from limited partners, typically large institutions, and also from their own personal wealth. Our analysis though focuses on the relationship between VCs and the portfolio companies they invest in.

The starting phase of the VC-entrepreneur relationship is one that matches entrepreneurs (owners of startup companies) and VCs. Entrepreneurs communicate the value of their idea and/or product, the competence of the startup team, their plan for commercial development and the resources they require to attain it, usually in dollar amounts, to VCs. VCs evaluate the risks and potential rewards associated with the proposed venture through considerable due diligence and the lens of their experience. During this process, the entrepreneurs deliver business plans and presentations to the VC partners, and the partners visit the potential portfolio company's startup facilities. This evaluation and screening process costs money and time for both VCs and entrepreneurs — resources entrepreneurs could alternatively use to develop and market their products, and resources VCs could use to evaluate alternative investment opportunities or monitoring the investments already in their portfolio. Of course, VCs and entrepreneurs will likely each court many suitors for each investment made.

Once a VC firm and a portfolio company identify a match, a pre-money valuation for the company is negotiated and the VC purchases equity in the company based on that valuation. For example, if a VC adds \$1 million to a firm with a \$2 million pre-money valuation, the VC is issued shares worth a third of the company. According to PricewaterhouseCoopers' 2006 Q4 MoneyTree Report mean pre-money valuations for Early Stage, Expansion and Late Stage companies were \$6.94million, \$54.89 million and \$81.25 million respectively; however, these averages vary significantly from year to year. VCs typically acquire "preferred" shares, which among other things, gives them exceptional rights to replace senior management. They also typically receive one or more board seats and influence the appointment of so-called independent directors of the board (Gompers and Lerner 1999).

The growth of a venture backed company is demarcated by a series of financing rounds, or tightly metered infusions of capital by VCs, followed by the attainment of clear milestones. This capitalization scheme limits the downside exposure for VCs and dilution for the entrepreneurs. It also ensures that the monitoring done by VCs between rounds is enforceable—if the entrepreneurs do not achieve progress up to VCs' expectations, it is difficult to receive further rounds of financing, even from other VCs. When the company exhausts its funds, the top-level executives of the company, together with existing VCs, attempt to raise more capital through successive financing

rounds. The average time between financing rounds is 14 months (Bengtsson and Sensoy, 2011). Conditional on the round's success, each tends to be larger than the previous, both in terms of capital infused, and the number of participating VC firms. The following table summarizes this average investment (from 1995 to 2010) and number of venture investors (from 1978 and 1989):<sup>6,7</sup>

| Stage of Development   | Seed        | Early Stage | Expansion   | Later Stage  |
|------------------------|-------------|-------------|-------------|--------------|
| Average Investment     | \$3,209,000 | \$5,287,519 | \$8,878,462 | \$10,412,341 |
| Mean Venture Investors | 2.2         | 3.3         | 4.2         | —            |

In the earliest rounds, companies are thinly staffed and capital consumption is relatively low, but uncertainty surrounding technology, products, markets, the cohesion and quality of the management team is extremely high. As companies grow, so do their appetites for capital, but technological and commercial uncertainties diminish. Some VCs specialize in identifying early stage firms and supporting them from infancy, while the preferences, skill sets and networks of other VCs cause them to focus on later stage firms. Thus, the potential for matching entrepreneurs to new VCs occurs at every financing round. The ultimate goal of virtually all VCs is to successfully exit a firm by selling it, either on a public stock exchange (known as an IPO) or to another firm (known as an acquisition).

The typical VC spends its first three or so years selecting companies to invest in, and then nurtures them over the next few years (Ljungqvist and Richardson 2003)—average duration from early stage investment to IPO is 4.76 years, while firms eventually acquired require 5.39 years (Espenlaub, *et al.* 2011). During the time between the funding decision and eventual exit, VCs actively provide strategic direction to their portfolio companies from their board seats and periodic visits to the companies' operational facilities. Through their networks and reputations VCs also attract new customers and suppliers, additional financing through institutions and others VCs in their "syndicates," and also fill critical staffing gaps for the young company. Hence, overall, VCs play a critical role in the selection of startup companies to invest in and the subsequent performance of the companies.

## 2.2 The role of ethnic distance in the VC-entrepreneur relationship

Much of the cost incurred by entrepreneurs and VCs during the selection (matching) and growth (monitoring) phases stems from information asymmetries between the parties. At the selection stage, entrepreneurs wish to overrepresent their probability of success to increase their odds of obtaining funding and inflate their company's value, while VCs may present inferior comparables to deflate the company's value. In the growth phase, VCs and entrepreneurs may face disagreements regarding the style of management, strategic direction and the timing of important milestones, and each may pursue their own objective. Indeed, contracts between entrepreneurs and VCs are written

<sup>6</sup> Average investment size is calculated from data published by the NVCA. Average number of investors in each round is taken from Lerner (1994) Table 1. Lerner reports the averages for round 1, round 2 and rounds 3+.

<sup>7</sup> Typically VCs are structured as a collection of different funds each of which is a typically closed-ended, limited partnership. While VC funds have a (typically) ten-year life span, the VC firms that manage the funds have no predetermined lifespan. We do not distinguish here between VC funds and firms since the difference is not material to our analysis.

to solve these asymmetric information problems; *e.g.* management's fixed salaries are set lower than their outside option in traditional employment and entrepreneurs are left with substantial ownership of the firm, while VCs retain many control rights, including rights to hire and fire management (Kaplan and Stromberg). But these contracting solutions do not eliminate the informational costs in the VC-entrepreneur relationship.

Ethnicity-based networks can help reduce the costs, of both selection and monitoring, in several ways. First, ethnic networks reduce screening costs by bringing together entrepreneurs and potential investors. For example, Saxenian, in her pioneering account of ethnic entrepreneurs in the Bay Area describes the growth of Chinese and Indian networks in the Bay Area of California as follows: "Feeling like outsiders to the old boys network created by the region's native-born engineers, immigrant Indian and Chinese engineers organized their own ethnicity-based networks. They found one another socially first because of shared backgrounds, as well as common culture, language and history...Over time they adapted the networks to professional ends, providing first-generation immigrants with access to role models, contact, advice, funding and the local market knowledge required to identify partners and business opportunities. Associations like The Indus Entrepreneur (TiE in 1992) Chinese Institute of Engineers (CIE in 1979) wanted to make it easier for future generations of Indians and Chinese emigrants to start new businesses." Vinod Khosla, mentioned at the outset, summarizes the situation thus: "The ethnic networks clearly play a role here: people regularly talk to each other, they test their ideas, they suggest other people they know, who are likely to be of the same ethnicity. There is more trust because the language and cultural approach are so similar (quote excerpted from Saxenian 2006)."

Second, the VC-entrepreneur relationship hinges on the bi-lateral communication of verifiable information. Verifying statements made in a familiar style and context is easier. Hence, when the discourse style of the entrepreneurial team and the VCs are common, each receives a more reliable signal of the others' quality — to the extent that shared-ethnicity implies similarity of discourse style, co-ethnicity enhances the reliability of signals and decreases communication costs. These costs can be significant if the entrepreneur is either foreign or recently immigrated to a country where the VC partner is a member of the ethnic majority (or vice versa). Similarly, an entrepreneur can convey his experience or the reach of his business network better to someone of similar background—co-ethnicity proxies for a great deal of latent context in which to interpret the other party.<sup>8</sup>

Third, the trust and behavioral norms implicit in co-ethnic relationships may fill gaps left in contracts owing to unspecified contingencies. For example, it is impossible to explicitly enumerate every scenario which could lead a VC to dismiss a CEO—the litany of scenarios and correct business responses cannot be specified. Given this, being ousted by VCs genuinely concerns many founders of startup companies. However, a CEO may feel much more confident that she will agree with a co-ethnic VC on performance expectations, given their common cultural context, when

---

<sup>8</sup> For example, if the CEO of a Chinese startup explains that through Party connections the company obtained nationwide monopoly rights to sell a particular service, an ethnic Chinese VC partner in a US firm will be better able to evaluate that statement than most—she is more likely to be able to read the documents in her native language, to understand how stable government granted rights are, how tied they are to the CEO on a personal level, how to prosecute infringement, and how to determine the value of those monopoly rights. Even if she lacks the background to evaluate these things herself, her network is more likely to include individuals who can.

unforeseeable circumstances arise. She may, therefore, feel like she (and her company) may enjoy greater success funded by a VC of the same community. As Satish Gupta, a serial entrepreneur based in the Bay Area of California, notes: “[Ethnic] networks work primarily with trust... Elements of trust are not something that people develop in any kind of formal manner... Trust has to do with the believability of a person, body language, mannerisms, behavior, background... If you don’t fulfill your obligations, you could be an outcast... the pressure of, hey, you better not do this because I’m going to see you at the temple or sitting around the same coffee table at the TiE meeting... and I know another five guys that you have to work with, so you better not do anything wrong (from Saxenian 2006).”

An ethnic group is a biologically self-perpetuating group that shares a common heritage, typically consisting of common language, ancestry, culture, religion and an interest in a specific geographic homeland. Thus, members of the same ethnic group are more likely to have lived in the same neighborhoods, focused on the same subjects in school, attended the same universities, gone to the same religious ceremonies, enjoyed the same food and music, and worked in the same industries. Although there is little theoretical difference between how these different social associations operate, we address them here together as “ethnicity-based” social capital and empirically identify the influence of ethnic distance on the VC-entrepreneur relationship as described in the following section.

### 2.3 Empirical specification

The first goal of our analysis is to estimate the marginal effect of changes in ethnic distance on the probability of funding deal between a VC and a potential portfolio company—in other words, how much more likely would VC be to invest in a given company if their respective key personnel were made a little more ethnically homogenous. Our second goal is to estimate how much ethnic similarity impacts the performance of an investment, conditional on the fact it is made.

Accordingly, the unit of analysis for all our empirical models is a VC-company pair. We start by constructing a sample of all VC-company pairs, both factual (for which  $y_{c,v} = 1$ ) and counterfactual (for which  $y_{c,v} = 0$ ). We then estimate the probability of a match between a VC and a Company ( $\Pr\{y_{c,v} = 1\}$ ) as a function of company-characteristics (denoted by the row vector  $C$ ), VC characteristics (denoted by the row vector  $V$ ) and Company-VC pair characteristics (denoted by the row vector  $CV$ ). That is,

$$\Pr\{y_{c,v} = 1\} = \beta_0 + \beta_1 C_c + \beta_2 V_v + \beta_3 CV_{c,v} + \varepsilon_{c,v} \quad (1)$$

The chief independent variable of interest, described in detail in Section 3.2, is a measure of the ethnic similarity of the VC-company pair (an element of  $CV$ ). We are not interested in all attributes of VCs, companies and the pair that explain the VC’s investment decision, but only the subset of attributes correlated with this measure of ethnic distance. Accordingly, we include the following pair level controls, which are potentially related to ethnic proximity: (1) geographic distance between the pair, and (2) industry distance between the pair, measured by the fraction of the VC’s investments in industries *other than* the industry of the company that it is paired with. We include variables indicating the country of each company, the number of top executives, the proportion of executives that belong to each ethnicity, and the year each company was founded in the vector of company

characteristics,  $C$ . The number of VC partners, the proportion of partners that belong to each ethnicity, and the year each VC was founded are included in  $V$ .

A second set of models investigate binary measures of performance of the VC-company pair, conditional on investment ( $z_{c,v} \in \{0,1\}$ ) as a function of variables in  $C$ ,  $V$  and  $CV$ .

$$\Pr\{z_{c,v} = 1 | y_{c,v} = 1\} = \beta_0 + \beta_1 C_c + \beta_2 V_v + \beta_3 CV_{c,v} + \varepsilon_{c,v} \quad (2)$$

As in equation 1, the chief independent variable of interest in equation 2, is a measure of the ethnic similarity (a member of  $CV$ ) described in detail in below. Other elements of  $C$ ,  $V$ , and  $CV$  are also described below.

### 3. The sample and variables

#### 3.1 The sample

We collect data on VCs and their investments from VentureXpert, a proprietary database of Venture Economics owned by Thomson Reuters. Venture Economics collects data on deals between VCs and their portfolio companies from the quarterly reports of VCs and other institutional investors. Venture Economics supplements this data with information from trade publications, company Web pages, mailed out-surveys, and telephone contacts with VCs and companies. The coverage of VentureXpert appears more comprehensive than other deals databases; Gompers and Lerner (1999) conclude that it contains over 90% of all venture investments, especially for the later years of their study, and Kaplan et al. (2008) report that it covers 85% of all deals.

VentureXpert's information on the VCs and portfolio companies includes their founding dates, geographic location, industry category, and the names of VC partners and companies' top-level executives.<sup>9</sup> Although VentureXpert covers over 290,000 unique deals between 1969 and the present from across the globe, we found data on the variables of interest for our analysis to be more complete for the investments of US-based VCs and companies founded after 1990. Hence, we restricted our sample to deals covering companies founded between 1991 and June 02, 2010, and funded by US-based VCs. This restriction and cleaning the raw data left 2,687 unique US based VCs and 13,119 unique companies involved in 78,372 (round-level) deals.<sup>10</sup> The deals covered 34,800 unique VC-company pairs.

#### 3.2 The variables

As explained in Section 2.3 the unit of analysis for our regressions is a company-VC pair. Our goal is to estimate the probability that the pair matches (a match occurs when the VC invests in the company), and the performance of the match, as functions of the ethnic-distance between the company and the VC. Accordingly, we employ a number of company, VC, and company-VC pair

<sup>9</sup> Unfortunately VentureXpert does not maintain a record of changes in the names of partners or executives, but the data are reported as of the latest update.

<sup>10</sup> The raw data from VentureXpert requires a substantial amount of work to eliminate duplicates, inconsistencies and other coding errors.

level characteristics since these variables are potentially correlated with ethnic distance and the VC's investment decisions. The following paragraphs describe the construction and sample characteristics of these explanatory and control variables.

### I. Company specific variables

(a) *Ethnic origins of top-executives*: VentureXpert lists the top-level executives of portfolio companies (and partners of venture capital firms) by given and family name.<sup>11</sup> We use an “anthroponomastic” classification of these to assign each executive a most likely ethnicity. The technique of identifying persons’ probable ethnic association has considerable commercial value to firms that conduct ethnically-targeted marketing campaigns. Thus, a number of vendors providing professional classification services have arisen in recent years—Origins Info Ltd., a well known vendor, processed the entire list of executive names from the VentureXpert database for us. Origins Info uses a proprietary database constructed from a variety of sources, like the American Dictionary of Family Names and international telephone directories to identify the most likely ethnic origin for over 1,800,000 family names and 700,000 given names.

The 13,119 unique companies in our database employed a total of 97,982 executives, after eliminating VC partners sitting on the companies’ boards.<sup>12</sup> Our classification assigned the 97,982 executives to one of 24 most common ethnic groups in the US. So far as we are aware, our classification represents the most comprehensive and granular treatment of ethnic categories to date. Given the extensive coverage of VentureXpert, we believe that the distribution of ethnic origins in our sample represents the origins of the top-executives of the population of US venture-backed companies well.

Table 1 compares the fraction of each ethnic origin in the overall US population provided by Origins Info. (Column 1) to the fractions for the executives of US based portfolio companies, (Column 2) and foreign portfolio companies (Column 3). Top-executives of US-based companies tend to be primarily of European descent (British, German, Irish, Scottish and Italian are the five most frequent ethnicities for executives) more or less comparable to their proportions in the overall U.S. population. The Jewish/Armenian and Asian-Indian ethnic groups account for a high proportion of executives in U.S. (3.8% and 3% respectively) relative to their overall populations (1% and 0.67%), whereas the Chinese ethnic group accounts for a high proportion of executives abroad (10.1%).

Next, for each portfolio company  $c$  in our sample, we calculated a unit vector  $\mathbf{e}_c$  indicating its position in 24-dimensional ethnic space, that is,

$$\mathbf{e}_c = (e_{c,1}, e_{c,2}, \dots, e_{c,24}) \quad (4)$$

---

<sup>11</sup> Unfortunately, VentureXpert does not identify the entry and exit of executives. Then names reflect the composition for the portfolio companies when VentureXpert last obtained/updated data on the companies.

<sup>12</sup> 14,264 (or 12.71% of all names) top-level executives listed under companies turned out to be VC partners and also figured among the list of VC partners in our sample. Almost all of these were listed as Executive non-managing board members in the companies. We drop these from our vector of company executives but retain them in the ethnicity vector of VC partners.

**Table 1: The distribution of ethnic origins (1991-2010)**

The Table reports the percentage of the 24 different ethnic origins in: (a) the overall United States population, (b) our sample of top-executives of U.S. companies funded by U.S.-based VCs (c) our sample of top-executives of foreign companies funded by U.S.-based VCs, and (d) our sample of U.S. based VC's. (a) is based on the ethnic composition inferred from over 1,800,000 family names and 700,000 personal names in the American Dictionary of names (b) is based on the names of 85,168 executives working at 11,235 startup companies based in the US, funded by US-based VCs, and started between 1991 and 2010 (c) is based on the names of 12,814 executives working at 1,884 startup companies based in abroad (non-US locales), funded by US-based VCs, and started between 1991 and 2010 (d) is based on the names of 22,110 partners working at 2687 VCs based in the US and started between 1991 and 2010.

| <b>Ethnic group</b>      | <b>(a)<br/>Overall</b> | <b>(b) US<br/>companies</b>  | <b>(c) Foreign<br/>companies</b> | <b>(d) US<br/>VC partners</b> |
|--------------------------|------------------------|------------------------------|----------------------------------|-------------------------------|
| ANGLO-SAXON: BRITISH     | 41.07%                 | 35.24%                       | 21.53%                           | 33.01%                        |
| ANGLO-SAXON: OTHER       | 3.81                   | 2.8                          | 0.95                             | 2.94                          |
| CELTIC: IRISH            | 4.50                   | 6.5                          | 4.07                             | 6.69                          |
| CELTIC: OTHER            | 3.75                   | 2.67                         | 1.75                             | 2.47                          |
| CELTIC: SCOTTISH         | 5.33                   | 5.74                         | 4.11                             | 5.62                          |
| EAST ASIAN: CHINESE      | 0.74                   | 1.8                          | 10.15                            | 2.93                          |
| EAST ASIAN: JAPANESE     | 0.24                   | 0.5                          | 1.77                             | 0.95                          |
| EAST ASIAN: KOREAN       | 0.37                   | 0.47                         | 1.62                             | 1.09                          |
| GREEK/GREEK CYPRIOT      | 0.23                   | 0.46                         | 0.37                             | 0.45                          |
| HISPANIC: EUROPEAN       | 5.66                   | 1.5                          | 2.01                             | 1.65                          |
| HISPANIC: SOUTH AMERICAN | 4.86                   | 0.87                         | 0.99                             | 0.92                          |
| ITALIAN                  | 3.87                   | 5.1                          | 2.96                             | 4.85                          |
| JEWISH/ARMENIAN          | 0.99                   | 3.79                         | 4.7                              | 3.71                          |
| MIDDLE EASTERN: MUSLIM   | 0.62                   | 1.17                         | 1.3                              | 1.15                          |
| NORDIC                   | 3.20                   | 3.64                         | 5.45                             | 3.34                          |
| SLAVIC: OTHER            | 1.76                   | 2.51                         | 2.57                             | 2.56                          |
| SLAVIC: POLISH           | 1.55                   | 1.69                         | 1.24                             | 1.75                          |
| SOUTH ASIAN: INDIAN      | 0.66                   | 3                            | 6.88                             | 3.2                           |
| SOUTH ASIAN: MUSLIM      | 0.54                   | 0.92                         | 1.48                             | 1.04                          |
| SOUTH/EAST ASIAN: OTHER  | 0.65                   | 0.94                         | 2.53                             | 0.93                          |
| UNCLASSIFIED AND OTHER   | 1.29                   | 0.31                         | 0.69                             | 0.27                          |
| WESTERN EUROPEAN: FRENCH | 2.30                   | 2.67                         | 6.21                             | 2.67                          |
| WESTERN EUROPEAN: GERMAN | 10.30                  | 13.61                        | 11.08                            | 13.53                         |
| WESTERN EUROPEAN: OTHER  | 1.70                   | 2.09                         | 3.57                             | 2.27                          |
| TOTAL                    |                        | 85,168 names<br>11,235 firms | 12,814 names<br>1,884 firms      | 22,110 names<br>2,687 VCs     |

Each dimension/coordinate in the vector indicates the proportion of the company's top-executives belonging to the corresponding ethnicity. We use this 24-column company-specific vector to

control for the distribution of ethnicities within firms and also to calculate the ethnic distance for each of our company-VC pairs. Table 2 shows sample statistics calculated with firm-level observations.

**Table 2: Descriptive statistics for the fraction of ethnicities in companies (1991-2010)**

The Table reports descriptive statistics for the fraction of the 24 different ethnicities of the top executives belonging to the 13,119 companies started between 1991 and 2010 and funded by the 2,687 U.S.-based VC's in our sample.

| <b>Ethnic group</b>      | <b>Mean</b> | <b>S.D.</b> | <b>Min</b> | <b>Max</b> |
|--------------------------|-------------|-------------|------------|------------|
| ANGLO-SAXON: BRITISH     | 0.33        | 0.25        | 0          | 1          |
| ANGLO-SAXON: OTHER       | 0.03        | 0.08        | 0          | 1          |
| CELTIC: IRISH            | 0.06        | 0.12        | 0          | 1          |
| CELTIC: OTHER            | 0.03        | 0.07        | 0          | 1          |
| CELTIC: SCOTTISH         | 0.05        | 0.11        | 0          | 1          |
| EAST ASIAN: CHINESE      | 0.04        | 0.15        | 0          | 1          |
| EAST ASIAN: JAPANESE     | 0.01        | 0.06        | 0          | 1          |
| EAST ASIAN: KOREAN       | 0.01        | 0.07        | 0          | 1          |
| GREEK/GREEK CYPRIOT      | 0.00        | 0.03        | 0          | 1          |
| HISPANIC: EUROPEAN       | 0.02        | 0.07        | 0          | 1          |
| HISPANIC: SOUTH AMERICAN | 0.01        | 0.05        | 0          | 1          |
| ITALIAN                  | 0.05        | 0.11        | 0          | 1          |
| JEWISH/ARMENIAN          | 0.04        | 0.11        | 0          | 1          |
| MIDDLE EASTERN: MUSLIM   | 0.01        | 0.06        | 0          | 1          |
| NORDIC                   | 0.04        | 0.10        | 0          | 1          |
| SLAVIC: OTHER            | 0.03        | 0.09        | 0          | 1          |
| SLAVIC: POLISH           | 0.02        | 0.06        | 0          | 1          |
| SOUTH ASIAN: INDIAN      | 0.04        | 0.12        | 0          | 1          |
| SOUTH ASIAN: MUSLIM      | 0.01        | 0.05        | 0          | 1          |
| SOUTH/EAST ASIAN: OTHER  | 0.01        | 0.06        | 0          | 1          |
| UNCLASSIFIED AND OTHER   | 0.00        | 0.03        | 0          | 1          |
| WESTERN EUROPEAN: FRENCH | 0.03        | 0.10        | 0          | 1          |
| WESTERN EUROPEAN: GERMAN | 0.13        | 0.18        | 0          | 1          |
| WESTERN EUROPEAN: OTHER  | 0.02        | 0.08        | 0          | 1          |

(b) *Number of top-executives*: Leaving out board members who are VC partners, the average portfolio company in our sample lists 8.55 top-level executives (SD = 5.26; Range = 1-56). The most common designations for these executives are: Board Members, Chief Financial Officers, Chief Executive Officers, Founders, President, Director and Vice-Presidents of various functions. We include the number of executives belonging to each firm to imperfectly control its size and capital requirements both of which may influence its ethnic composition and the probability of being matched with a random VC in the sample.

(c) *Nation of Headquarters*: The 13,119 companies in our sample are headquartered across 71 nations (see Table 2). Most (85%) of the companies are headquartered in the US, followed by the UK

(2.2%), China (2.1%), Israel (1.2%), and India (1.2%).<sup>13</sup> US companies are likely overrepresented in our sample since, as mentioned earlier, the majority of companies that drop out of our analysis (for lack of data on company-level variables) are located abroad. We expect the national domicile of a company to affect its ethnic composition and probability of funding – including nation-specific dummies on the RHS allows us to tease out the within country influences of ethnic distance on the probability and performance of VC investments.

(d) *Founding year*: Our sample companies were started during the years 1991-2010. An “average year in our sample produces 690 startups (except the year 2010, for which we have data on 11 firms started in the month of January).<sup>14</sup> The surge of start-up companies in the 1999 and 2000 years (1,479 and 1,192 startups) represents the “dotcom boom” and the steep drop in foundings during the years 2008-2009 (386 and 144 startups) reflects the economic downturn as well as truncation issues (VentureXpert generally collects data about accompany when a VC reports funding the company, typically 2-3 years after its start date).

(e) *Industry*: The top industries for VC investments are Internet Specific (21.5%), Computer Software (19.75%), Medical/Health (12%), Communications (8.8%), and Biotechnology (7.07%).<sup>15</sup> We include control dummies for the 18 industries of the sample companies.

## II. VC specific-variables

(a) *Ethnic origins of VC partners*: We used the same classification scheme, described under (I), to identify the ethnic origin of the 22,110 VC partners of the 2,687 U.S. based VCs in our sample. Column 4 of Table 1 reports the fraction of each ethnic origin in our sample of VC partners. The majority of VC partners have European heritage (British, German, Irish, Scottish and Italian are the five most frequent ethnicities) more or less comparable to their proportions in the overall US population. Jewish/Armenian, Asian-Indian, Chinese, Korean, and Japanese individuals are overrepresented as VC partners relative to the size of their ethnic communities in the US

Next, for each VC  $v$  in our sample, we calculated a unit vector  $\mathbf{e}_v$  indicating its position in 24-dimensional ethnic space. That is,

$$\mathbf{e}_v = (e_{v,1}, e_{v,2}, \dots, e_{v,24}) \quad (3)$$

Each dimension/coordinate in the vector indicates the proportion of partners belonging to the corresponding ethnicity. We use this VC-specific 24-column vector to control for the distribution of ethnicities within VCs and also to calculate the ethnic distance for each of our company-VC pairs. Table 3 shows sample statistics calculated with VC-level observations.

(b) *Number of partners*: The average VC in our sample has 8.2 partners (S.D.= 12.23, Range = 1-246). We include the number of VC partners as an imperfect proxy for VC size and the depth of its pockets, which may both influence the ethnic composition of the VCs and the probability of investing in any given company in our sample.

<sup>13</sup> Table 1 of the Appendix reports the list and frequency of different headquarter nations.

<sup>14</sup> Table 2 of the Appendix reports the frequency of founding years in our sample.

<sup>15</sup> Table 3 of the Appendix reports the full industry-distribution for the companies in our sample.

**Table 3: Descriptive statistics for the fraction of ethnicities in U.S.-based VC's**

The Table reports descriptive statistics for the fraction of the 24 different ethnicities of VC partners associated with the 2,687 U.S.-based VC's in our sample.

| <b>Ethnic group</b>      | <b>Mean</b> | <b>S. D.</b> | <b>Min</b> | <b>Max</b> |
|--------------------------|-------------|--------------|------------|------------|
| ANGLO-SAXON: BRITISH     | 0.35        | 0.28         | 0          | 1          |
| ANGLO-SAXON: OTHER       | 0.03        | 0.09         | 0          | 1          |
| CELTIC: IRISH            | 0.07        | 0.14         | 0          | 1          |
| CELTIC: OTHER            | 0.03        | 0.09         | 0          | 1          |
| CELTIC: SCOTTISH         | 0.06        | 0.14         | 0          | 1          |
| EAST ASIAN: CHINESE      | 0.02        | 0.09         | 0          | 1          |
| EAST ASIAN: JAPANESE     | 0.01        | 0.08         | 0          | 1          |
| EAST ASIAN: KOREAN       | 0.01        | 0.04         | 0          | 0.75       |
| GREEK/GREEK CYPRIOT      | 0.00        | 0.04         | 0          | 1          |
| HISPANIC: EUROPEAN       | 0.01        | 0.06         | 0          | 1          |
| HISPANIC: SOUTH AMERICAN | 0.01        | 0.04         | 0          | 0.5        |
| ITALIAN                  | 0.04        | 0.11         | 0          | 1          |
| JEWISH/ARMENIAN          | 0.04        | 0.11         | 0          | 1          |
| MIDDLE EASTERN: MUSLIM   | 0.01        | 0.06         | 0          | 1          |
| NORDIC                   | 0.04        | 0.10         | 0          | 1          |
| SLAVIC: OTHER            | 0.02        | 0.08         | 0          | 1          |
| SLAVIC: POLISH           | 0.02        | 0.07         | 0          | 1          |
| SOUTH ASIAN: INDIAN      | 0.03        | 0.09         | 0          | 1          |
| SOUTH ASIAN: MUSLIM      | 0.01        | 0.05         | 0          | 1          |
| SOUTH/EAST ASIAN: OTHER  | 0.01        | 0.03         | 0          | 0.5        |
| UNCLASSIFIED AND OTHER   | 0.00        | 0.02         | 0          | 0.5        |
| WESTERN EUROPEAN: FRENCH | 0.03        | 0.09         | 0          | 1          |
| WESTERN EUROPEAN: GERMAN | 0.14        | 0.19         | 0          | 1          |
| WESTERN EUROPEAN: OTHER  | 0.02        | 0.08         | 0          | 1          |

(c) *Founding year*: The VCs in our sample are on average older than the companies and 51% of them were founded before the year 1991. An “average year” between the years 1991 and 2010 produces 2.5 new VCs although the surge of start-up companies in the 1999 and 2000 years is matched by the formation of new VCs during these years (9 and 6 new VCs respectively). Including dummies for founding years controls for year-specific patterns of economic activity that may influence both investments and the ethnic composition of VCs and companies (such as the boom of software startup companies during the late-90's that may have increased both the investment activity of VCs and the fraction of Chinese and Indian personnel among VCs and companies).

All the VCs in our dataset are US-based, negating the need for country-specific controls.

### III. Company-VC pair specific variables

Our initial matching analysis requires constructing a sample of VC-company pairs, both actual, for which the investment happened, and counterfactual, for which investment could have happened but did not. Since our sample contains 2,687 VCs and 13,119 there are over 35 Million possible pairs, of which 34,800 are actual, and the rest, counterfactual.

Working with 35 Million observations is computationally challenging. To distill our sample to a manageable size, we eliminate matches that are not possible given the company's industry of operation and the VC's *revealed* preference for industry sectors based on the VC's history of investments through the year 2010. This reduction retains all of the 34,800 VC-company factual matches, but eliminates nearly 50% of the counterfactual ones, leaving about 18 Million counterfactual pairs. This reduction rule does not inject bias but serves our purpose of understanding the effect of ethnicity in a sample of VC-company pairs most likely to match based on other attributes such as industry preference. We draw random samples from this set of factual and counterfactual pairs for the rest of our analysis.<sup>16</sup> Accordingly, we draw a 10% random sample (1,791,486 pairs of which 3,520 were actual matches) and for each pair, calculate measures of geographic distance, industry distance, and ethnic distance as follows.

(a) *Geographic distance*: Previous research has shown that VCs tend to invest in geographically closer companies (Lerner 1995) because it reduces selection and monitoring costs (analogous to the effect of ethnic distance we hypothesize). We also know members of the same ethnic communities tend to cluster geographically (Kerr; Agrawal et al). Hence, geographic distance may be correlated to both ethnic distance and the likelihood of a VC-company match. To control for the geographic agglomeration of ethnicities, we calculate a measure of geographic distance between each VC-company pair by converting the physical addresses of firms reported by VentureXpert to longitude and latitude coordinates via the Google Geocoding API. Great-circle ('as-the-crow-flies') distances between venture capital firms and potential portfolio firms are then calculated using the Haversine formula (first published by Sinnott 1984, though long known by navigators).<sup>17</sup> Table 4 presents sample statistics for the geographic distance of matches separately for factual and counterfactual pairs. It is clear that matched pairs are, on average, located closer.

(b) *Industry distance*: VCs face lower information costs in selecting and monitoring investment opportunities in industries in which they have prior experience. Hence, their choice of companies to fund may be driven by industry preferences acquired through experience. Further, VCs and entrepreneurs belonging to certain ethnicities likely share similar interests and may sort into particular industries. In such cases, similarity of industry experience may correlate to both ethnic distance and the likelihood of a VC-company match. To control for the mutual industry interests of

---

<sup>16</sup> This method, sometimes called "case-cohort" sampling because it picks counterfactual matches based on identifying other members of a cohort where the basis for a cohort are variables such as founding year, industry, etc (as in Stuart & Sorenson, 2001).

<sup>17</sup> The spherical law of cosines yields great circle distances but is subject to large rounding errors if the distance is small. The Haversine formula is more numerically stable at small distances. The Vincenty formula, while slightly more accurate, is computationally more expensive. Given that the shortest geodetic distance is being used as a proxy for many things related to geographic proximity, like ease of communication, the slight difference in accuracy is immaterial.

a company-VC pair, we construct a variable of industry distance as the percentage of investments that the VC has made in industries other than the one in which the paired company operates. In assigning companies to industries, we use the VentureXpert's categorization of companies into 18 industry groups.<sup>18</sup>

**Table 4: Descriptive statistics for distance between matched & counterfactual VC-company pairs**

The Table reports descriptive statistics for our measures of Geographic distance (Haversine or as the crow flies distance in miles), Industry distance (computed as the fraction of the VC's investments made in industries other than the industry of the company with which it is matched), and Ethnic distance (computed using both Euclidean Distance and Mahalanobis Distance). The statistics are reported separately for actual or "matched" pairs and counterfactual pairs.

|                                     | <u>Counterfactual pairs; N=1787966</u> |         |     |          | <u>Matched pairs; N=3520</u> |         |     |        |
|-------------------------------------|----------------------------------------|---------|-----|----------|------------------------------|---------|-----|--------|
|                                     | Mean                                   | SD      | Min | Max      | Mean                         | SD      | Min | Max    |
| <u>Geographic Distance in Miles</u> |                                        |         |     |          |                              |         |     |        |
| Haversine Distance                  | 1889.28                                | 1828.42 | 0   | 11618.67 | 1180.49                      | 1616.74 | 0   | 10381  |
| Industry Distance                   | 0.77                                   | 0.22    | 0   | 1        | 0.77                         | 0.20    | 0   | 1      |
| <u>Ethnic Distance</u>              |                                        |         |     |          |                              |         |     |        |
| Euclidean Distance                  | 44.48                                  | 62.50   | 0   | 1430.41  | 30.17                        | 44.65   | 0   | 1175   |
| Mahalanobis Distance                | 42.43                                  | 61.78   | 0   | 1428.78  | 28.77                        | 44.19   | 0   | 1170.7 |

This measure of industry distance ranges from 0, when all of a VC's prior investments fall in the matched company's industry, to 1, when the VC has no investments in the company's industry. In calculating the measure, we exclude the matched company—if the company were the only one of the VC's portfolio companies operating in an industry, the industry distance between the VC and the portfolio company is 1. Table 4 shows that matched VC-company pairs are not significantly closer than the counterfactual pairs by our measure of industry distance. This apparent lack of closeness among matched pairs is partly driven by our omission of counterfactual pairs for which industry distance, by definition, is 1.

(c) *Ethnicity-based social distance*: We calculate the ethnic distance between each VC-company pair as the Mahalanobis distance between their ethnicity position vectors,  $\mathbf{e}_c$  and  $\mathbf{e}_v$  described under I-a and II-a above. Formally, the Mahalanobis distance  $d(\mathbf{e}_v, \mathbf{e}_c)$  is calculated as:

$$d(\mathbf{e}_v, \mathbf{e}_c) = \sqrt{(\mathbf{e}_v - \mathbf{e}_c)^T \mathbf{S}^{-1} (\mathbf{e}_v - \mathbf{e}_c)} \quad (5)$$

where  $\mathbf{e}_v$  and  $\mathbf{e}_c$  are the vectors representing the ethnic positions of VCs and companies respectively,  $\mathbf{S}$  is the covariance matrix and  $T$  the matrix transpose operator. Mahalanobis distance

<sup>18</sup> Table A3 of the Appendix presents the 18 categories and the distribution of the sample companies across the categories

measures the proximity of two points, accounting for the statistical prevalence of the points. The covariance matrix normalizes the ethnic dimensions, such that intuitively, distance between the two points is measured in standard deviations. First, this corrects for statistical spread within each dimension—if the proportion British exhibits lower variance than the proportion Japanese in the population, then a difference of  $x$  in the British dimension is larger than a difference of  $x$  in the Japanese dimension. Second, this normalization corrects for correlation between dimensions. Suppose, for illustration, that our ethnic position vector consisted of just three ethnic dimensions, British, Nordic and Japanese, in that order, and that we wished to compare the ethnic distance of a VC with  $\mathbf{e}_v = \langle \frac{1}{2}, \frac{1}{4}, \frac{1}{4} \rangle$  to a company with  $\mathbf{e}_{c1} = \langle \frac{1}{4}, \frac{1}{2}, \frac{1}{4} \rangle$  and another with  $\mathbf{e}_{c2} = \langle \frac{1}{4}, \frac{1}{4}, \frac{1}{2} \rangle$ . Clearly, all three points are equidistant by Euclidean measure (or by Mahalanobis distance if  $S$  is the identity matrix). But if the correlation between British and Nordic were positive (*i.e.* the covariance matrix  $S$  had identical positive elements at  $S_{12}$  and  $S_{21}$ ), then the Mahalanobis distance between the VC and company 1 is greater than the distance between the VC and company 2. Thus, by using Mahalanobis distance, we remove the fact that certain ethnic compositions of firms are statistically more prevalent and can isolate the substantive effect of ethnic distance. We also compute the Euclidean measure for ethnic distance and compare it to the results obtained by using the Mahalanobis distance as a robustness check.<sup>19</sup>

Table 4 presents sample statistics for the ethnic distance between VC-company pairs separately for our factual and counterfactual matches. Both Euclidean and Mahalanobis measures yield similar distance magnitudes, which is not too surprising since the variables in our ethnicity vector, representing fractions, are scale invariant. The descriptives reveal that the matched pairs are, on average, ethnically closer. The next section investigates this relationship more formally in multivariate regressions.

## 4. How does ethnicity affect the VC-company relationship?

### 4.1 Ethnic distance and the selection of portfolio companies

In this section, we analyze the influence of ethnic distance and other variables on the conditional probability of a match between a VC and a company (*i.e.*  $\Pr\{y_{c,v} = 1\}$  in equation 1). In all our following estimations, we specify ethnic distance, geographic distance, the number of company executives, and the number of VC partners in logs since we expect the effect of the variables to diminish at higher values. We obtain estimates of the influence of these variables on the probability of match through Maximum Likelihood Probit Estimations. Recall that the sample is randomly drawn from the set of all plausible and realized matches between VCs and companies—here *plausible* means the VC has invested at least once in the same industry as the matched company operates in.

The descriptives in Table 4 suggest a negative correlation between ethnic distance and the

---

<sup>19</sup> The Mahalanobis distance was originally proposed by P.C. Mahalanobis to assess the divergence between two populations of different racial origins based on their physical characteristics. This generalized measure of distance enjoys some advantages over the computationally simpler Euclidean distance including: it corrects for correlation between the different dimensions and automatically accounts for the scaling of the coordinate axes.

probability of a VC-company match. First, we confirm this in a univariate regression and then progressively add other explanatory variables to the regression. Table 5 presents the results from this exercise – we report Probit estimates in Panel A of the table, and since these are hard to interpret, Panel B presents the marginal effects of the relevant independent variables.

**Table 5: The effect of ethnic distance on matching VC's and Startup companies**

The Table reports Probit MLE estimations of the effect of ethnic distance and other control variables on the probability that the given VC invests in the company with which it is paired. The estimation sample consists of 1,791,486 (or 1,544,187) unique actual and counterfactual VC-company pairs (unit of analysis). We restrict the counterfactual pairs such that VC's are only matched with companies which are in industries that the VC had at least once invested in before the year 2010. Panel A reports Probit estimates and Panel B reports the corresponding marginal effects of the variables, computed at the means of the variables. Columns 2, 3 and 5 successively add control variables to the baseline specification in Column 1 are estimated for the full sample of US and foreign-based companies. Columns 4 & 6 represent estimations for the subsample of US-based companies funded by the US based VC's in the sample.

**Panel A: Probit Coefficients**

| Specification #                             | -1                  | -2                  | -3                  | -4                  | -5                  | -6                  |
|---------------------------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Dependent variable = VC-Company match (0/1) |                     |                     |                     |                     |                     |                     |
| Log ethnic distance                         | -0.145**<br>[0.006] | -0.138**<br>[0.007] | -0.124**<br>[0.013] | -0.115**<br>[0.014] | -0.087**<br>[0.016] | -0.115**<br>[0.017] |
| Log geographic distance                     |                     | -0.111**<br>[0.002] | -0.119**<br>[0.003] | -0.120**<br>[0.003] | -0.119**<br>[0.003] | -0.120**<br>[0.003] |
| Industry distance                           |                     | -0.008<br>[0.026]   | -0.419**<br>[0.029] | -0.417**<br>[0.030] | -0.419**<br>[0.029] | -0.418**<br>[0.030] |
| Log # Co executives                         |                     |                     | 0.057**<br>[0.010]  | 0.071**<br>[0.011]  | 0.077**<br>[0.011]  | 0.074**<br>[0.012]  |
| Log # VC partners                           |                     |                     | 0.140**<br>[0.008]  | 0.126**<br>[0.008]  | 0.155**<br>[0.008]  | 0.128**<br>[0.009]  |
| Co Year fixed effects (19)                  | N                   | N                   | Y                   | Y                   | Y                   | Y                   |
| VC Year Fixed effects (80)                  | N                   | N                   | Y                   | Y                   | Y                   | Y                   |
| Country fixed effects (71)                  | N                   | N                   | Y                   | Only US             | Y                   | Only US             |
| Industry fixed effects (18)                 | N                   | N                   | Y                   | Y                   | Y                   | Y                   |
| % of different ethnicities                  | N                   | N                   | Y                   | Y                   | Y                   | Y                   |
| Ethnicity Interaction Terms                 | N                   | N                   | N                   | N                   | Y                   | Y                   |
| Constant                                    | -2.427**            | -1.744**            | -1.284**            | -1.099**            |                     |                     |
| Likelihood ratio chi-square                 | 552.9               | 2403.1              | 4581.6              | 4057.1              | 4671.5              | 4106.0              |
| Prob > Chi2                                 | 0                   | 0                   | 0                   | 0                   | 0                   | 0                   |
| Observations                                | 1,791,486           | 1,791,486           | 1,791,486           | 1,544,187           | 1,791,486           | 1,544,187           |

Standard errors in brackets; \*\* p<0.01, \* p<0.05, + p<0.1

**Table 5 Continued.****Panel B: Marginal effects calculated from Panel A of Table 4**

| Specification #                             | -1       | -2        | -3        | -4        | -5        | -6        |
|---------------------------------------------|----------|-----------|-----------|-----------|-----------|-----------|
| Dependent variable = VC-Company match (0/1) |          |           |           |           |           |           |
|                                             | -        |           |           |           |           |           |
| Log ethnic distance                         | 0.0008** | -0.0007** | -0.0005** | -0.0005** | -0.0003** | -0.0005** |
| Log geographic distance                     |          | -0.0005** | -0.0004** | -0.0005** | -0.0004** | -0.0005** |
| Industry distance                           |          | 0         | -0.0016** | -0.0017** | -0.0015** | -0.0017** |
| Log # Co executives                         |          |           | 0.0002**  | 0.0003**  | 0.0003**  | 0.0003**  |
| Log # VC partners                           |          |           | 0.0005**  | 0.0005**  | 0.0006**  | 0.0005**  |

Standard errors in brackets; \*\* p<0.01, \* p<0.05, + p<0.1

Column 1 shows a statistically significant negative correlation between ethnic distance and the probability that a VC invests in the given company. The likelihood ratio chi-square of 552.9 with a p-value of 0.0001 tells us that our model, with just one variable, is statistically significant; that is, the model with ethnic distance as an explanatory variable fits the sample data significantly better than a model with no predictors.

Column 2 adds the influence of geographic distance, industry distance, as well as dummy variables for the founding year of each VC and company, the national domicile of the company's headquarters, and its industry. The effect of geographic distance is comparable to the effect of ethnic distance – a 1% increase in either distance reduces the probability of a funding match by 0.05-0.07% (both statistically significant at p<0.01). Including the number of partners and executives reduces the marginal effect of the two distances slightly (see Column 3),—a 1% decrease in (ethnic or geographic) distance increases the probability of match by 0.04-0.05%. Industry closeness appears as a strong predictor of matches in models estimated with industry-fixed effects (although we do not report this regression separately, we confirm that industry distance is significant only in models that include industry-fixed effects).

Although we control for country-specific effects related to the companies, our estimate of the effect of ethnic distance (and geographic distance) includes the effect of foreign investments; e.g. a US based VC with many Korean partners is more likely to invest in a Korean company that naturally employs Korean executives. Although this scenario is consistent with our interpretation of ethnicity-based social capital—a co-ethnic VC has a clear informational advantage in evaluating the opportunities and hazards of investing in her ethnic homeland—we also want to know whether ethnicity influences investments in locales other than the nations of ethnic origin. This is because we have argued that ethnic capital proxies for common behavioral norms, discourse styles and local networks—all features which should be salient in ethnic communities outside of their homelands. Hence, we investigate whether ethnic ties matter for purely local (US) investments. Accordingly, Column 4 reports estimates obtained by restricting the sample to only those pairs (actual and counterfactual) involving US-based companies. The estimates from this “US-only” sample are not statistically different than those obtained from the full sample of companies—ethnic distance matters even in transactions conducted completely outside the boundaries of relevant ethnic homelands. Furthermore, this suggests that a cultural component (norms, sanctions, etc.) underpins ethnicity based social capital rather than just correlated nation-specific knowledge.

The models reported in Columns 3 and 4 control for the fractions of executives in every company and partners of every VC belonging to each of the 24 different ethnic origins – hence the ethnic distance measure represents an average effect of ethnicity-based social distance, not the behavior of any one ethnicity. This is not to say the impact of ethnicity-based social capital is homogenous across all ethnic groups—we next investigate the heterogeneity in the strength of ties across different ethnic groups.

#### 4.2 Are some ethnic ties stronger than others?

Having established that ethnic proximity increases the probability a VC funds an entrepreneurial company, we now ask, “Does this effect of ethnic proximity vary from one ethnic group to the next?” At least two potential explanations, not necessarily mutually exclusive, suggest that the strength of co-ethnic ties vary across different ethnicities. One explanation is that members of ethnic minority groups are drawn more closely to co-ethnic members than others not only because of their desire to mingle socially with those who share a common culture, language, and history but also because of a sense of exclusion they experience from members of the majority communities (Saxenian 2006, p 49). In the words of Lester Lee, a native of Szechwan, early immigrant from the region to Silicon Valley, and founder of a company called Recortec: “When I first came to Silicon Valley, there were so few of us that if I saw another Chinese on the street, I would go over and shake his hand...Nobody wanted to sell us [Chinese] houses in the 1960s.” Members of such communities respond by forming their own “new boys network.”

A second explanation ties the cultural roots of different ethnicities to the strength of their co-ethnic networks. According to the social psychologist Geert Hofstede, the social ties among individuals in some societies, owing to a combination of historical, religious and economic factors, are loose (members of such societies look after him/herself and his/her immediate family) and in others, “people from birth onwards are integrated into strong, cohesive in-groups, often extended families (with uncles, aunts and grandparents) which continue protecting them in exchange for unquestioning loyalty.” Social associations among individuals in the latter “collectivist” societies are strong (*a la* Grief 1993).

We examine the “collectivist societies” and “minority groups” explanations for heterogeneity among ethnicities by interacting the fractions of co-ethnic VC partners and company executives for each VC-company pair. Consider a hypothetical VC company with one Japanese and three British partners paired with a startup company led by three Japanese and two British executives—this potential funding match yields two meaningful interaction terms related to co-ethnic influence: (i) VC-Japanese  $\times$  Company-Japanese ( $0.25 \times 0.6$ ), and (ii) VC-British  $\times$  Company-British ( $0.75 \times 0.4$ ). The two interaction terms (after controlling for the main effects) allow us to compare the influence of co-ethnic British VC partners and company executives *vis-à-vis* the influence of co-ethnic Japanese partners and executives.<sup>20</sup> Since these 24 co-ethnic interaction terms are estimated conditional on the main effects of the ethnic fractions, the coefficients on the terms can be interpreted as the complementary effect of co-ethnicity on the probability of matching for each of the 24 ethnic origins in our sample. Column 5 reports the results of models including interaction terms for the full sample and Column 6 for the “US-only” sample.

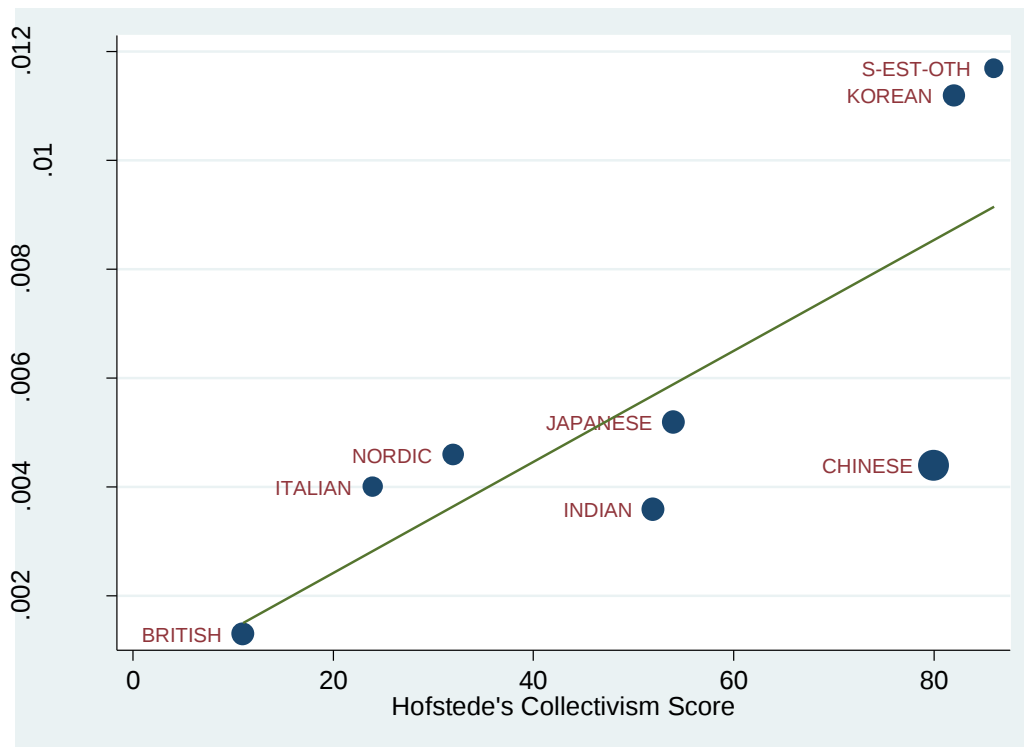
<sup>20</sup> We could naturally examine ties among VC partners and company executives belonging to different ethnicities (interacting the fraction of British VC partners with Japanese executives would be one such example), but absent a compelling theoretical rationale for doing so, do not pursue this exercise.

The interaction terms are positive and statistically significant (at  $p < 0.01$ ) for the following eight ethnic groups (*in decreasing order of the magnitude of point estimates*): South/East Asian-Other (category comprised of Taiwanese and Singapore origins), Korean, Japanese, Nordic, Chinese, Italian, Indian and British. This means that over and above the average effect of ethnic distance, the probability of a VC funding a company increases even more when the leadership of both comes from one of these communities.

We examine the “collectivist societies” hypothesis first by plotting the point estimates of the interaction coefficient for the eight statistically significant communities against Hofstede’s collectivism scores (collectivism scores as calculated as the inverse of Hofstede’s original individualism scores) for the ethnicities (see Figure 1). In fact, we find a strong positive correlation between the collectivism scores and the coefficient estimates (beta of 0.78) suggesting that ethnic ties are stronger for the more collectivist communities.

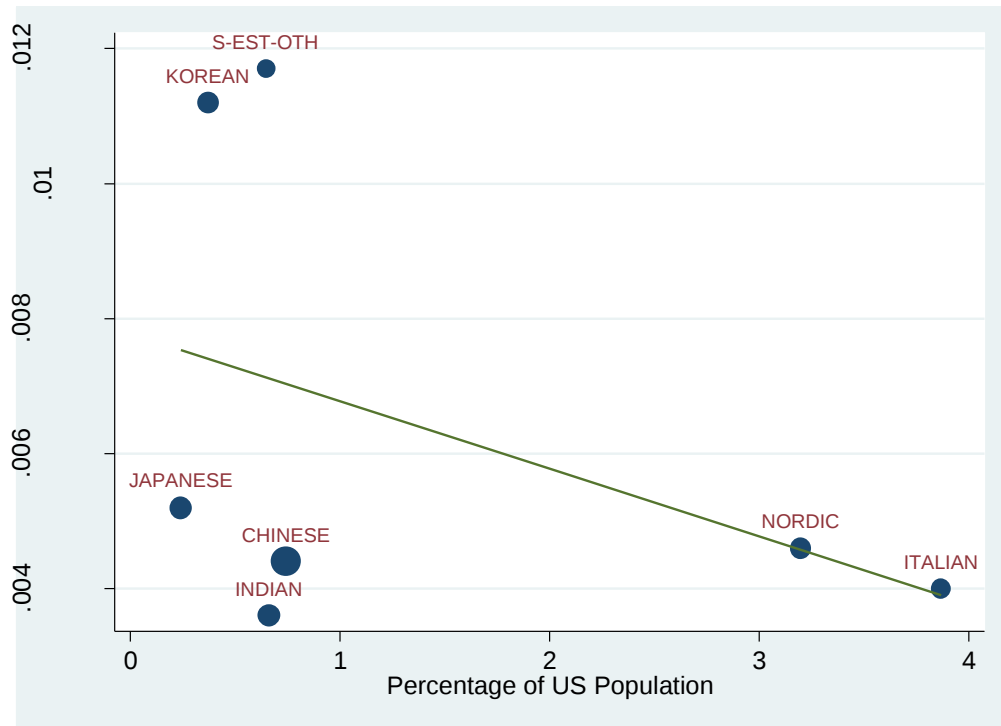
**Figure 1: Collectivism and the strength of co-ethnic ties**

The figure shows the relationship between Gert Hofstede’s collectivism scores (calculated as  $100 - \text{Hofstede's individualism scores}$ ) and the coefficients on the VC-Company co-ethnic interaction terms obtained from estimating the model shown in Column 5 of Table 5. The latter indicates the strength of co-ethnic networks in predicting a match between VC’s and startup companies. The eight ethnic groups shown here are the ones for which the interaction terms were significant at  $p < 0.01$ . The size of the bubbles indicates statistical-significance such that larger bubbles are associated with higher t-stats. The green line on the graph is obtained by fitting a linear regression to the data points.



**Figure 2: Representation and the strength of co-ethnic ties**

The figure shows the relationship between the representation of ethnicities in the US population (calculated as the fraction of the ethnicities in the overall U.S. population) and the coefficients on the VC-Company co-ethnic interaction terms obtained from estimating the model shown in Column 5 of Table 5. The latter indicates the strength of co-ethnic networks in predicting a match between VC's and startup companies. The eight ethnic groups shown here are the ones for which the interaction terms were significant at  $p < 0.01$ . The size of the bubbles indicates statistical-significance such that larger bubbles are associated with higher t-stats. The green line on the graph is obtained by fitting a linear regression to the data points.



Next we examined the “excluded minority groups” hypothesis, but found the fraction of the overall US population of the different ethnicities to be a relatively noisy predictor of the interaction effects (a correlation coefficient of -0.5 between the two variables drops to -0.3 if we leave out the majority outlier or “British” category). The extent of collectivism and minority status may be correlated for ethnicities, so we examined the relationship between the two variables and the interaction coefficient (*Coethnic\_Influence*) in a multiple regression. The estimated positive effects of Hofstede’s collectivism scores (*Collectivism*) on co-ethnic ties emerged statistically significant from this exercise as below.

$$\widehat{Coethnic\_Influence} = 0.047 + 0.010 \text{ Collectivism} - 0.001 \text{ US\_Fraction} \quad (N=8)$$

(0.004)                      (0.009)

These correlations are admittedly crude and simplistic, but nevertheless provide a first step in understanding the theoretical drivers of the strength of co-ethnic ties.

### 4.3 Does ethnic similarity matter more when information costs are high?

Companies receive funding in a succession of capital infusions, known as “rounds.” Although rounds are not strictly demarcated by expense category, investments in the initial rounds tend to fund riskier activities. A typical first round raises money for early-stage product development and manufacturing. In the subsequent round, companies that have met with some development and manufacturing success seek additional working capital to market their products. The third and subsequent rounds typically infuse money into a company generating significant revenues, or even profits, to speed its expansion rapidly and secure market position. In each new round, existing VCs and often new ones exchange working capital for company equity (in fact, in our data 100% of the VCs that funded the company in round  $N$ , also funded the company in round  $N+1$ , if it occurs).

As the fledgling company matures, uncertainty resolves for both VCs and the company. Some of this resolution comes simply because information is becoming less imperfect—technological uncertainties diminish as concepts become prototypes and then evolve into finished products, market uncertainties too fall as consumers begin to sample the product, and so on. Some of this resolution comes because the asymmetries between VCs and their portfolio companies dwindle—management of the two firms get to know each other, their strengths and weakness, how they will respond to future crises becomes more clear. Each financing round represents a snapshot into this informational maturing process. Thus, we expect factors that soften the information costs of transactions between VCs and companies, such as ethnicity-based social distance, to be more important in the earlier rounds when the costs are highest.

To test this hypothesis, we examine how ethnic distance’s predictive power over the probability of a VC-company match varies over financing round. Our analysis focuses on the first three funding rounds, not only because they are the most important, but also because much of the uncertainty is resolved in these three rounds. Many companies move from early-stage development to breaking-even and making profits in the first three rounds. However, considering later rounds does not change our results.

As before, the dependent variable in Table 6 is an indicator variable, equaling one if the VC-company pair was actually matched in the corresponding round, and zero if it did not. We construct the factual and counterfactual matches for this analysis anew to incorporate round-level information. Since a matched VC-company pair in round  $N$  is 100% likely to be matched in the next (conditioned on the company not being written off in Round  $N$ ), we restrict the realized pairs in the estimating samples for each round to ones that are new to the round. In other words, our estimated effects of ethnic distance are for VC investments that are undertaken in the company for the first time. Also, as before, we only retain those pairs that are plausible matches given the company’s industry and the VC’s revealed industry-preference.

We estimate three separate models for each of the three subsamples representing the first three rounds. Clearly, as survival to round  $N+1$  is conditional on having survived to round  $N$ , and we only consider the new matches in each round, the sample size decreases from round to round. All models are estimated using Probit MLE and Table 6 presents the results.

**Table 6: The effect of ethnic distance on matching VC's and Startup companies by funding round**

The Table reports Probit MLE estimations of the effect of ethnic distance and other control variables on the probability that the given VC invests in the company with which it is paired for Round numbers 1,2, and 3. The estimation sample for each round consists of actual VC-company pairs (unit of analysis) new to that round and counterfactual pairs. In other words, VC's that funded companies during Round 1 do not enter the Round 2 sample and VC's that funded companies in the previous two rounds not enter the Round 3 sample (either in actual or counterfactual pairings). As before, we restrict the counterfactual pairs such that VC's are only matched with companies which are in industries that the VC had at least once invested in before the year 2010. Panel A reports Probit estimates and Panel B reports the corresponding marginal effects of the variables, computed at the means of the variables. Columns 1, 2 and 3 estimate the effect of RHS variables on the probability of investment for Rounds 1, 2, and 3 respectively.

**Panel A: Probit Coefficients**

| Specification #                             | -1                  | -2                  | -3                  |
|---------------------------------------------|---------------------|---------------------|---------------------|
| Dependent variable = VC-Company match (0/1) |                     |                     |                     |
| Log ethnic distance                         | -0.098**<br>[0.010] | -0.125**<br>[0.016] | -0.072**<br>[0.021] |
| Log geographic distance                     | -0.129**<br>[0.002] | -0.094**<br>[0.003] | -0.082**<br>[0.004] |
| Industry distance                           | -0.772**<br>[0.022] | -0.562**<br>[0.037] | -0.417**<br>[0.050] |
| Log # Co executives                         | -0.015+<br>[0.008]  | -0.002<br>[0.013]   | 0.092**<br>[0.018]  |
| Log # VC partners                           | 0.150**<br>[0.006]  | 0.106**<br>[0.009]  | 0.098**<br>[0.012]  |
| Co Year fixed effects (19)                  | Y                   | Y                   | Y                   |
| VC Year Fixed effects (80)                  | Y                   | Y                   | Y                   |
| Country fixed effects (71)                  | Y                   | Y                   | Y                   |
| Industry fixed effects (18)                 | Y                   | Y                   | Y                   |
| % of different ethnicities                  | Y                   | Y                   | Y                   |
| Ethnicity Interaction Terms                 | N                   | N                   | N                   |
| Constant                                    | -0.289              | -1.324**            | -2.273**            |
| Likelihood ratio chi-square                 | 7496.0              | 2298.8              | 1174.5              |
| Prob > Chi2                                 | 0                   | 0                   | 0                   |
| Observations                                | 4,261,782           | 2,899,688           | 1,926,033           |

Standard errors in brackets; \*\* p<0.01, \* p<0.05, + p<0.1

**Table 6 Continued.****Panel B: Marginal effects calculated from Panel A of Table 5**

| Specification #                             | -1        | -2        | -3        |
|---------------------------------------------|-----------|-----------|-----------|
| Dependent variable = VC-Company match (0/1) |           |           |           |
| Log ethnic distance                         | -0.0002** | -0.0002** | -0.0001** |
| Log geographic distance                     | -0.0003** | -0.0002** | -0.0001** |
| Industry distance                           | -0.0018** | -0.0009** | -0.0007** |
| Log # Co executives                         | -0.0000+  | 0         | 0.0001**  |
| Log # VC partners                           | 0.0003**  | 0.0002**  | 0.0002**  |

Standard errors in brackets; \*\*  $p < 0.01$ , \*  $p < 0.05$ , +  $p < 0.1$ 

The results from the subsample regressions support our expectation that ethnic distance plays a more significant role in earlier rounds (i.e. rounds with potentially greater information problems). The estimated marginal effect can be interpreted as follows: a 1% increase in ethnic distance decreases the probability of match by 0.02% in the first round and the second round (both at  $p < 0.01$ ); by the third round the effect drops to 0.01%. The estimates for the first two rounds are not statistically different from each other (although the coefficient for R1 is estimated with higher precision), but the difference between the round 3 effect and the effects in rounds 1 and 2 is statistically significant ( $p < 0.01$ ). The effects of geographic distance follow the same pattern, consistent with the explanation that informational barriers shrink as the company matures. The likelihood ratio chi-square values also suggest that the models fit the data better for the earlier rounds.

## 5. How does ethnicity affect the VC-company performance?

### 5.1 Survival to the next round

We now turn to estimating the effect of ethnic distance on the performance of the VC-entrepreneur pair. In the absence of company-level rate of return data, we measure performance of the VC's investments indirectly through two measures. First, for each of the first three funding rounds, we estimate the likelihood that a company proceeds to a subsequent round, rather than being written off. Next, we examine the likelihood that companies exit via an IPO or an acquisition. Finally, since we lack financial data on the extent of VC investments, we use our IPO results to imperfectly impute the difference ethnicity-based investing makes to the VC's IRR.

We begin our performance analysis by restricting the sample to factual VC-company pairs, i.e. pairs where the VCs invested in the company. Hence, our estimates represent the effect of the RHS variables on the performance of the VC-company relationship, conditioned on the fact that the relationship actually exists.

For the analysis examining survival to the next round, we restrict attention to the new VC-company matches formed during each round, and examine the probability that the company successfully

moves to the next round as a function of the ethnic distance between the pair. Since we focus on survival from the first three rounds (i.e.,  $N=1..3$ ), we estimate three separate models labeled in the table as “survived round 1,” “...2,” and “...3” (equivalently moved to round 2,3, and 4). Table 7 displays the results. Since survival to round  $N+1$  is conditional on having survived to round  $N$ , and because we restrict the samples to only the new matches formed in each subsequent round, the sample size decreases from round to round.

**Table 7: The effect of ethnic distance on the survival of companies to subsequent rounds**

The Table reports Probit MLE estimations of the effect of ethnic distance and other control variables on the probability that the company in the given VC-company pair (unit of analysis) survives to the next round rather than being written off. The estimation sample for each round consists of actual VC-company pairs new to each round. In other words, VC-Company pairs that were formed (by the VC investing in the company) during Round 1 are not part of the Round 2 sample and VC's that funded companies in the previous two rounds do not enter the Round 3 sample. Panel A reports Probit estimates and Panel B reports the corresponding marginal effects of the variables, computed at the means of the variables. Columns 1, 2 and 3 estimate the effect of RHS variables on the probability of survival of companies to Rounds 2, 3, and 4 respectively.

**Panel A: Probit Coefficients**

| Round #                                           | -1                  | -2                  | -3                 |
|---------------------------------------------------|---------------------|---------------------|--------------------|
| Dependent variable = Proceed to next round? (0/1) |                     |                     |                    |
| Log ethnic distance                               | -0.117**<br>[0.024] | -0.058<br>[0.044]   | 0.051<br>[0.057]   |
| Log geographic distance                           | -0.024**<br>[0.005] | -0.029**<br>[0.008] | -0.017+<br>[0.010] |
| Industry distance                                 | -0.203**<br>[0.063] | -0.148<br>[0.109]   | -0.112<br>[0.140]  |
| Log # Co executives                               | 0.487**<br>[0.019]  | 0.392**<br>[0.035]  | 0.461**<br>[0.050] |
| Log # VC partners                                 | -0.069**<br>[0.015] | -0.072**<br>[0.025] | 0.015<br>[0.034]   |
| Co Year fixed effects (19)                        | Y                   | Y                   | Y                  |
| VC Year Fixed effects (80)                        | Y                   | Y                   | Y                  |
| Country fixed effects (71)                        | Y                   | Y                   | Y                  |
| Industry fixed effects (18)                       | Y                   | Y                   | Y                  |
| % of different ethnicities                        | Y                   | Y                   | Y                  |
| Ethnicity Interaction Terms                       | N                   | N                   | N                  |
| Constant                                          | -2.681**            | -2.804**            | -3.424**           |
| Likelihood ratio chi-square                       | 3712.5              | 1123.3              | 616.4              |
| Prob > Chi2                                       | 0                   | 0                   | 0                  |
| Observations                                      | 17,278              | 6,919               | 4,225              |

Standard errors in brackets; \*\*  $p < 0.01$ , \*  $p < 0.05$ , +  $p < 0.1$

**Table 7 Continued.****Panel B: Marginal effects calculated from Panel A of Table 7**

| Specification #                             | -1        | -2        | -3       |
|---------------------------------------------|-----------|-----------|----------|
| Dependent variable = VC-Company match (0/1) |           |           |          |
| Log ethnic distance                         | -0.0413** | -0.0187   | 0.0167   |
| Log geographic distance                     | -0.0086** | -0.0094** | -0.0056+ |
| Industry distance                           | -0.0717** | -0.0482   | -0.0364  |
| Log # Co executives                         | 0.1717**  | 0.1273**  | 0.1494** |
| Log # VC partners                           | -0.0243** | -0.0234** | 0.0049   |

Standard errors in brackets; \*\* p<0.01, \* p<0.05, + p<0.1

The results from the three round-level subsample regressions support our expectation—ethnic distance plays the greatest role in transition to the subsequent round primarily for the first round and then the effect fades away. The effects are particularly strong for survival from the first round to the next—a 1% increase in ethnic distance (around the means) increases the probability of moving from Round 1 to Round 2 by 4.1% and the effect fades away for the investments associated with the new VCs in the subsequent rounds. This result rationalizes the finding in the previous section that ethnic distance is more likely to predict matching in the earlier rounds of funding. In comparison, although the effect of geographic distance also fades away for Round 3, its overall impact on predicting successful transition to the next round is muted in comparison to the effect of ethnic distance. The results also reveal that industry similarity, like ethnic distance, is associated with successful transitions when information costs are highest.

## 5.2 Successful exit through acquisitions and IPOs

Finally, we examine whether ethnicity driven matches are more likely to be financially successful as measured by exits through acquisitions and IPO's. Although it is not clear whether acquisitions measure good performance or bad, IPO is a widely accepted if coarse measure of a portfolio company's success. Table 8 shows that 25.3% of the companies in our sample are eventually acquired and 9% exited through IPOs. Firms started during the later years of our sample are less likely to have had the time to either get acquired or exit through an IPO (typically these outcomes occur between 3-6 years the company receives its first round of funds) and year-specific dummies in our models capture the average exit rates through either of these outcomes.

**Table 8: Status of portfolio companies funded by US based VC's**

The table reports the status (as of July 2010) distribution of the 13,119 companies started during 1991-2010 and funded by US VC's.

| Company current situation | Frequency | Percentage |
|---------------------------|-----------|------------|
| Acquisition               | 3,319     | 25.30%     |
| Active                    | 7,794     | 59.41      |
| Bankruptcy - Chapter 11   | 30        | 0.23       |
| Bankruptcy - Chapter 7    | 6         | 0.05       |
| Defunct                   | 30        | 0.23       |
| In Registration           | 71        | 0.54       |
| LBO                       | 511       | 3.90       |
| Merger                    | 122       | 0.93       |
| Other                     | 4         | 0.03       |
| Pending Acquisition       | 60        | 0.46       |
| Went Public (IPO)         | 1,172     | 8.93       |
| Total                     | 13,119    |            |

Table 9 presents the results of Probit MLE models that estimate the effect of ethnic distance and other variables on the probability that the company is acquired. The sample is restricted to actual matches between VCs and companies, and contains every unique VC-company pair, regardless of the round. The results suggest that neither ethnic distance, nor geographic distance have a statistically significant effect on the probability that a company is acquired. Since VentureXpert sometimes underreports exit events for companies abroad, we rerun the estimations for a sample with only U.S. companies (Column 2)—we find similar results. We also include the co-ethnic interaction terms to explore the effect of each of the 24 ethnic origins on outcomes, but find no significant effect of any of the ethnicities on acquisition outcomes (Column 3 for the overall sample and Column 4 for the US sample). The only variable that appears to significantly predict acquisitions (apart from the fixed effects) is the number of executives – companies with smaller number of executives appear more likely to exit through acquisitions.

Finally, Table 10 presents the results of Probit MLE models that estimate the effect of ethnic distance and other variables on the probability that the company exits through an IPO. This estimation uses the same sample as used in our acquisition analysis. We find that ethnic distance between a matched VC-Company pair has a strong negative effect on the likelihood of an exit through IPO – a 1% increase in ethnic distance between a matched VC-Company pair decreases the probability of an IPO by 0.67% (at  $p < 0.01$ ). The effect is stronger in samples restricted to US companies (Column 2 and Column 4) and for models estimated with the co-ethnic interaction terms (Column 3 and Column 4). Interestingly, geographic distance does not make a statistically significant difference to our measure of investment performance, while industry distance does.

**Table 9: The effect of ethnic distance on the probability that companies exit through acquisitions**

The Table reports Probit MLE estimations of the effect of ethnic distance and other control variables on the probability that the company in the given VC-company pair (unit of analysis) exits through an acquisition. The estimation sample consists of actual VC-company pairs regardless of round (each pair is represented once, regardless of whether the VC funds the company in multiple rounds). Panel A reports Probit estimates and Panel B reports the corresponding marginal effects of the variables, computed at the means of the variables. Columns 1 and 3 report estimates of the effect of RHS variables on the probability of acquisitions for the full sample of companies and Columns 2 and 4 for the sample restricted to companies based in the US.

**Panel A: Probit Coefficients**

| Specification #                         | -1                  | -2                  | -3                  | -4                  |
|-----------------------------------------|---------------------|---------------------|---------------------|---------------------|
| Dependent variable = Acquisition? (0/1) |                     |                     |                     |                     |
| Log ethnic distance                     | -0.007<br>[0.019]   | -0.007<br>[0.020]   | -0.042+<br>[0.022]  | -0.036<br>[0.024]   |
| Log geographic distance                 | -0.004<br>[0.003]   | -0.003<br>[0.003]   | -0.004<br>[0.003]   | -0.004<br>[0.003]   |
| Industry distance                       | -0.137**<br>[0.047] | -0.129**<br>[0.049] | -0.135**<br>[0.047] | -0.124*<br>[0.049]  |
| Log # Co executives                     | -0.177**<br>[0.015] | -0.192**<br>[0.016] | -0.195**<br>[0.016] | -0.207**<br>[0.017] |
| Log # VC partners                       | -0.012<br>[0.011]   | -0.014<br>[0.012]   | -0.026*<br>[0.012]  | -0.026*<br>[0.013]  |
| Year fixed effects (19)                 | Y                   | Y                   | Y                   | Y                   |
| Country fixed effects (71)              | Y                   | US Only             | Y                   | US Only             |
| Industry fixed effects (18)             | Y                   | Y                   | Y                   | Y                   |
| % of different ethnicities              | Y                   | Y                   | Y                   | Y                   |
| Ethnicity Interaction Terms             | N                   | N                   | Y                   | Y                   |
| Constant                                | -3.202**            | -3.549**            | -2.989**            | -3.437**            |
| Likelihood ratio chi-square             | 5207.3              | 4670.0              | 5243.9              | 4700.6              |
| Prob > Chi2                             | 0                   | 0                   | 0                   | 0                   |
| Observations                            | 34,353              | 31,732              | 34,353              | 31,732              |

Standard errors in brackets; \*\* p<0.01, \* p<0.05, + p<0.1

**Table 9 Continued.****Panel B: Marginal effects calculated from Panel A of Table 9**

| Specification #                             | -1        | -2        | -3        | -4        |
|---------------------------------------------|-----------|-----------|-----------|-----------|
| Dependent variable = VC-Company match (0/1) |           |           |           |           |
| Log ethnic distance                         | -0.0022   | -0.0022   | -0.0139+  | -0.0121   |
| Log geographic distance                     | -0.0013   | -0.0012   | -0.0014   | -0.0013   |
| Industry distance                           | -0.0453** | -0.0436** | -0.0445** | -0.0421*  |
| Log # Co executives                         | -0.0587** | -0.0653** | -0.0645** | -0.0701** |
| Log # VC partners                           | -0.0041   | -0.0047   | -0.0086*  | -0.0088*  |

Standard errors in brackets; \*\* p&lt;0.01, \* p&lt;0.05, + p&lt;0.1

**Table 10: The effect of ethnic distance on the probability that companies exit through IPO**

The Table reports Probit MLE estimations of the effect of ethnic distance and other control variables on the probability that the company in the given VC-company pair (unit of analysis) exits through an IPO. The estimation sample consists of actual VC-company pairs regardless of round (each pair is represented once, regardless of whether the VC funds the company in multiple rounds). Panel A reports Probit estimates and Panel B reports the corresponding marginal effects of the variables, computed at the means of the variables. Columns 1 and 3 report estimates of the effect of RHS variables on the probability of IPO for the full sample of companies and Columns 2 and 4 for the sample restricted to companies based in the US.

**Panel A: Probit Coefficients**

| Specification #                 | -1                  | -2                  | -3                  | -4                  |
|---------------------------------|---------------------|---------------------|---------------------|---------------------|
| Dependent variable = IPO? (0/1) |                     |                     |                     |                     |
| Log ethnic distance             | -0.073**<br>[0.028] | -0.109**<br>[0.031] | -0.087**<br>[0.033] | -0.140**<br>[0.037] |
| Log geographic distance         | 0.002<br>[0.005]    | 0.001<br>[0.005]    | 0.003<br>[0.005]    | 0.002<br>[0.005]    |
| Industry distance               | -0.232**<br>[0.065] | -0.242**<br>[0.068] | -0.233**<br>[0.065] | -0.240**<br>[0.068] |
| Log # Co executives             | 1.040**<br>[0.026]  | 1.070**<br>[0.029]  | 1.040**<br>[0.027]  | 1.063**<br>[0.030]  |
| Log # VC partners               | 0.009<br>[0.016]    | -0.005<br>[0.017]   | 0.007<br>[0.018]    | -0.015<br>[0.020]   |
| Co Year fixed effects (19)      | Y                   | Y                   | Y                   | Y                   |
| VC Year Fixed effects (80)      | Y                   | Y                   | Y                   | Y                   |
| Country fixed effects (71)      | Y                   | US Only             | Y                   | US Only             |
| Industry fixed effects (18)     | Y                   | Y                   | Y                   | Y                   |
| % of different ethnicities      | Y                   | Y                   | Y                   | Y                   |
| Ethnicity Interaction Terms     | N                   | N                   | Y                   | Y                   |
| Constant                        | -4.785**            | -4.250**            | -4.813**            | -4.115**            |
| Likelihood ratio chi-square     | 7776.7              | 7238.2              | 7816.4              | 7279.3              |
| Prob > Chi2                     | 0                   | 0                   | 0                   | 0                   |
| Observations                    | 34,353              | 31,732              | 34,353              | 31,732              |

Standard errors in brackets; \*\* p&lt;0.01, \* p&lt;0.05, + p&lt;0.1

**Table 10 Continued.****Panel B: Marginal effects calculated from Panel A of Table 10**

| Specification #                             | -1        | -2        | -3        | -4        |
|---------------------------------------------|-----------|-----------|-----------|-----------|
| Dependent variable = VC-Company match (0/1) |           |           |           |           |
| Log ethnic distance                         | -0.0066** | -0.0094** | -0.0078** | -0.0119** |
| Log geographic distance                     | 0.0002    | 0.0001    | 0.0003    | 0.0001    |
| Industry distance                           | -0.0213** | -0.0209** | -0.0210** | -0.0204** |
| Log # Co executives                         | 0.0951**  | 0.0926**  | 0.0937**  | 0.0903**  |
| Log # VC partners                           | 0.0008    | -0.0005   | 0.0006    | -0.0013   |

Standard errors in brackets; \*\*  $p < 0.01$ , \*  $p < 0.05$ , +  $p < 0.1$

### 5.3 Robustness checks

(i) We validate the robustness of our results in a number of alternate specifications. In one set of unreported regressions, we extend the sample of matches to an unrestricted sample with no condition on industry match but an industry-match dummy variable as an additional regressor. This model cannot be estimated by probit (because the dummy variable predicts separation perfectly, MLE estimates the corresponding coefficient as close to infinity and fails to estimate the slope) so we used a LPM model and attain qualitatively similar results.

(ii) We have interpreted the positive relationship between ethnic distance and IPO probability, obtained in the previous section, as indicative of the superior screening and reduction in monitoring costs brought about by the shared norms of co-ethnic networks. Yet, an alternative explanation is that some VCs hire partners of certain ethnic communities that are systematically better at selecting and monitoring startup companies and produce better quality startups. Although we do not have an explicit measure of the quality of VC partners, we explore this possibility by including VC-fixed effects (which control not only for VC-specific quality but other potential unobserved characteristics of VCs as well) to the four regressions in the previous section that predict the probability of successful exit through IPO. Hence, we estimate the “within VC-effect” of ethnic distance on the probability of IPO, conditional on investment. Table 11 presents the corresponding results.

We find that the estimated effect of ethnic-distance on IPO probability is stronger for all models with VC-fixed effects relative to those without, and nearly doubles for the regression on the US-only sample with co-ethnic interaction effects (2% at  $p < 0.01$ ). Hence, even within a given VC’s portfolio (i.e. holding constant VC-unobserved characteristics), startup companies which are ethnically the closest to the VC’s enjoy the highest probability of successful exit through IPO. This confirms our interpretation that ethnic similarity positively influences performance through a reduction of transaction costs.

**Table 11: “Within-VC” effects of ethnic distance on the probability that companies exit through IPO**

The Table reports Probit MLE estimations, with VC-fixed effects of the effect of ethnic distance and other control variables on the probability that the company in the given VC-company pair (unit of analysis) exits through an IPO. The estimation sample consists of actual VC-company pairs regardless of round (each pair is represented once, regardless of whether the VC funds the company in multiple rounds). Panel A reports Probit estimates and Panel B reports the corresponding marginal effects of the variables, computed at the means of the variables. Columns 1 and 3 report estimates of the effect of RHS variables on the probability of IPO for the full sample of companies and Columns 2 and 4 for the sample restricted to companies based in the US.

**Panel A: Probit Coefficients**

| Specification #                 | -1        | -2        | -3        | -4        |
|---------------------------------|-----------|-----------|-----------|-----------|
| Dependent variable = IPO? (0/1) |           |           |           |           |
| Log ethnic distance             | -0.074*   | -0.133**  | -0.105*   | -0.192**  |
|                                 | [0.036]   | [0.041]   | [0.046]   | [0.053]   |
| Log geographic distance         | -0.019**  | -0.020**  | -0.018**  | -0.019**  |
|                                 | [0.006]   | [0.006]   | [0.006]   | [0.006]   |
| Industry distance               | -0.218+   | -0.205+   | -0.226*   | -0.211+   |
|                                 | [0.113]   | [0.119]   | [0.114]   | [0.119]   |
| Log # Co executives             | 1.113**   | 1.151**   | 1.103**   | 1.130**   |
|                                 | [0.031]   | [0.035]   | [0.033]   | [0.038]   |
| Log # VC partners               | 8.388+    | 8.330+    | 8.191+    | 7.795+    |
|                                 | [4.362]   | [4.418]   | [4.377]   | [4.444]   |
| Co Year fixed effects (19)      | Y         | Y         | Y         | Y         |
| VC Year Fixed effects (80)      | Y         | Y         | Y         | Y         |
| VC Fixed effects (2687)         | Y         | Y         | Y         | Y         |
| Country fixed effects (71)      | Y         | US Only   | Y         | US Only   |
| Industry fixed effects (18)     | Y         | Y         | Y         | Y         |
| % of different ethnicities      | Y         | Y         | Y         | Y         |
| Ethnicity Interaction Terms     | N         | N         | Y         | Y         |
| Constant                        | -161.336+ | -158.687+ | -156.989+ | -146.888+ |
| Likelihood ratio chi-square     | 7807.9    | 7248.5    | 7845.4    | 7292.2    |
| Prob > Chi2                     | 0         | 0         | 0         | 0         |
| Observations                    | 34,353    | 31,732    | 34,353    | 31,732    |

Standard errors in brackets; \*\* p<0.01, \* p<0.05, + p<0.1

Table 11 Continued.

Panel B: Marginal effects calculated from Panel A of Table 11

| Specification #                                           | -1        | -2        | -3        | -4        |
|-----------------------------------------------------------|-----------|-----------|-----------|-----------|
| Dependent variable = VC-Company match (0/1)               |           |           |           |           |
| Log ethnic distance                                       | -0.0085*  | -0.0146** | -0.0119*  | -0.0208** |
| Log geographic distance                                   | -0.0021** | -0.0022** | -0.0020** | -0.0021** |
| Industry distance                                         | -0.0248+  | -0.0226+  | -0.0255*  | -0.0228+  |
| Log # Co executives                                       | 0.1267**  | 0.1267**  | 0.1244**  | 0.1225**  |
| Log # VC partners                                         | 0.9546+   | 0.9171+   | 0.9235+   | 0.8450+   |
| Standard errors in brackets; ** p<0.01, * p<0.05, + p<0.1 |           |           |           |           |

### 5.4 Effect of coethnic matching on performance

Our analysis reveals that co-ethnicity between VC and entrepreneur increases the probability of that a portfolio investment sells to the public—Initial Public Offerings (IPOs) represent venture capitalists' most favorable exit option. How much is this increased likelihood of IPO worth?

We now compute the positive impact of an increase in IPO probability on the *ex ante* expected on rate of return for an investment as the derivative of expected rate of return with respect to IPO probability. First, condition the expected rate of return ( $r$ ) on the IPO event

$$\mathbb{E}[r] = \mathbb{E}[r|IPO]p + \mathbb{E}[r|no\ IPO](1 - p) \quad (6)$$

where  $p$  is the probability that an IPO occurs. Then, the derivative with respect to  $p$  is just the difference between the expected rates of return when an IPO occurs and when it does not

$$\frac{d\mathbb{E}[r]}{dp} = \mathbb{E}[r|IPO] - \mathbb{E}[r|no\ IPO] \quad (7)$$

Since data on rates of return for individual investments, which do not end in IPO, are not generally available, we can isolate  $\mathbb{E}[r|no\ IPO]$  from (6) and substitute it into (7)

$$\frac{d\mathbb{E}[r]}{dp} = \mathbb{E}[r|IPO] - \frac{\mathbb{E}[r] - \mathbb{E}[r|IPO]p}{1 - p}$$

Simplifying further

$$\frac{d\mathbb{E}[r]}{dp} = \frac{\mathbb{E}[r|IPO] - \mathbb{E}[r]}{1 - p}$$

Estimates for these three parameters can be found in the literature.

Cochrane (2005) estimated mean returns of 698% on venture capital investments that ultimately exit in IPOs or acquisitions—since IPOs generally return significantly more than acquisitions, this

number may be regarded as a conservative lower bound on  $\mathbb{E}[r|IPO]$ . Accounting for the strong selection, which occurs prior to a successful exit event, Cochrane estimates overall *ex ante* expected returns to venture capital investments ( $\mathbb{E}[r]$ ) of 59%. In his sample, 21.4% ( $p$ ) of firms IPO (not including an additional 3.7% registered for IPO). Substituting these values into (3, our simplified derivative equation) yields  $d\mathbb{E}[r]/dp = 8.13$ . This implies that our observed increase in the probability of IPO ranging from 0.5% to 1.1% increases the expected rate of return between 4% and 9% at the time of investment—thus, using Cochrane’s estimates conservatively, a venture capitalist gains between 7% and 15% of his *ex ante* expected rate of return by selecting entrepreneurs ethnically similar to himself.<sup>21</sup> This evidence favors a rational social capital explanation of co-ethnic matching over taste-based discrimination.

## 6. Concluding thoughts

We find significant evidence that when the leadership of a prospective portfolio company and venture investors are ethnically similar, a funding deal is more likely to be struck between them. This effect is stronger when the shared ethnic communities are “collectivist” (as measured by Hofstede’s collectivism score) or the opportunity is earlier in the startup company’s development. Moreover, conditional on a funding deal, greater ethnic similarity between investors and company management increases the probability that the venture exits in an IPO—a one percent decrease in the ethnic distance between VC and portfolio company may increase the VC’s *ex ante* expected IRR by 7-15%.

These findings, while demonstrating the profound role played by ethnic similarity in the VC industry, also fill some significant gaps in the broader social capital literature. Because individuals choose neither their ethnicity nor that of others in their ethnic community (i.e. their exogenously assigned social network), we disentangle the economic performance impact of ethnicity based social capital—difficult in other settings, because agents often cultivate their social associations based on their beliefs about their economic value. That co-ethnicity’s importance declines as the high-risk ventures mature suggest that social capital, as anticipated by a predominantly descriptive literature, is exceptionally valuable in the face of imperfect information.

Our study opens up several avenues for future research. First, while we have focused on the role of ethnic similarity in matching startup companies to VC partners, the industry is driven by several other associations such as those among VCs (syndication networks) and company executives (in supplier-customer relationships) that might plausibly be explained by ethnic similarity and worth investigating. Second, although we have disentangled the effect of two primary attributes – the locational and industry preferences of VC’s and entrepreneurs – from the effects of ethnic similarity, the precise mechanisms through which ethnicity reduces information costs merits further investigation. Ethnicity is a complex composite of social and economic attributes, and it is useful to understand whether the benefits of co-ethnic networks are driven by members sorting into economically relevant associations (as when two ethnic Chinese, who are alums of the Tsinghua

---

<sup>21</sup> In our sample, we can only attach an IPO event to about 9% of firms (though exit events are relatively sparse in our data). But even using this worst case value for the probability of IPO ( $p$ ) yields  $d\mathbb{E}[r]/dp = 6.95$ . Our observed 0.5% to 1.1% increase in IPO probability still implies a gain of 3.5% to 8% in overall *ex ante* expected rate of return to venture capitalists.

University choose to migrate to the US and influence a VC-company pairing) or by their adherence to socio-cultural norms. A third question is whether ethnic ties between first-generation immigrants are stronger than those between individuals who are better assimilated in the host nations. Fourth, our work quantifies the value of ethnic similarity *between* a given VC and portfolio company and suggests that ethnic distance is actually harmful. Of course, this says nothing about ethnic homogeneity *within* a company or VC, or whether an ethnically diverse staff might actually increase opportunities for a match and its success, by increasing the opportunities for co-ethnic interactions between VCs and companies. These represent important directions for future investigation.

Finally, our findings may also be interpreted as evidence that apart from the standard imperfect information considerations, informal barriers for the success of startup companies are quite large. Although we have demonstrated an important role for ethnicity for matching VCs and startup companies, anecdotal evidence suggests that the role of co-ethnic networks in the provision of “seed funds” for entrepreneurs by angel investors is even more dominant. If ethnic similarity plays such a vital role in the screening and success of startup companies, our results point to a vital area of concern for investors and policy-makers: in a world where economic opportunity lies in far and distinct ethnic enclaves, how should capitalists in the West organize themselves to profit from these opportunities? If strong co-ethnic networks serve as conduits for the transmission of information regarding opportunities and substitute for weak national and international legal structures, the recipe for the competitiveness of investors and nations may be a multiplicity of ethnically distinct populations.

## References

- Arrow, Kenneth 1972. Gifts and Exchanges, *Philosophy and Public Affairs*, I (1972), 343-362.
- Agrawal, A., D. Kapur, and J. McHale 2007. Birds of a Feather-Better Together? Exploring the Optimal Spatial Distribution of Ethnic Inventors, NBER working paper no. 12823 (2007).
- Bengtsson, O. and Hsu, D. H. 2010 How Do Venture Capital Partners Match with Startup Founders, Wharton Working Paper Series dated August 2010
- Cochrane, J. 2006. The Risk and Return of Venture Capital, *Journal of Financial Economics*, 75: 3-52.
- Gompers, Paul A., and Josh Lerner. 1999. *The Venture Capital Cycle* (MIT Press).
- Granovetter, Mark 1973. The Strength of Weak Ties *American Journal of Sociology*, LXXVIII (1973), 1360-1380.
- Greif, Avner. 1993. Contract Enforceability and Economic Institutions in Early Trade: the Maghribi Traders' Coalition. *American Economic Review*, 83: 525-48.
- Greif, Avner. 1989. Reputation and Coalitions in Medieval Trade: Maghribi Traders, *Journal of Economic History*, LIX (1989), 857-882.

Greif, Avner. 1996. Contracting, Enforcement, and Efficiency: Economics Beyond the Law, Presented at the World Bank Conference on Development Economics, Washington, DC, April 1996.

Hochberg, Y., A. Ljungqvist and Y. Lu. 2007. Whom You Know Matters: Venture Capital Networks and Investment Performance”, *Journal of Finance*, 1: 266-301.

Kaplan, S., B. Sensoy and P. Stromberg. 2008. How Well Do Venture Capital Databases Reflect Actual Investments?, University of Chicago, Ohio State University, Swedish Institute for Financial Research, Working Paper.

Kerr, W. 2008. Ethnic Scientific Communities and International Technology Diffusion. *Review of Economics and Statistics*, 90: 518-537.

Lerner, J. 1995. Venture Capitalists and the Oversight of Private Firms,” *Journal of Finance*, 50: 301–318.

Ljungqvist, Alexander, and Matthew Richardson, 2003, The investment behavior of private equity fund managers, Unpublished working paper, New York University.

Putnam, Robert, 1993. (with Robert Leonardi and Raffaella Y Nanetti), *Making Democracy Work* Princeton, NJ: Princeton University Press, 1993

Saxenian, A. 2006. *The New Argonauts: Regional Advantage in a Global Economy*, Harvard University Press.

Stuart, T. and O. Sorenson. 2001. Syndication Networks and the Spatial Distribution of Venture Capital Investments,” *American Journal of Sociology*, 106: 1546-88.

Weidenbaum, M., & Hughes, S. 1996. *The bamboo network: How expatriate Chinese entrepreneurs are creating a new economic superpower in Asia*. New York: Free Press

**Appendix: Descriptive statistics for control variables****Table A1: Domicile nations of U.S.-based VC's portfolio companies (1991-2010)**

The Table shows the location of companies funded by the 2,687 U.S.-based VC's and started during the years 1991-2010 in our sample.

| Headquarters Nation   | Companies |
|-----------------------|-----------|
| UNITED STATES         | 11,235    |
| UNITED KINGDOM        | 294       |
| CHINA                 | 277       |
| ISRAEL                | 161       |
| INDIA                 | 155       |
| CANADA                | 116       |
| GERMANY               | 104       |
| FRANCE                | 100       |
| SWITZERLAND           | 53        |
| JAPAN                 | 45        |
| NETHERLANDS           | 42        |
| SWEDEN                | 42        |
| TAIWAN                | 42        |
| SOUTH KOREA           | 40        |
| IRELAND               | 38        |
| AUSTRALIA             | 35        |
| HONG KONG             | 28        |
| BRAZIL                | 27        |
| BERMUDA               | 26        |
| SINGAPORE             | 26        |
| OTHERS (51 Countries) | 233       |
| TOTAL                 | 13,119    |

**Table A2: Founding years of U.S.-based VC's portfolio companies (1991-2010)**

The Table shows the founding years of the U.S.-based VC's and their portfolio companies during the years 1991-2010.

| <b>Founding Year</b> | <b>VC's</b>  | <b>Companies</b> |
|----------------------|--------------|------------------|
| Before 1991          | 662          | -                |
| 1991                 | 37           | 281              |
| 1992                 | 46           | 330              |
| 1993                 | 48           | 373              |
| 1994                 | 74           | 439              |
| 1995                 | 117          | 592              |
| 1996                 | 115          | 752              |
| 1997                 | 161          | 864              |
| 1998                 | 159          | 986              |
| 1999                 | 239          | 1,479            |
| 2000                 | 268          | 1,192            |
| 2001                 | 118          | 701              |
| 2002                 | 101          | 727              |
| 2003                 | 82           | 748              |
| 2004                 | 86           | 766              |
| 2005                 | 116          | 837              |
| 2006                 | 76           | 831              |
| 2007                 | 83           | 680              |
| 2008                 | 48           | 386              |
| 2009                 | 48           | 144              |
| 2010                 | 3            | 11               |
| <b>TOTAL</b>         | <b>2,687</b> | <b>13,119</b>    |

**Table A3: Industry-distribution of U.S.-based VC's portfolio companies (1991-2010)**

The Table shows the industry distribution of companies funded by U.S.-based VC's and started during the years 1991-2010 in our sample.

| Industry category         | Companies |
|---------------------------|-----------|
| Internet Specific         | 2,826     |
| Computer Software         | 2,591     |
| Medical/Health            | 1,569     |
| Communications            | 1,155     |
| Biotechnology             | 928       |
| Semiconductor/Electronics | 868       |
| Industrial/Energy         | 679       |
| Consumer Related          | 652       |
| Computer Hardware         | 472       |
| Financial Services        | 424       |
| Business Serv.            | 368       |
| Transportation            | 172       |
| Other                     | 157       |
| Manufacturing             | 135       |
| Construction              | 55        |
| Computer Other            | 23        |
| Utilities                 | 23        |
| Agr/Forestr/Fisheries     | 22        |
| TOTAL                     | 13,119    |