Self-Managed Work Teams: An Efficiency-Rationale for Pay-Compression
– Online-Appendix –

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In this appendix we discuss the robustness of our results with respect to the model's assumptions about market structure, compensation, information, and the functional relation between effort and success. We first explain why competition is crucial for our results before extending our model by allowing for: (1) Project success to depend non-linearly on efforts and hence efforts to be inter-dependent; (2) Workers to be heterogeneous in their likelihood to become informed; (3) Information to consist of non-verifiable imperfect signals; (4) Bonuses to be project-specific. It turns out that the conflict between disclosure-incentives and effort-incentives (Observation 1) continues to exist under these modifications. As this conflict constitutes the central driver of our results about pay-compression (Corollary 1) and empowerment (Proposition 3), we contemplate that the main conclusions of our theory hold more generally.

I. Competition

In our model, teams exist within firms (to enable an analysis of delegation) and efficiency emerges as the firm's objective due to the presence of perfect competition in the labor market (zero-profits). This resonates well with the literature on moral hazard in teams where

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team-surplus is maximized subject to budget-balancedness. However, in the absence of perfect competition, it might be more suitable to consider the firm as a principal, maximizing revenue net of compensation subject to the workers' participation constraints.

To fix ideas, assume that workers have a reservation utility normalized to zero. Due to our assumption of limited liability, the principal is unable to extract the workers' surplus via a negative salary. Instead, the principal will offer bonus contracts b_L and b_H to maximize the firm's profit $(1 - b_L - b_H)R$. As workers can always choose to exert zero effort, their participation is thereby guaranteed.

From our analysis in Section 3, it follows that for a standard team, firm profit is proportional to $(1 - b_L - b_H)(\gamma^2 b_L + b_H)$ and is therefore maximized by setting $b_L^{st} = 0$ and $b_H^{st} = \frac{1}{2}$. A profit-maximizing principal would induce a standard team to take effort only on the more decisive task. The reason is similar to the case of perfect competition. Inducing effort on task H is not only less costly but also more beneficial than inducing effort on task L. However, because the principal considers only his private costs of inducing effort (i.e. the reduction in his share of revenue) rather than the social costs, he reduces b_L to zero whereas under competition workers' effort costs are internalized and their convexity makes it optimal to induce efforts on both tasks.

If the principal employs a self-managed work team rather than a standard team, the above conclusion remains unchanged , i.e. $(b_L^*, b_H^*) = (b_L^{st}, b_H^{st}) = (0, \frac{1}{2})$. The reason is that, inducing merely one worker (H) to exert effort is not only optimal for motivation from the principal's point of view, but leads to full disclosure of information, as argued at the beginning of Section 4.1. Interestingly, the presence of a principal allows for an alignment of effort-incentives with disclosure-incentives.

In summary, we can therefore conclude that, for a self-managed work team, competition plays an equally important role as the assumption of budget-balancedness for a standard team. While in standard teams, the presence of a principal (budget-breaker) helps to overcome the free-riding problem, in self-managed work teams it removes the conflict between motivation and adaptation.

II. Technology

Our model assumes a linear relation between individual efforts and the projects' likelihood of success. In the following we relax this assumption by letting

$$R(e_L, e_H, x_n) = \frac{1}{2} r(\Sigma) x_n \qquad \text{with} \qquad \Sigma = \gamma e_L + e_H. \tag{1}$$

The function r is assumed to be increasing and concave and to take values in $[0, 2]$. Note that when workers have identical expectations $\hat{x}_n$ about project n's quality, then equilibrium efforts, $e_L^*(\hat{x}_n)$ and $e_H^*(\hat{x}_n)$, are uniquely defined as the solution to the system of equations

$$\begin{aligned} e_L &= \gamma b_L r'(\Sigma) \hat{x}_n & (2)\\ e_H &= b_H r'(\Sigma) \hat{x}_n. & (3) \end{aligned}$$

Using the firm's zero profit constraint, it must therefore hold that

$$\frac{\Sigma}{r'(\Sigma)} = (b_L \gamma^2 + 1 - b_L) \hat{x}_n. \tag{4}$$

Define the solution to this equation as $\Sigma^*(b_L)$ and note that $\Sigma^*(b_L)$ is decreasing by the concavity of r. Using $\Sigma^*(b_L)$ we can write $e_L^* = \frac{b_L \gamma}{b_L \gamma^2 + 1 - b_L} \Sigma^*(b_L)$ and $e_H^* = \frac{1 - b_L}{b_L \gamma^2 + 1 - b_L} \Sigma^*(b_L)$. If workers have identical expectations $\hat{x}_n$, the surplus-maximizing compensation scheme is thus given by

$$\arg \max_{b_L \in [0,1]} r(\Sigma^*(b_L)) \hat{x}_n - \frac{1}{2} \frac{b_L^2 \gamma^2 + (1 - b_L)^2}{(b_L \gamma^2 + 1 - b_L)^2} \Sigma^*(b_L)^2. \tag{5}$$

Using (4) the first order condition of this maximization problem can be written as

$$\left[1 - \frac{b_L^2 \gamma^2 + (1 - b_L)^2}{b_L \gamma^2 + 1 - b_L}\right] r'(\Sigma^*(b_L)) \hat{x}_n \frac{\partial \Sigma^*(b_L)}{\partial b_L} + \frac{(1 - 2b_L)\gamma^2}{(b_L \gamma^2 + 1 - b_L)^3} \Sigma^*(b_L)^2 = 0. \tag{6}$$

As the first term is negative, for the first order condition to hold, the second term must be positive, i.e. $b_L < \frac{1}{2}$ and hence $b_L < b_H$. In the benchmark of a standard team, workers' expectations about project quality are identical, and take values p or $\hat{x}_Q(a)$. Ex ante, the firm is uncertain which of the two cases will apply but, because setting $b_L < b_H$ would be optimal in both cases, it must hold that $b_L^{st} < b_H^{st}$. This shows that in the benchmark of a standard team, the firm will offer a larger bonus for the more decisive task.

Next, consider the workers' disclosure incentives. Full disclosure is an equilibrium if and only if the following two inequalities are satisfied:

$$U_L^d = b_L r(\gamma e_L^*(p) + e_H^*(p)) \cdot p - \frac{1}{2}e_L^*(p)^2 \geq \max_{e_L} b_L r(\gamma e_L + e_H^*(1))q - \frac{1}{2}e_L^2 = U_L^c \quad (7)$$

$$U_H^d = b_H r(\gamma e_L^*(p) + e_H^*(p)) \cdot p - \frac{1}{2}e_H^*(p)^2 \geq \max_{e_H} b_H r(e_H + \gamma e_L^*(1))q - \frac{1}{2}e_H^2 = U_H^c. \quad (8)$$

From (2) and (3) it follows that $e_L^*(.) = \frac{\gamma b_L}{1-b_L}e_H^*(.)$ and setting $b_L = b_L^d = \frac{1}{1+\gamma^2}$ and $b_H = b_H^d = \frac{\gamma^2}{1+\gamma^2}$ therefore implies that $U_H^d = \gamma^2 U_L^d$ and $U_H^c = \gamma^2 U_L^c$.[1] Hence, $U_L^d \geq U_L^c$ if and only if $U_H^d \geq U_H^c$ or, in other words, disclosure incentives are equalized, $p_L^d = p_H^d$, when $b_L = b_L^d$. As before, the parameter space for which full disclosure constitutes an equilibrium is maximized when the less decisive task receives a larger bonus, i.e. $b_L^d > b_H^d$.

While for technologies such as (1) a closed form solution for the firm's optimal compensation scheme (b_L^*, b_H^*) proves elusive, the above analysis reveals that for a SMWT, optimal incentives for information-sharing, (b_L^d, b_H^d), and optimal incentives for effort, (b_L^{st}, b_H^{st}), can be expected to be opposed quite generally.

III. Information

Our model assumes that in a SMWT, workers are homogeneous with respect to their ability to obtain information and that information consists of verifiable evidence. In this section we show that Observation 1 remains unchanged when these assumptions are relaxed. Disclosure-incentives and effort incentives continue to be opposed diametrically, i.e. $b_L^d = 1 - b_L^{st}$, when the worker assigned to the more decisive task is more likely to become informed and when workers can not only conceal but misrepresent their information. In order to simplify notation, for the remainder we let $\gamma_L = \gamma$ and $\gamma_H = 1$.

[1] To see that $U_H^c = \gamma^2 U_L^c$, transform the maximization variable e_H into $z = \frac{e_H}{\gamma}$ and use the fact that for $b_L = \frac{1}{1+\gamma^2}$, $\gamma e_L^*(1) = e_H^*(1)$.

Heterogeneity

Our model assumed that in a SMWT, either one or the other worker obtains evidence of project Q's low quality with certainty. One may argue that workers assigned to more important tasks are also likely to be better informed. In order to allow for heterogeneity in the workers' informedness, in the following we assume that conditional on $x_Q = q$, each worker receives (independently) evidence of Q's low quality with a certain probability $\pi_i \in (0, 1)$, $i \in \{L, H\}$.

What changes is that when obtaining evidence, workers can no longer deduct that their coworker failed to do so and under full disclosure, workers can no longer be sure that $x_Q = 1$ in the absence of evidence. More specifically, worker i's expectation of Q's quality in the absence of evidence is now given by

$$\hat{x}_Q^i = \frac{(1 - a_j\pi_j)(1 - \pi_i)q + 1}{(1 - a_j\pi_j)(1 - \pi_i) + 1}. \tag{9}$$

Following the same steps as in our analysis in Section 4.1 it is straight forward to show that full disclosure constitutes an equilibrium if and only if $p \geq \max\{p_L^d, p_H^d\}$ with

$$p_i^d \equiv \left[\frac{q\{qb_i\gamma_i^2[2 - \pi_i - \pi_j(1 - \pi_i)] + 2b_j\gamma_j^2[1 + (1 - \pi_j)(1 - \pi_i)q]\}}{(b_i\gamma_i^2 + 2b_j\gamma_j^2)[2 - \pi_i - \pi_j(1 - \pi_i)]}\right]^{1/2}. \tag{10}$$

As before, worker i's full-disclosure threshold p_i^d decreases in his own bonus b_i and increases in his coworker's bonus b_j. Therefore, we again maximize the range of full disclosure by minimizing the maximum of these two thresholds. The range is maximized when the thresholds are just equal which again happens at $b_L = \frac{\gamma_H^2}{\gamma_H^2+\gamma_L^2} = b_L^d$. Hence, our result that information sharing is optimized by awarding a larger bonus to the more important task also holds when worker H is not only more decisive but also better informed.

Signals

In this section we consider the possibility that workers receive unverifiable and imperfect information. In comparison to our model with evidence, two novelties arise. First, workers are able to misrepresent their information and truth-telling becomes the issue. Second, workers are more motivated to exert effort on a given project when their "opinions" agree rather than disagree.

More specifically, we modify our model as follows. Each worker i receives a private, unverifiable, imperfect signal $s_i \in \{q, 1\}$ about project Q's quality. Signals are independent and each signal has the same probability $\sigma \in (\frac{1}{2}, 1)$ of being correct. Workers communicate by sending a message $m_i \in \{q, 1\}$. As signals are unverifiable, workers may misrepresent their information by choosing $m_i \neq s_i$ or simply tell the truth $m_i = s_i$. We modify Assumption 1 by requiring $p > \underline{x}_Q$ rather than $p > q$ with $\underline{x}_Q$ as defined in (11). This insures that project P exhibits a higher (expected) quality than project Q if and only if $s_L = s_H = q$, so that it requires messages $m_L = m_H = q$ for project P to become selected (in a truth-telling equilibrium).

In the following we derive the conditions that have to be satisfied for truth-telling $m_i = s_i$ to constitute an equilibrium. In a truth-telling equilibrium, project Q's (updated) expected quality is given by

$$\hat{x}_Q = \begin{cases} \frac{\sigma^2+(1-\sigma)^2 q}{\sigma^2+(1-\sigma)^2} \equiv \bar{x}_Q & \text{if} \quad s_L = s_H = 1 \\ \frac{1+q}{2} = E[x_Q] & \text{if} \quad s_L \neq s_H \\ \frac{\sigma^2 q+(1-\sigma)^2}{\sigma^2+(1-\sigma)^2} \equiv \underline{x}_Q & \text{if} \quad s_L = s_H = q \end{cases} \tag{11}$$

and worker i with bonus b_i and task-productivity γ_i who expects project n's quality to be $\hat{x}_n^i$ exerts effort $e_i^*(\hat{x}_n^i) = \gamma_i b_i \hat{x}_n^i$. Not surprisingly, workers have no incentive to lie when they observe "good news", $s_i = 1$, but might be tempted to misrepresent "bad news" by issuing $m_i = 1$ upon observation of $s_i = q$. Worker i's payoff from truth-telling $m_i = s_i = q$ is given by

$$\begin{aligned} U_i^t &= \frac{1}{2}[\sigma^2 + (1-\sigma)^2]\left\{b_i[\gamma_i e_i^*(p) + \gamma_j e_j^*(p)]p - \frac{1}{2}e_i^*(p)^2\right\} \\ &\quad +\sigma(1-\sigma)\left\{b_i[\gamma_i e_i^*(E[x_Q]) + \gamma_j e_j^*(E[x_Q])]E[x_Q] - \frac{1}{2}e_i^*(E[x_Q])^2\right\} \end{aligned} \tag{12}$$

whereas lying by issuing $m_i = 1$ when $s_i = q$ gives

$$\begin{aligned} U_i^l &= \frac{1}{2}[\sigma^2 + (1-\sigma)^2]\left\{b_i[\gamma_i e_i^*(\underline{x}_Q) + \gamma_j e_j^*(E[x_Q])]\underline{x}_Q - \frac{1}{2}e_i^*(\underline{x}_Q)^2\right\} \\ &\quad +\sigma(1-\sigma)\left\{b_i[\gamma_i e_i^*(E[x_Q]) + \gamma_j e_j^*(\bar{x}_Q)]E[x_Q] - \frac{1}{2}e_i^*(E[x_Q])^2\right\}. \end{aligned} \tag{13}$$

Truth-telling is optimal for worker i if and only if $U_i^t \geq U_i^l$ or equivalently $p > p_i^d$ with

$$p_i^d = \frac{\frac{1}{2}b_i^2\gamma_i^2\underline{x}_Q^2 + b_i b_j \gamma_j^2 \underline{x}_Q E[x_Q] + \frac{2\sigma(1-\sigma)}{\sigma^2+(1-\sigma)^2} b_i b_j \gamma_j^2 (\bar{x}_Q - E[x_Q])E[x_Q]}{\frac{1}{2}b_i^2\gamma_i^2 + b_i b_j \gamma_j^2}. \tag{14}$$

Truth-telling, $(m_L, m_H) = (s_L, s_H)$, forms an equilibrium if and only if $p \geq \max\{p_L^d, p_H^d\}$. Perhaps surprisingly, the range of parameters for which truth-telling constitutes an equilibrium is again maximized when $b_L = \frac{\gamma_H^2}{\gamma_H^2+\gamma_L^2} = b_L^d$.

Our analysis in this section shows that Observation 1 remains valid in settings with non-verifiable information. In the model with signals the economic mechanisms involved are similar to the ones in the model with evidence. However, there exists one additional mechanism. This mechanism is similar to a subordinate's propensity to conform with the views of his superior (Prendergast, 1993). Each worker has an incentive to issue a message that reinforces rather than contradicts his coworker's signal. Since messages are issued simultaneously and signals are more likely to coincide than to contradict each other, workers therefore have an additional incentive to tell the truth. It is reassuring that Observation 1 remains unchanged even in the presence of such a "propensity to agree".

IV. Compensation

Blanes i Vidal and Möller (2016) have shown that information sharing in teams can be improved when workers are rewarded for the disclosure of "bad news". As in our model, project P is implemented only when bad news about project Q has been disclosed, rewarding success in P more strongly than success in Q should therefore have a positive effect on a worker's disclosure incentive. In our model this possibility was ruled out by the simplifying assumption that bonuses cannot differ across projects. In the following we extend our model by allowing for project-specific bonuses.

Let b_i^Q and b_i^P denote the bonuses rewarded to the worker in charge of task $i \in \{L, H\}$ conditional on the successful execution of project Q and P, respectively. Simplifying notation by $\gamma_L = \gamma$ and $\gamma_H = 1$, worker i's expected payoff from the disclosure of bad news is given by

$$U_i^d = \frac{1}{2} b_i^P [\gamma_i e_i^*(p) + \gamma_j e_j^*(p)] \cdot p - C(e_i^*(p)), \tag{15}$$

whereas concealment leads to the payoff

$$U_i^c \equiv \frac{1}{2} b_i^Q [\gamma_i e_i^*(q) + \gamma_j e_j^*(\hat{x}_Q^j)] \cdot q - C(e_i^*(q)). \tag{16}$$

Following the same steps of analysis as in Section 4.1, we can determine the threshold $p^d = \max\{p_L^d, p_H^d\}$ above which full disclosure constitutes an equilibrium:

$$p_i^d = \sqrt{\frac{b_i^Q}{b_i^P} \frac{\gamma_i^2 b_i^Q q^2 + 2\gamma_j^2 b_j^Q q}{\gamma_i^2 b_i^P + 2\gamma_j^2 b_j^P}}. \tag{17}$$

Making use of project-specific rewards the firm can indeed raise worker *i*'s incentive for disclosure by setting $b_i^P > b_i^Q$. This indicates that in firms with self-managed work teams, project-specific rewards might be optimal and contrasts with the fact that in firms with standard teams project-specific rewards have no bite.

Although information sharing can be improved by use of project-specific rewards, the tension between information sharing and motivation persists. To see this, suppose that for one of the projects, say Q, the firm chooses the bonuses that are optimal for motivation, i.e. $b_L^Q = b_L^{st} = \frac{\gamma_L^2}{\gamma_L^2 + \gamma_H^2}$. Then adaptation is optimized, i.e. p^d is minimized, by setting $b_L^P > b_L^Q$. We can therefore conclude that, although project-specific bonuses generically improve a firm's ability to induce information sharing within self managed work teams, the trade-off between motivation and adaptation tends to persist.

References

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