Reputation in Team Production

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March 1, 2001

Abstract

Consider team production with two people. Each is characterized by a prior distribution that he will do *Right* or *Wrong*. After the outcome of the project is observed, these probabilities are updated. When output depends on the weakest link in production, following project failure the posterior probability that a person did *Right* declines with the probability that the other worker did *Right*. The same holds when output depends on the best shot in production and the team effort succeeded. A leader concerned about his reputation may therefore prefer to work with a person unlikely to do *Right*.

1 Introduction

Think of a graduate student who is considering whether to co-author a paper with a highly regarded professor, or instead with a fellow graduate student who is as poorly known as himself. The resulting paper is likely better if co-authored with the professor. But the student also realizes that the high quality may be attributed to the professor rather than to the student. The student may therefore prefer to work with a fellow student. The story thus suggests that a worker concerned about his reputation may prefer to work with someone of low rather than of high quality.

The problem is of course more general. A presidential candidate such as George Bush may have nominated a weak figure, such as Daniel Quayle, who would not overshadow him. Richard Nixon had reason to worry that foreign policy successes would be attributed to his advisor, Henry Kissinger. Teachers may be unsure of a child's contribution to a science fair project if the parents are themselves scientists.

2 Literature

The idea that a leader cares about his reputation appears in important earlier works. Scharfstein and Stein (1990) show that concern about reputation may induce managers to engage in herd-like behavior. The importance of reputation and credit claiming in politics is a central point in Mayhew's (1974) book about congressmen. Rogoff (1990) notes that political business cycles may send signals about agent quality and therefore create superior outcomes, but he focuses on the generation of political business cycles rather than on how one actor's reputation affects another's.

A different line of research examines a manager who wants to signal his ability by continuing policies he had adopted in the past.[1]

Levy (1999) considers able decision makers who are better informed than unable decision makers. He shows that an able decision maker may choose an unable advisor to signal his own ability. Making a decision that contradicts the advice signals confidence in his own information and thereby in his own ability. Unable decision makers choose able advisors since they need better information. Relatedly, Swank (2000) considers a principal who can seek the advice of a well-informed agent. But any disagreement between the principal and agent casts doubt on the principal's independent ability in gathering or analyzing information. A principal who cares about his reputation may therefore choose not to get advice from an agent.

[1]See Kanodia, Bushman, and Dickhaut (1989), Boot (1992), Prendergast and Stole (1996), and Brandenburger and Polak (1996).

Segendorff (2000) investigates under what circumstances a separating equilibrium exists in which competent leaders choose incompetent co-workers, and incompetent leaders choose competent co-workers. The competent leader is risk averse; if things go wrong he benefits by blaming the incompetent co-worker and retaining his own reputation for high ability. For the low-ability leader the expected gain from such an insurance is outweighed by its costs in lowering expected policy outcomes. Our approaches differ in that here we assume that a worker's prior quality is observable, but his action is unobservable, and that we can find strong results even with a simple production technology and under different compensation methods.

The spirit of our analysis resembles Carmichael's (1998) explanation for tenure: members of an academic department may fear that hiring high-quality faculty will reduce the future income of current members.

Other papers, less related to ours, study strategic use of information and reputational or career concerns (see Effinger and Polborn (1999), Gibbons and Murphy (1992), Jeon (1998), Meyer and Vickers (1997), and Trueman (1994)).

3 Assumptions

3.1 Production

A leader and a co-worker engage in team production. Each can either do *Right* or else do *Wrong*. We shall consider two different technologies. In weakest-link production a project fails if either team member did *Wrong*. In best-shot production a project fails if both team members did *Wrong*.

Best-shot games often apply to problems of *what* to do—the best plan proposed by team members is adopted, and the project succeeds if that best plan is good enough. Weakest-link games often apply to problems of implementation—a project fails if any part of it is poorly executed.

3.2 Evaluation of leader

The leader is called A and the co-worker is called B. The leader's utility increases, in general, with both the value of production and with his reputation. We focus on reputation. Person i's reputation is the posterior probability, ρ_i, that he did *Right*. One specification we consider, related to risk-neutrality, is that only the expected value of reputation matters. But in many circumstances the payoffs are more complicated, and lead to more interesting results. In particular, compensation systems often offer an award only when performance exceeds some critical level. We shall also consider such threshold compensation. Blinder and Rosen (1985) demonstrate that, in general, continuous incentives are inferior to threshold compensation. Harris and Raviv (1979) prove that in general optimal principal-agent contracts contain some threshold compensation.

Non-linear compensation also appears in contests. A prize or reward may be awarded to the person viewed as having done best in the contest. This is common in elections. We can think of each political party as having a presidential candidate supported by a vice-presidential candidate and staff. Voters support the party whose presidential candidate they think is best.

In such threshold compensation, a leader wins a reward if and only if the posterior belief that he did *Right* exceeds a critical value, R. As stated, we let the expected reward increase with the posterior probability that the leader did *Right*. Since we also suppose that a leader is characterized by a prior probability that he does *Right*, it is worth elaborating on why the posterior probability matters. One reason is that the outcome of the project generates additional information on the leader's ability, making the posterior estimate more accurate. Another reason may be that the prior probability is based on performance which is imperfectly correlated with performance on the job considered, and that performance on the current job yields information on performance in similar jobs in the future. The model presented below is then one important element of a more complete model, which allows leaders to be of different types. A different motivation may arise from incentives. If performance depends on effort, then compensation which rewards good performance will induce more effort. Again, the analysis given here is a building block in a more complete model. A third motivation may be that a leader learns with experience. If he did *Right* in one period, then he will be better able to do *Right* in following periods.

4 Weakest link

With weakest-link production the project succeeds if and only if both team members did *Right*. Thus, if the project succeeded, then both the leader and his co-worker must have done *Right*; the prior probabilities of their quality do not affect the posterior probabilities that each did *Right*, and $\rho_i = 1$. If the project failed, then at least one of them did *Wrong*. The posterior probability is based on the prior probabilities that each team member does *Right*, and on the result of the project. Let the prior probability that the leader does *Right* be α; the corresponding probability for the co-worker is β.[2]

We use Bayes' theorem to determine the posterior probability, ρ_A, that A did *Right* given that the project failed:

$$\begin{aligned} \rho_A|\text{Failure} &= \text{pr(A Right}|\text{Failure)} \qquad (1) \\ &= \frac{\text{pr(Failure}|\text{A Right)pr(A Right)}}{\text{pr(Failure}|\text{A Right)pr(A Right)+pr(Failure}|\text{A Wrong)pr(A Wrong)}} \\ &= \frac{(1-\beta)\,\alpha}{(1-\beta)\,\alpha + (1-\alpha)} = \frac{\alpha - \alpha\beta}{1-\alpha\beta}. \end{aligned}$$

Note that for $\alpha > 0$ or $\beta > 0$, this posterior probability is smaller than the prior probability, α.

4.1 Expected reputation

Consider first linear rewards, so that the leader aims to maximize his expected reputation, which is the expected posterior probability that he did *Right*:

$$\begin{aligned} \rho_A &= \text{pr(Success)+pr(A Right}|\text{Failure)pr(Failure)} \\ &= \alpha\beta \\ &\quad + \frac{(1-\beta)\,\alpha}{(1-\beta)\,\alpha + (1-\alpha)}\,(1-\alpha\beta)\,. \\ &= \alpha. \end{aligned}$$

So the leader's expected reputation depends solely on his own prior reputation. He gets no reputational benefit from working with a better team member.

[2] These prior beliefs may themselves be subject to a contest, as discussed later.

4.2 Threshold compensation

Consider next threshold compensation. The leader wins the reward if and only if his reputation (the posterior probability that he did *Right*) exceeds R, with $0 \leq R \leq 1$. If the project succeeded, then his reputation is 1. Suppose the project failed. For $\rho_A|\text{Failure}$ to exceed R it must be that

$$\rho_A|\text{Failure} = \frac{(1-\beta)\,\alpha}{(1-\beta)\,\alpha + (1-\alpha)} = \frac{\alpha - \alpha\beta}{1-\alpha\beta} > R. \tag{2}$$

The solution is

$$\beta < \frac{\alpha - R}{\alpha\,(1-R)}, \tag{3}$$

where $(\alpha - R)\,/\alpha(1-R) < 1$.

As a check, note that

$$\frac{\partial\left(\frac{\alpha-R}{\alpha(1-R)}\right)}{\partial R} = -\frac{1-\alpha}{\alpha\,(R-1)^2} < 0. \tag{4}$$

Now if $\beta < \frac{\alpha-R}{(1-R)\alpha}$, then the leader is sure to win the reward; if β exceeds that critical level then the leader wins the reward only after a success. Thus, a leader may prefer a co-worker of low ability.

In contrast, if R is sufficiently high so that even with $\beta = 0$ (3) is unsatisfied, then the leader wins the reward only if the project succeeded. He would then want a co-worker with a high value of β.

4.3 Contests

To show the robustness of the conclusion that a leader may prefer a low-ability co-worker, we examine next a different situation which generates the same results.

We aim to show that equilibria can exist in which a leader does not always hire the best possible co-worker. We first show that a solution in which both leaders appoint the best possible co-worker is not a Nash equilibrium. Consider therefore a contest between two leaders who are a priori identical. Suppose for simplicity that they have the same prior probability of doing *Right*. The two leaders simultaneously choose co-workers. After the project outcomes are realized, the leader with the higher posterior probability of having done *Right* wins a reward.

If the leaders work with identical team members, then each leader wins with probability 1/2. The same holds if both teams succeeded, since the two leaders under the weakest-link technology are then known to have done *Right*. Now if one leader's co-worker is somewhat less likely than the other co-worker to do *Right*, and if both projects fail in a weakest-link game, then the leader with the worse co-worker has a higher posterior probability of having done *Right*. He is therefore judged better and wins the contest. A Nash equilibrium therefore cannot have each leader always appoint a co-worker of the highest feasible ability.

We show next a stronger result: the Nash equilibrium may have each leader appoint a co-worker of the lowest possible ability. We demonstrate this with the simplest model that can illustrate such an outcome.

4.4 A contest with only bad co-workers appointed

As before, consider a contest under the weakest-link technology, where reputation changes if the project fails. Each leader has a prior probability, α, of doing *Right*. Each of the two competing leaders simultaneously chooses a co-worker who is either *good* (with a probability $\overline{\beta}$ of doing *Right*) or *bad* (with a probability $\underline{\beta}$ of doing *Right*), where $0 \leq \underline{\beta} < \overline{\beta} \leq 1$. Write the ability of leader i's co-worker as β_i.

Leader 1 wins under the following conditions.

If $\beta_1 = \beta_2$ then leader 1 wins with probability 1/2. That is

$$\Pr(1 \text{ Wins} \mid \beta_1 = \beta_2) = 1/2. \tag{5}$$

If $\beta_1 > \beta_2$ then leader 1 wins in two cases. (a) Project 1 succeeded and the other project failed. (b) Both projects succeeded, with leader 1 then winning with probability 1/2. (Note that if both projects failed, then the posterior probability that leader 1 did *Right* given that $\beta_1 > \beta_2$ is less than the posterior probability that leader 2 did *Right*, and so leader 1 loses in that case). Thus,

$$\Pr(1 \text{ Wins} \mid \beta_1 > \beta_2) = \alpha\beta_1(1 - \alpha\beta_2) + \alpha\beta_1\alpha\beta_2/2 = \alpha\beta_1(1 - \alpha\beta_2/2). \tag{6}$$

If $\beta_1 < \beta_2$, then leader 1 wins in three cases: (a) Both projects failed. (b) Project 1 succeeded and the other project failed. (c) Both projects succeeded, with leader 1 then winning with probability 1/2. Thus

$$\begin{aligned} \Pr(1 \text{ Wins} \mid \beta_1 < \beta_2) &= 1 - \Pr(2 \text{ Wins} \mid \beta_1 < \beta_2) = \qquad (7) \\ & 1 - \alpha\beta_2 (1 - \alpha\beta_1/2) . \qquad (8) \end{aligned}$$

Comparing these probabilities shows that a leader appoints a *good* co-worker if (6) exceeds 1/2, since this condition implies that (8) is less than 1/2. Similarly, if (6) is less than 1/2, then appointing a *bad* co-worker is always the leader's best choice.

Proposition 1. For all values of $\alpha, \underline{\beta}$ and $\overline{\beta}$ a Nash equilibrium in pure strategies exists.

Proof. For leader i, the choice $\overline{\beta}$ is always a best response if $\alpha\overline{\beta}\left(1 - \frac{\alpha}{2}\underline{\beta}\right) \geq 1/2 \geq 1 - \alpha\overline{\beta}\left(1 - \frac{\alpha}{2}\underline{\beta}\right)$. This holds if $\alpha\overline{\beta}\left(1 - \frac{\alpha}{2}\underline{\beta}\right) \geq 1/2$ in which case $\left(\overline{\beta}, \overline{\beta}\right)$ is a Nash equilibrium. Similarly, $\underline{\beta}$ is always a best response if $\alpha\overline{\beta}\left(1 - \frac{\alpha}{2}\underline{\beta}\right) \leq 1/2$, in which case $\left(\underline{\beta}, \overline{\beta}\right)$ is a Nash equilibrium. Hence, for any allowed combination of $\alpha, \underline{\beta}$ and $\overline{\beta}$ a Nash equilibrium in pure strategies exists. ■

Mixed equilibria only exist if (6)=(8)=1/2, in which case any pair of mixed strategies constitutes a Nash equilibrium. We focus on pure equilibria since such equilibria always coexist with mixed equilibria. Expression (6) is quadratic and increasing in α. Equation (6)=1/2 has two solutions in α, but we only need consider the lower value of α; the higher value will always be too high, that is, above 1. Let α^W denote the lower value. Then

$$\alpha^W = \frac{1}{\underline{\beta}}\left(1 - \sqrt{1 - \frac{\underline{\beta}}{\overline{\beta}}}\right).$$

Notice that if *good* and *bad* co-workers are sufficiently similar, then $\alpha^W > 1$.

Corollary 1. (a) If $\alpha < \alpha^W$ then $\left(\underline{\beta}, \underline{\beta}\right)$ is the unique equilibrium. (b) If $\alpha = \alpha^W$ then two pure equilibria exist: $\left(\underline{\beta}, \underline{\beta}\right)$ and $\left(\overline{\beta}, \overline{\beta}\right)$. (c) If $\alpha > \alpha^W$ then $\left(\overline{\beta}, \overline{\beta}\right)$ is the unique equilibrium.

Proof. If $\alpha < \alpha^W$ then $\alpha\overline{\beta}\left(1 - \frac{\alpha}{2}\underline{\beta}\right) < 1/2$ and if $\alpha > \alpha^W$ then $\alpha\overline{\beta}\left(1 - \frac{\alpha}{2}\underline{\beta}\right) > 1/2$. The rest of the proof follows from the proof of Proposition 1.

A *bad* leader (one with a low value of α) always chooses a *bad* co-worker. A *good* leader (one with a high value of α) may choose a *good* or a *bad* co-worker, depending on how greatly the two types of co-workers differ. The intuition is that a *bad* leader knows his project will likely fail, even with a *good* co-worker. Since this also holds for the other leader, each aims to maximize his probability of winning in the event the project fails. Each therefore chooses a *bad* co-worker. A *good* leader has a high probability of success with a *good* co-worker; he maximizes his chances of winning the contest by choosing a *good* co-worker. If, however, the *bad* co-worker is sufficiently good then the *good* leader does better by choosing a *bad* co-worker.

5 Best shot

We now turn from games with weakest-link production to games with best-shot production, reverting to consider a single team rather than a contest. If the project failed, then with certainty each worker did *Wrong*; the prior probabilities are irrelevant. The interesting results appear if at least one worker did *Right*, making the project succeed. The posterior probability that the leader did *Right* is

$$\begin{aligned} \rho_A|\text{Success} &= \text{pr(A Right|Success)} \\ &= \frac{\text{pr(Success|A Right)pr(A Right)}}{\text{pr(Success|A Right)pr(A Right)+pr(Success|A Wrong)pr(A Wrong)}} \\ &= \frac{\alpha}{\alpha + (1-\alpha)\beta}. \end{aligned} \tag{9}$$

The leader's expected reputation depends both on his reputation if the project succeeded and on the probability it succeeds. We have

$$E\rho_A = \text{pr(Success)}\left(\text{pr (A Right|Success)}\right) \tag{10}$$

$$
\begin{aligned}
&= (1-(1-\alpha)(1-\beta))\left(\frac{\alpha}{\alpha+(1-\alpha)\beta}\right) \qquad (11)\\
&= \alpha
\end{aligned}
$$

As in the weakest-link game wth linear compensation, the co-worker's quality is irrelevant in determining a leader's expected reputation. One interpretation is that a leader has no incentive to pay a premium to work with a high-quality person; he would rather invest in improving his own quality than in spending anything at all on improving his co-worker's quality.

5.1 Threshold compensation

Let the leader win the reward only if the posterior probability that he did *Right* exceeds R. If the project failed, the leader is known to have done *Wrong* and he wins no reward. If the project succeeded, the leader wins a reward if

$$\rho_A \mid \text{Success} = \frac{\alpha}{\alpha+(1-\alpha)\beta} > R. \qquad (12)$$

Rewriting (12) shows that the leader wins nothing if his co-worker's ability is too high:

$$\beta < \frac{\alpha(1-R)}{R(1-\alpha)}. \qquad (13)$$

The critical value of the co-worker's ability decreases with the threshold

$$\frac{\partial\left(\frac{\alpha(1-R)}{R(1-\alpha)}\right)}{\partial R} = \frac{-\alpha}{R^2(1-\alpha)} < 0.$$

As with weakest-link production, the leader may prefer a co-worker with low ability.

5.2 Contests

Consider the same type of contest as described in Section 4.3. Recall that in the weakest-link setting with both projects failing, the leader with the weaker co-worker has a higher posterior probability of having done *Right.* Under best-shot production both contestants are known to have done *Wrong* if both teams fail; then each wins with probability 1/2. When instead both projects succeed the leader with the inferior co-worker is judged to be the better one. Leader 1 may consequently win under the following conditions:

Both projects succeed. If leader 1's co-worker is weaker than leader 2's co-worker, then leader 1 wins.

Project 1 succeeded and project 2 failed.

Both projects failed. Leader 1 then wins with probability 1/2.

Each leaders chooses a co-worker, who is either *good* ($\overline{\beta}$) or *bad* ($\underline{\beta}$). Again, let β_i denote the ability of leader i's co-worker. Then leader 1 wins with probability

$$\Pr\left(1 \text{ Wins} \mid \beta_1 = \beta_2\right) = 1/2, \tag{14}$$

$$\Pr\left(1 \text{ Wins} \mid \beta_1 > \beta_2\right) = \left(1 - \frac{(1-\alpha)(1-\beta_1)}{2}\right)(1-\alpha)(1-\beta_2) \tag{15}$$

$$\Pr\left(1 \text{ Wins} \mid \beta_1 < \beta_2\right) = 1 - \left(1 - \frac{(1-\alpha)(1-\beta_2)}{2}\right)(1-\alpha)(1-\beta_1). \tag{16}$$

When (15) exceeds 1/2 and leader 2 has a *bad* co-worker, leader 1 always prefers a *good* co-worker. If (15) exceeds 1/2 then (16) is smaller than 1/2: appointing a *good* co-worker is also a best reply to a *good* co-worker. If instead (15) is smaller than 1/2, then a *bad* co-worker is always the best choice.

Proposition 2. For all values of $\alpha, \underline{\beta}$ and $\overline{\beta}$ a Nash equilibrium in pure strategies exists.

Proof. For leader i, $\overline{\beta}$ is always a best response if $\left(1 - \frac{(1-\alpha)\left(1-\overline{\beta}\right)}{2}\right)(1-\alpha)\left(1-\underline{\beta}\right) \geq 1/2 \geq 1 - \left(1 - \frac{(1-\alpha)\left(1-\overline{\beta}\right)}{2}\right)(1-\alpha)\left(1-\underline{\beta}\right)$. This holds if $\left(1 - \frac{(1-\alpha)\left(1-\overline{\beta}\right)}{2}\right)(1-\alpha)\left(1-\underline{\beta}\right) \geq 1/2$, in which case $\left(\overline{\beta}, \overline{\beta}\right)$ is a Nash equilibrium. Similarly, $\underline{\beta}$ is always a best response if $\left(1 - \frac{(1-\alpha)\left(1-\overline{\beta}\right)}{2}\right)(1-\alpha)\left(1-\underline{\beta}\right) \leq 1/2$, in which case $\left(\underline{\beta}, \overline{\beta}\right)$ is a Nash equilibrium. Hence, for any allowed combination of $\alpha, \underline{\beta}$ and $\overline{\beta}$ a Nash equilibrium in pure strategies exists. ■

Mixed equilibria only exist when the abilities of the leader and the two types of co-workers satisfy (15)=(15)=1/2. Any pair of mixed strategies is then an equilibrium, just as in the weakest-link setting. We thus focus on pure equilibria for the same reason. Notice that (15) decreases in α, is positive when $\alpha = 0$, and is zero when $\alpha = 1$. It follows that (15) is either smaller than 1/2 for all allowed values of α or smaller than 1/2 for high values of α and greater than 1/2 for low values of α. Solving the quadratic equation (15)=1/2 for α gives two solutions, with the smaller one negative. The larger solution is

$$\alpha^B = \frac{-\overline{\beta} + \sqrt{\frac{\left(\overline{\beta}-\underline{\beta}\right)}{1-\underline{\beta}}}}{\left(1-\overline{\beta}\right)}.$$

Notice that α^B is positive if the *bad* co-worker is sufficiently good. Thus

Corollary 2. (i) If $\alpha < \alpha^B$ then $\left(\overline{\beta}, \overline{\beta}\right)$ is the unique equilibrium. (ii) If $\alpha = \alpha^B$ then two pure equilibria exist: $\left(\underline{\beta}, \underline{\beta}\right)$ and $\left(\overline{\beta}, \overline{\beta}\right)$. (iii) if $\alpha > \alpha^B$ then the unique equilibrium is $\left(\underline{\beta}, \underline{\beta}\right)$.

Proof. If $\alpha < \alpha^B$ then $\left(1 - \frac{(1-\alpha)\left(1-\overline{\beta}\right)}{2}\right)(1-\alpha)\left(1-\underline{\beta}\right) > 1/2$ and if $\alpha > \alpha^B$ then $\left(1 - \frac{(1-\alpha)\left(1-\overline{\beta}\right)}{2}\right)(1-\alpha)\left(1-\underline{\beta}\right) < 1/2$. The rest of the proof follows from the proof of Proposition 2.

Corollary 2 mirrors Corollary 1. Here, a *good* leader (with a high α) always chooses a *bad* co-worker; a *bad* leader (with a low α) may choose a *good* or a *bad* co-worker, depending on how *bad* and *good* they are. The basic intuition is that if a contestant is *good* then the project likely succeeds, and this also holds for his rival. In choosing a *bad* co-worker, each of the competing leaders aims to gain in the event both projects succeed. With best-shot production, a *bad* co-worker little reduces the probability of success. For a *bad* leader, who is unlikely to do *Right*, choosing a *good* co-worker much increases the probability of success. This gain exceeds the cost of losing the advantage in the event both projects succeed. If, however, the *bad* co-worker is sufficiently good, then a *bad* leader will also choose a *bad* co-worker.

6 Conclusion

We analyzed several reasonable situations which can make a leader's utility decrease with his co-worker's quality. The result can of course appear for other reasons. For example, Glazer (2001) reaches a conclusion similar to ours—a leader may not want to work with an able co-worker. But the motive there is not the loss of reputation, but the theft of assets. Or, for another example, when labor of person A complements labor of person B, then the marginal product of B and therefore his market wage may fall with A's quality.

But the situations we considered, focusing as they do on reputation, differ. Other things equal, a leader prefers that the project succeed. And were a leader able to keep his co-worker's ability secret, the leader would prefer one with high ability. Indeed, a leader may want an able co-worker whose ability he denigrates.

7 Notation

R Threshold for compensation

α Prior probability that the leader did *Right*

β Prior probability that the co-worker did *Right*

ρ_i Posterior probability that team member i did *Right*

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