

# Self-Managed Work Teams: An Efficiency-Rationale for Pay Compression\*

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## Abstract

This paper uncovers a novel mechanism through which pay dispersion can have a negative effect on firm performance, even in the absence of equity or fairness considerations. We use a stylized model of a self-managed work team to show that, when team-work involves heterogeneous tasks, the provision of incentives to exert effort conflicts with the provision of incentives to share information relevant for decision-making. Pay dispersion deteriorates information sharing as it induces workers to conceal “bad news” in order to maintain their co-workers motivation. The practical implications of our theory are that team empowerment should go hand in hand with pay compression and that empowerment should be avoided when team production involves strongly heterogeneous tasks.

*JEL classification:* D2; D8; L2

*Keywords:* Teams; Empowerment; Delegation; Information disclosure; Pay dispersion.

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# 1 Introduction

The effect of pay dispersion on individual and organizational performance has been a topic of great interest in the economics and management literature.<sup>1</sup> While incentive- and tournament-theories have advocated the positive motivation- and sorting-aspects of pay dispersion (e.g. Lazear and Rosen, 1981; Lazear, 2000), equity and fairness arguments have been employed to point out its potentially negative consequences for cooperation (e.g. Akerlof and Yellen, 1990; Charness and Kuhn, 2007). Pfeffer and Langton's (1993) finding of the adverse effect of pay dispersion on the productivity of university faculty has spurred empirical research into the relationship. However, results are rather inconclusive ranging from positive (e.g. Hibbs and Locking, 2000; Beaumont and Harris, 2003) to negative (e.g. Bloom, 1999; Yanadori and Cui, 2013) and it has been noted that "*a significant gap in our knowledge concerns the underlying mechanisms or the mediators between pay dispersion and outcomes at the organizational, team, and individual levels.*" (Shaw, 2014, p.538). This paper contributes to filling this gap by examining the consequences of pay dispersion for the performance of self-managed work teams.

Self-managed work teams constitute an increasingly prevalent organizational form. For instance, Lazear and Shaw (2007) document that in 1999, 72% of U.S. firms employed self-managed work teams, an increase from 27% in 1987. Self-managed work teams differ from standard teams in that they decide on a wide range of issues such as staffing, scheduling and budgeting, and therefore enjoy a considerable degree of autonomy in "how to get the job done". Firms thus face the double challenge of providing self managed work teams not only with incentives to exert efforts but also with incentives to share information relevant for decision-making.

The central insight of our theory is that, in self-managed work teams, pay dispersion may have a negative effect on information sharing and hence decision making which counteracts, and potentially dominates, its positive effect on effort. Our theory thus identifies a novel mechanism, through which pay dispersion influences organizational performance, and whose overall effect can be negative, even in the absence of equity or fairness considera-

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<sup>1</sup> See Shaw (2014) for a recent survey.

tions. Besides its potential for informing empirical research our theory might be of interest for practitioners because the identified trade-off has direct implications for organizational design variables, such as team empowerment and task allocation.

The idea that pay dispersion may deteriorate information sharing in teams is in line with an influential study by Beersma et al. (2003) for an experimental setting where team performance depends on both speed (effort) and accuracy (information). The authors find that pay systems that reward all team members equally, have a negative effect on speed but a positive effect on accuracy, “because they promote diffusion of knowledge throughout a team” (Beersma et al., 2003, p.582). A direct implication of this effect is that in firms with self managed work teams the overall effect of pay dispersion on performance should be less positive. Indeed, regressing plant-level productivity on pay dispersion and the extent of use of self-managed work teams, Shaw et al. (2002) find a significant, negative value for the interaction coefficient. Although Shaw et al. (2002) consider an industry where the average use of self-managed work teams is rather low (Trevor et al., 2012), their results are at least indicative of the importance of the mechanism identified by our theory.

In Section 2 we propose a stylized model of a self-managed work team by including a project-selection stage into an otherwise standard team-production framework a la Holmström (1982). A competitive firm hires two workers to jointly choose and execute one out of two mutually exclusive projects,  $P$  and  $Q$ . Workers receive bonuses conditional on project success which depends on project quality and the workers’ non-contractible individual efforts. Project  $Q$  is of uncertain quality and, although  $Q$ ’s quality is higher than  $P$ ’s from an ex-ante perspective, each worker may privately and independently receive “bad news” about  $Q$ . From an individual workers’ viewpoint, information sharing is subject to a trade-off between *adaptation* and *motivation*: On one hand, disclosure of bad news about  $Q$  leads to the adoption of the (ex post) higher quality project  $P$ . On the other hand, concealment of bad news maintains the co-worker’s motivation to exert high effort on project  $Q$ .<sup>2</sup>

The trade-off between adaptation and motivation extends from the individual to the organizational level when workers are assigned to tasks (e.g. product-engineering and product-

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<sup>2</sup>In equilibrium the absence of bad news is understood as either no bad news having been received or bad news having been concealed, i.e. information does not “unravel” as in Milgrom (1981) and the absence of bad news signifies good news about  $Q$ .

marketing) which differ in that effort spent on one task is more decisive for project-success than effort spent on the other. In Section 3 we consider as a benchmark a firm with a *standard team*, where access to information concerning project-quality and the authority to choose the project are restricted to the firm's owner. We show that the efficiency losses from free-riding are minimized by offering a larger bonus to the worker assigned to the *more* decisive task.<sup>3</sup> In contrast, in Section 4 we find that, in a firm with a self-managed work team, information sharing is optimized when a larger bonus is given to the worker assigned to the *less* decisive task. Optimal incentives for information sharing turn out to be diametrically opposed to optimal incentives for effort, because those tasks that are easiest to incentivize via a bonus are precisely those that are easiest to manipulate via the concealment of bad news. As a consequence, the effect of pay dispersion on performance becomes ambiguous: Pay dispersion increases efforts but may result in a break-down of information sharing and a *reduction* in the firm's quality of decision-making. This finding contrasts with the common view that team empowerment leads to greater organizational adaptability (Wageman, 1997) but is consistent with case studies emphasizing the importance of communication within self-managed work teams (e.g. Griffin and Hauser, 1992; Cummings, 2004).

A practical implication of the above trade off is that, in self managed work teams, differences in compensation across tasks should be compressed. The fact that corporate partnerships – an extreme example of self managed work teams – have adopted a culture of “equal revenue sharing” can be taken as a sign that this recommendation tends to match with observed practice. For example, Encinosa et al. (2007) investigate medical practices and find that 54% of partnerships consisting of three to five doctors share revenues equally, with equal sharing still playing an important role (24%) in larger organizations (16 to 24 members).<sup>4</sup>

Finally, in Section 5 we turn attention to the issue of empowerment by comparing the performance of firms using self-managed work teams with firms employing standard teams.

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<sup>3</sup>This is in line with the free-riding evidence provided by Gaynor et al. (2004). Investigating the cost-saving efforts of physicians facing a group-based incentive to meet a common budgetary target, they find that physicians with a larger number of patients (whose cost-saving efforts are more decisive for meeting the target) are promised a greater share of the bonus.

<sup>4</sup>Farrell and Scotchmer (1988) discuss the practice, common within law firms, to equalize shares across partners of similar seniority. In many countries, equal revenue-sharing constitutes the default in the corporate definition of a partnership (e.g. United States Uniform Partnership Act §18a).

To make our analysis non-trivial, we assume that the firm owner obtains less information than what could be obtained via the use of a self-managed work team *on aggregate*, for example because the owner lacks expertise in one of the two tasks. We show that firms should opt for empowerment when team production involves tasks that are sufficiently homogeneous and that environments where adaptation is important allow for self-managed work teams with a larger degree of task heterogeneity. Again, this finding resonates well with the fact that corporate partnerships are most frequently employed in industries where “production” involves rather homogeneous tasks (e.g. law, accounting, medical). It is in line with the idea that “*high-performing self managed teams often have a built-in capability to rotate roles*”, as task rotation serves to make team production more homogenous (Magpili and Pazos, 2018, p.79). We hope that our theory will trigger further empirical research into the determinants of team empowerment.

In summary, this article identifies a novel channel – information sharing in self managed work teams - through which pay dispersion can have a negative impact on firm performance. Our results are driven by a conflict between disclosure and effort incentives which, as we argue in the Conclusions, persists for technologies of production and information structures more general than those in our stylized model. The practical implications of our theory are that team empowerment should go hand in hand with pay compression and that self-management should be avoided for teams working on strongly heterogeneous tasks.

*Related literature.* Our theory contributes to the literature on team organization. Typically, this literature takes the team’s technology of production as exogenously given (e.g. McAfee and McMillan, 1991; Che and Yoo, 2001; Rayo, 2007; Franco et al., 2011). While we have in common with other models of team production the coexistence of moral hazard and asymmetric information (e.g. Hermalin, 1998; Gershkov et al., 2016), the distinguishing feature of our framework is the introduction of a project-selection stage. In a similar setting, Blanes i Vidal and Möller (2016) use a mechanism design approach to determine the optimal institution and size for a *homogeneous* team, taking as given the team’s power to take decisions. In contrast, we focus on the implications of task-heterogeneity for the team’s compensation and investigate the optimal allocation of authority. This complementary approach allows for

novel insights about the organization of team production.

More generally, our model relates to a recent but growing literature recognizing the importance of information disclosure and communication in decentralized organizations. While this literature's focus has been on a trade-off between adaptation and coordination (e.g. Alonso et al., 2008; Hagenbach and Koessler, 2016) our model examines organizational responses to the existence of a trade-off between adaptation and motivation. Gershkov and Szentes (2009) and Campbell et al. (2014) share with us the feature that members of a group may fail to communicate their information in order to affect their colleagues' motivation to exert effort. However, in their models effort refers to the acquisition of decision-relevant information rather than the execution of a joint project. Moreover, while in Campbell et al. (2014) communication failures induce delay in decisions, in our setting they lead to the adoption of suboptimal projects. Consequences of the trade-off between adaptation and motivation have been identified for settings where decision-making and execution lie at different levels of the organizational hierarchy (Zábojník, 2002; Blanes i Vidal and Möller, 2007; Landier et al., 2009). In contrast, we determine the optimal organization for a team where decisions are taken and implemented *jointly* by the same group of individuals.

Because our notion of team empowerment entails the decentralization of an organization's information, our theory relates to the literature on team leadership initiated by Hermlin (1998). Komai et al. (2007) show that restricting information to a single individual – the team leader – can overcome a team's free-riding problem and induce efficient effort levels. In our setting, empowerment increases the efficiency losses from free-riding, but improves the team's project choice. The latter effect is absent in the leadership literature where the team's technology is taken as given.

Finally, our result that team-work may constitute an obstacle for the delegation of decision-making authority is novel to the literature on delegation. Dating back to the seminal contribution by Aghion and Tirole (1997), this literature advocated the idea of an informational advantage being harnessed through delegation. However, while in delegation models information typically resides at the bottom of the firm's hierarchy, in our framework, information is best thought of as originating from the top (e.g. industry data, demand forecasts, financial accounts). Through empowerment, workers are given access to the firm's information and

an informational advantage arises due to the team members' *combined* expertise to derive insights from this information. This is in line with the self-managed work teams observed in practice where decision-making authority and access to decision-relevant information typically go hand in hand (Yeatts and Hyten, 1998). The delegation literature has emphasized that delegation can be advantageous because it frees managerial capacity (Geanakoplos and Milgrom, 1991), encourages subordinates' information acquisition (Aghion and Tirole, 1997), induces more timely decisions (Radner, 1993), and avoids problems of strategic communication (Dessein, 2002). On the negative side, delegation may entail a loss of control (Aghion and Tirole, 1997) or lead to mis-coordinated actions (Alonso et al., 2008). We add to this list of disadvantages the efficiency losses from augmented free-riding, which may arise when authority is delegated not to a single decision-maker but to a team.<sup>5</sup>

## 2 Setup

Consider a firm that employs two workers to collaborate in a team. Each worker performs a task  $i \in \{L, H\}$  (e.g. engineering and marketing) by exerting individual, non-contractible effort  $e_i \in [0, 1]$  with costs

$$C(e_i) = \frac{1}{4}e_i^2. \quad (1)$$

There are two, *mutually exclusive*, projects  $n \in \{Q, P\}$ . A project generates a revenue normalized to one when it turns out to be successful. Otherwise, project revenue is zero. A project's quality  $x_n \in (0, 1]$  together with the workers' efforts,  $e_L$  and  $e_H$ , determine the project's likelihood

$$R(e_L, e_H, x_n) = \frac{1}{2}(\gamma e_L + e_H)x_n \quad (2)$$

of success.<sup>6</sup> The parameter  $\gamma \in (0, 1)$  accounts for the fact that task  $H$  is more decisive for the project's outcome than task  $L$ . We will determine to what extent the firm's profit-maximizing

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<sup>5</sup>Delegation to a team shares some features with the literature on collusive lobbying (Martimort and Semenov, 2008) where a policy maker designs mechanisms to aggregate information that is dispersed across several interest groups.

<sup>6</sup>The fact that  $R$  is assumed to be linear in efforts simplifies our exposition but is not necessary for our results. We discuss the robustness of our results with respect to more general functional forms in the Conclusions.



compensation policy should reflect these differences in task importance or productivity.

There exists uncertainty about project  $Q$ 's quality. We model this by assuming that  $Q$ 's quality is either high (and normalized to),  $x_Q = 1$ , or low,  $x_Q = q \in (0, 1)$ . Ex-ante, both realizations are equally likely and we denote project  $Q$ 's expected quality by  $E[x_Q] = \frac{1+q}{2}$ .<sup>7</sup> For simplicity, project  $P$ 's quality is assumed to be certain and is denoted as  $x_P = p$ .<sup>8</sup> While for  $p < q$ , project  $Q$  would be unconditionally superior, our subsequent analysis will show that for  $p > E[x_Q]$ , no trade-off between adaptation and motivation would exist. The following parametric restriction is thus necessary for our analysis to be non-trivial:

**Assumption 1.**  $p \in (q, E[x_Q])$ .

Assumption 1 requires that ex ante project  $Q$  is superior but, conditional on project  $Q$ 's quality being low, project  $P$  exhibits a higher quality. The difference  $p - q$  will be denoted as the *value of adaptation*.

*Information and Organization.* The firm is endowed with an information system that, conditional on  $x_Q = q$ , contains (hard) evidence of project  $Q$ 's low quality.<sup>9</sup> For time or other resource constraints, access to the firm's information system is restricted to the decision-making party and therefore depends on the firm's organization. If the firm employs a *self-managed work team (SMWT)*, both workers are given access to the firm's information system and jointly determine which project becomes selected. We assume that, conditional on  $x_Q = q$ , one of the workers, picked uniformly random, obtains evidence of project  $Q$ 's low quality from the firm's information system, while the other worker remains uninformed.<sup>10</sup> For example, low quality may be caused by a problem concerning engineering or marketing and is identified only by the worker in charge of the respective task. Information sharing thus requires that the informed worker discloses his evidence to the uninformed worker. Alterna-

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<sup>7</sup>The assumption that high and low quality are equally likely only simplifies the exposition and can be relaxed.

<sup>8</sup>Alternatively, project qualities could be assumed to be stochastically independent and  $p = E[x_P]$  be used to denote project  $P$ 's expected quality.

<sup>9</sup>Assuming that the information system may contain only "bad news" but no "good news" simplifies the analysis but is not important for our results. Evidence for  $x_Q = 1$  would be disclosed in every equilibrium because, unlike bad news, it is beneficial for both adaptation *and* motivation.

<sup>10</sup>This simplistic information structure is chosen for tractability. A discussion of more general information structures can be found in the Conclusions.



tively, the firm may employ a *standard team* by restricting access to the firm’s information system and the authority to select a project to the firm’s owner. We assume that, conditional on  $x_Q = q$ , the firm owner obtains evidence of project  $Q$ ’s low quality from the firm’s information system with probability  $\phi$ . In order to make the issue of empowerment, that is the choice between a SMWT and a standard team, non-trivial, we assume that the owner is less informed than a SMWT *on aggregate*:

**Assumption 2.**  $\phi < 1$ .

For example, the owner might fail to be an expert in engineering *and* marketing, making it harder for him to detect problems in at least one of the team’s tasks.

*Compensation.* The firm operates in a competitive labor market and compensates workers via bonus payments conditional on the project’s payoff.<sup>11</sup> We assume that workers are protected by limited liability, i.e. their compensation cannot be negative. In order to provide workers with incentives to exert effort, the firm therefore offers zero compensation in case of project-failure and positive compensation, i.e. a bonus, in case of project-success. Most generally, the size of these bonuses could depend on the identity of the chosen project and on whether or not evidence has been disclosed.<sup>12</sup> Here we abstract from this possibility by assuming that, although team output (zero or one) is observable, the firm refrains from monitoring the precise way in which it has been achieved. This assumption resonates well with our focus on SMWTs whose decision-making is meant to be subject to a considerable degree of autonomy. It implies that the firm is restricted to the choice of a *compensation policy*  $(b_L, b_H)$  specifying, for each task  $i$ , a bonus  $b_i \geq 0$  conditional on project-success, awarded to the worker performing the respective task. The difference in bonuses across tasks,  $|b_H - b_L|$ , will serve as our measure of *pay dispersion*.

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<sup>11</sup>Competition is important for our results as it ensures that bonus payments are chosen to maximize the team’s surplus, i.e. the difference between (expected) revenue and (aggregate) effort costs. The resulting zero-profit condition plays the role of the budget-balancedness assumption in models of moral hazard in teams, making our results comparable to this literature. A discussion of the effects of the existence of a budget-breaker (principal) is postponed until our Conclusions.

<sup>12</sup>Using a mechanism design approach, Blanes i Vidal and Möller (2016) have shown that it might be optimal to bias a team’s decision-making and to reward the disclosure of bad news. A discussion of the effects of project-specific bonuses can be found in the Online Appendix.

*Timing.* Production involves four stages. In Stage 1, the firm chooses its organizational structure (SMWT versus standard team) and sets its bonuses  $(b_L, b_H)$ . In Stage 2, workers decide whether to join the firm. In Stage 3, the party who obtained bad news about project  $Q$  (if any) decides whether to disclose or conceal the corresponding evidence. Project  $P$  is selected if bad news has been disclosed, otherwise project  $Q$  is chosen.<sup>13</sup> Finally, in Stage 4, workers choose their efforts (simultaneously) and receive the promised bonuses when the selected project turns out to be successful. Our solution concept is Perfect Bayesian Equilibrium. It requires that workers form beliefs about the selected project's quality which are consistent with the informed party's disclosure strategy and that effort-choices are sequentially rational given those beliefs.

*Worker payoffs.* Given the firm's compensation scheme  $(b_L, b_H)$ , if workers exert efforts  $e_L$  and  $e_H$  on project  $n \in \{Q, P\}$  with quality  $x_n$ , then worker  $i$ 's expected payoff is given by

$$U_i = b_i R(e_L, e_H, x_n) - C(e_i). \quad (3)$$

If workers  $L$  and  $H$  expect project  $n$ 's quality to be  $\hat{x}_n^L$  and  $\hat{x}_n^H$  (updated expectations may not be identical when workers' information differs), their expected payoffs are therefore maximized by exerting efforts

$$e_L^*(\hat{x}_n^L) = \gamma b_L \hat{x}_n^L \quad \text{and} \quad e_H^*(\hat{x}_n^H) = b_H \hat{x}_n^H \quad (4)$$

respectively. Worker  $i$ 's (maximized) expected payoff when the project's (actual) quality is  $x_n$  and workers expect the project's quality to be given by  $\hat{x}_n^L$  and  $\hat{x}_n^H$  is then given by

$$U_i(x_n, \hat{x}_n^L, \hat{x}_n^H) = b_i R(e_L^*(\hat{x}_n^L), e_H^*(\hat{x}_n^H), x_n) - C(e_i^*(\hat{x}_n^i)). \quad (5)$$

*Firm objective.* Following the literature on pay compression (e.g. Lazear, 1989), we assume that the firm operates in a competitive labor market. As a consequence, the firm will maximize workers' expected payoff from joining the firm subject to a zero profit condition. As profits are zero when expected compensation  $E[R] \cdot (b_L + b_H)$  equals expected revenue

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<sup>13</sup>Note that our model abstracts from the precise way in which a SMWT decides which project to select. It is straight forward to show that the assumed project selection rule in Stage 3 can be rationalized as the outcome of an arbitrary voting procedure.

$E[R] \cdot 1$ , the firm's maximization problem is constrained by the condition that

$$b_L + b_H = 1. \quad (6)$$

The exact specification of the firm's problem depends on its organizational structure. In the following section we start our analysis by considering as a benchmark a firm with a standard team before we turn our attention to SMWTs in Section 4.

### 3 Benchmark: Standard teams

In this section we consider as a benchmark a firm with a standard team, where project-choice and access to the firm's information system are restricted to the owner. From the firm's zero profit condition (6) it follows that, at the project selection stage, the owner will be indifferent between projects  $P$  and  $Q$ . Ex ante, the owner can therefore commit (credibly) to an "adaptation policy"  $a \in [0, 1]$ , specifying the probability of selecting project  $P$  in response to bad news about project  $Q$ . The workers' updated expectations about project  $Q$ 's quality conditional on  $Q$  being selected are then given by

$$\hat{x}_Q(a) = \frac{1 + (1 - \phi a)q}{2 - \phi a} \quad (7)$$

and workers' expected payoffs from joining the firm with a standard team can be written as

$$E^{st}[U_i] = \frac{1}{2}\phi a U_i(p, p, p) + (1 - \frac{1}{2}\phi a) U_i(\hat{x}_Q(a), \hat{x}_Q(a), \hat{x}_Q(a)). \quad (8)$$

The first term refers to the case where project  $Q$ 's quality is low and the owner has observed bad news and reacted to it by adopting project  $P$ . In all other cases, project  $Q$  becomes selected and workers expect its quality to be given by  $\hat{x}_Q(a)$ . The firm chooses its adaptation policy  $a$  and its compensation policy  $(b_L, b_H)$  to solve

$$\max_{a \in [0, 1], b_L, b_H \geq 0} E^{st}[U_L] + E^{st}[U_H] \quad (9)$$

subject to the zero profit constraint (6). Substituting (4) and (5) the firm's objective becomes

$$E^{st}[U_L] + E^{st}[U_H] = \left[ \left(1 - \frac{1}{2}\phi a\right) \hat{x}_Q(a)^2 + \frac{1}{2}\phi a p^2 \right] \left[ \gamma^2 b_L \left(1 - \frac{b_L}{2}\right) + b_H \left(1 - \frac{b_H}{2}\right) \right]. \quad (10)$$

From (10) we see that the firm's optimal choices of adaptation policy  $a$  and compensation policy  $(b_L, b_H)$  are independent. When decision-making and execution lie at different levels of the firm's hierarchy, the firm's problem can be decomposed and its solution is straight forward:

**Proposition 1.** *If the firm employs a standard team, it will commit to full adaptation, i.e.  $a^{st} = 1$ , and offer a larger bonus to the worker employed at the more decisive task by setting  $(b_L^{st}, b_H^{st}) = (\frac{\gamma^2}{1+\gamma^2}, \frac{1}{1+\gamma^2})$ .*

*Proof:* See Appendix.

To understand the first part of Proposition 1 note that an increase in the firm's probability of adaptation,  $a$ , has two effects. First, it increases the likelihood with which the firm chooses the project with the highest quality. Second, it brings the workers' expectations of project  $Q$ 's quality in the absence of bad news,  $\hat{x}_Q(a)$ , closer to its true value  $\hat{x}_Q(1)$ . Both effects contribute positively to the workers' expected payoff from working at the firm. The intuition for the second part is simple and, as we argue in the Conclusions, extends to more general technologies of team production. The worker exercising the more decisive task  $H$  is given a larger bonus, i.e.  $b_H^{st} > b_L^{st}$ , because his effort is both more productive and easier to incentivize. Due to the convexity of effort costs, not all incentives are given to the same task, i.e.  $b_H^{st} < 1$ .

## 4 Self-managed work teams

In a firm with a SMWT, workers determine the firm's project upon their observation of the firm's information system. A worker who obtained evidence of project  $Q$ 's low quality can either disclose his evidence and induce the adoption of the superior project  $P$ , or conceal his evidence in order to maintain his uninformed co-workers motivation to work on project  $Q$ . Let  $a_i \in [0, 1]$  denote worker  $i$ 's equilibrium probability of disclosing bad news (to be determined below), leading to the adoption of project  $P$ . Then from an ex ante viewpoint (before workers learn about project quality) worker  $i$ 's expected payoff from working at the

firm is given by

$$\begin{aligned}
E[U_i] &= \frac{1}{2}U_i(1, \hat{x}_Q^i, \hat{x}_Q^j) + \frac{1}{4}(a_L + a_H)U_i(p, p, p) \\
&+ \frac{1}{4}(1 - a_i)U_i(q, q, \hat{x}_Q^j) + \frac{1}{4}(1 - a_j)U_i(q, \hat{x}_Q^i, q).
\end{aligned} \tag{11}$$

The first term refers to the case where  $Q$ 's quality is high ( $x_Q = 1$ ) and both workers update their beliefs about  $Q$ 's quality in the absence of bad news using Bayes rule:

$$\hat{x}_Q^i = \frac{2 + (1 - a_j)q}{3 - a_j}. \tag{12}$$

For the second term,  $Q$ 's quality is low ( $x_Q = q$ ) and the team has reacted by adopting the better project  $P$  upon the disclosure of bad news by worker  $L$  or  $H$  respectively. Finally, terms three and four refer to the cases where bad news about  $Q$  has been received but concealed by one of the workers  $i$ , leaving the other worker  $j \neq i$  with unrealistically high expectations  $\hat{x}_Q^j > E[x_Q]$  about project  $Q$ 's quality.

In contrast to the case of a standard team analyzed in the previous section, the firm cannot influence project choice directly but must induce adaptation ( $a_L, a_H$ ) by its SMWT via its compensation policy ( $b_L, b_H$ ). Hence the firm must solve

$$\max_{b_L, b_H \geq 0} E[U_L] + E[U_H] \tag{13}$$

subject to the zero profit constraint (6). In comparison to the case of a standard team, the firm's problem is complicated by the fact that, in a SMWT, workers' expected utilities  $E[U_L]$  and  $E[U_H]$  depend on the compensation policy ( $b_L, b_H$ ) through its influence on efforts and the adaptation probabilities  $a_L$  and  $a_H$ . The determination and comparative statics of these adaptation probabilities is the subject of the following Section 4.1.

## 4.1 Information sharing

In a SMWT, workers may hold private information about project-quality and information sharing becomes an issue. In this section, we consider the workers' disclosure choices  $a_L$  and  $a_H$ , given the firm's choice of compensation policy ( $b_L, b_H$ ).

For this purpose, first note that the firm can induce full information disclosure,  $a_L = a_H = 1$ , rather trivially by setting  $b_L = 0$  or  $b_H = 0$ . For example, if  $b_L = 0$  worker  $L$  will exert zero effort  $e_L^* = 0$  independently of project-choice, which means that worker  $H$  has no incentive to manipulate his colleague's beliefs by concealing information. The same holds for worker  $L$  because his expected payoff is always zero. However, inducing information disclosure in this extreme way turns out to be sub-optimal because, as we have seen in Section 3, team surplus is higher when efforts are induced from both workers rather than from only one.

More relevant is therefore the remaining case where both bonuses are strictly positive. To shed light on the workers' incentives to share information, consider worker  $L$  after obtaining bad news (for worker  $H$  an analogous argument applies). If the worker discloses his evidence, project  $P$  becomes selected. Hence, worker  $L$ 's expected payoff from disclosure (indexed by "d") is

$$U_L^d \equiv \frac{1}{2}b_L[\gamma e_L^*(p) + e_H^*(p)] \cdot p - C(e_L^*(p)). \quad (14)$$

Alternatively, worker  $L$  may conceal his evidence of project  $Q$ 's low quality, in order to maintain or, more precisely, improve (see below) worker  $H$ 's motivation to exert effort on project  $Q$ . If worker  $L$  conceals his bad news then the team will work on project  $Q$ , and worker  $L$ 's expected payoff from concealment (indexed by "c") is

$$U_L^c \equiv \frac{1}{2}b_L[\gamma e_L^*(q) + e_H^*(\hat{x}_Q^H)] \cdot q - C(e_L^*(q)). \quad (15)$$

From the definition of worker  $H$ 's updated belief in (12) it is easy to see that, independently of worker  $L$ 's equilibrium disclosure probability  $a_L$ , it holds that  $\hat{x}_Q^H > E[x_Q]$ , i.e. the absence of bad news constitutes good news with respect to project  $Q$ 's quality. Given that ex-ante project  $Q$  was perceived to be the better project, i.e.  $E[x_Q] > p$ , it follows from (4) that  $e_H^*(\hat{x}_Q^H) > e_H^*(p)$ . Hence, after receiving bad news, worker  $L$  faces the following trade-off: Disclosure enables the selection of the better project ( $p > q$ ) but concealment induces higher effort from the uninformed co-worker ( $e_H^*(\hat{x}_Q^H) > e_H^*(p)$ ). In equilibrium, it has to hold that  $a_L = 1$  if  $U_L^d > U_L^c$ ,  $a_L = 0$  if  $U_L^d < U_L^c$ , and  $a_L \in [0, 1]$  if  $U_L^d = U_L^c$ . From these conditions, and their analogues for worker  $H$ , the equilibrium disclosure probabilities  $a_L$  and  $a_H$  are readily determined. Denoting task productivities by  $\gamma_L = \gamma$  and  $\gamma_H = 1$  and defining for

$i, j \in \{L, H\}, i \neq j$ , the thresholds  $p_i^c$  and  $p_i^d$  by

$$q < p_i^c \equiv \sqrt{\frac{3\gamma_i^2 b_i q^2 + 2\gamma_j^2 b_j q(2+q)}{3\gamma_i^2 b_i + 6\gamma_j^2 b_j}} < p_i^d \equiv \sqrt{\frac{\gamma_i^2 b_i q^2 + 2\gamma_j^2 b_j q}{\gamma_i^2 b_i + 2\gamma_j^2 b_j}} < E[x_Q] \quad (16)$$

we obtain the following result:

**Lemma 1.** *In a firm with a self-managed work team, worker  $i \in \{L, H\}$  will disclose evidence with probability*

$$a_i^* = \begin{cases} 0 & \text{if } p \leq p_i^c \\ \frac{3\gamma_i^2 b_i + 2\gamma_j^2 b_j [1 - 2\frac{q-p_i^c}{p_i^c - q^2}]}{\gamma_i^2 b_i + 2\gamma_j^2 b_j} \in (0, 1) & \text{if } p \in (p_i^c, p_i^d) \\ 1 & \text{if } p \geq p_i^d. \end{cases} \quad (17)$$

A worker's propensity to share information increases with his own bonus but decreases with his coworker's bonus, i.e.  $\frac{dp_i^c}{db_i} < 0 < \frac{dp_i^c}{db_j}$ ,  $\frac{dp_i^d}{db_i} < 0 < \frac{dp_i^d}{db_j}$ , and  $\frac{da_i}{db_j} < 0 < \frac{da_i}{db_i}$  for all  $p \in (p_i^c, p_i^d)$ . When bonuses are equal, the worker exercising the less decisive task has a weaker incentive to disclose, i.e. for  $b_L = b_H$  it holds that  $a_L^* \leq a_H^*$ , with strict inequality for all  $p \in (p_H^c, p_L^d)$ .

*Proof:* See Appendix.

Because an increase in project  $P$ 's quality tilts the payoff comparison in favor of disclosure, information sharing is increasing in  $p$ . This can be seen in Figure 1 which plots the workers' equilibrium disclosure probabilities,  $a_L^*$  and  $a_H^*$ , as a function of project  $P$ 's quality, for the case of equal bonuses  $b_L = b_H = \frac{1}{2}$ . To understand why, for equal bonuses, worker  $L$  has a weaker incentive to disclose than worker  $H$ , observe from (4) that for  $b_L = b_H$ , worker  $H$ 's effort is more reactive to his beliefs about the project's quality. Hence, worker  $L$ 's benefit from motivating worker  $H$  (via concealment of bad news) is larger than worker  $H$ 's benefit from motivating worker  $L$ . Concealment is more beneficial for worker  $L$  because worker  $H$ 's effort, besides being more productive, is easier to manipulate.

Lemma 1 shows that in SMWTs, bonuses not only affect the workers' incentives to exert effort but also their propensity to share (project-relevant) information. A higher bonus induces a worker to share his private information with a higher probability. However, given that the firm's zero-profit condition puts a constraint (6) on the set of available bonuses, raising the disclosure-incentive of one worker may lead to a reduction in the disclosure-incentive of the other.



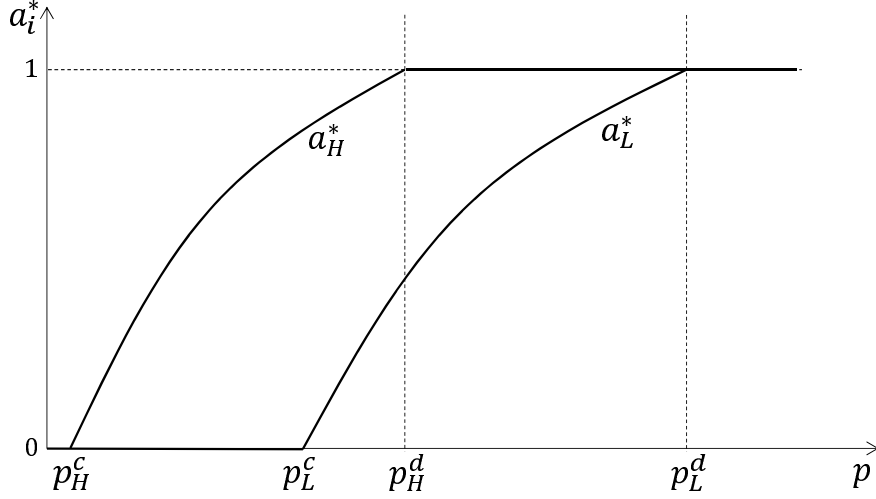


Figure 1: **Information sharing.** Probabilities of disclosure,  $a_L^*$  and  $a_H^*$ , for workers  $L$  and  $H$  in a self-managed work team as a function of project  $P$ 's quality  $p$ . The plot depicts the case where bonuses are  $b_L = b_H = \frac{1}{2}$ .

In order to build intuition for our subsequent results, it is useful to consider the bonus scheme  $(b_L^d, b_H^d)$  that, while inducing efforts from both workers, maximizes the range of project quality parameters for which full disclosure,  $a_L^* = a_H^* = 1$ , constitutes an equilibrium. Full disclosure comprises an important benchmark, because only under full disclosure the firm is able to adopt the highest quality project with certainty. In order to determine  $(b_L^d, b_H^d)$ , note from Lemma 1 that both workers share their information (with certainty) if and only if

$$p \geq p^d \equiv \max\{p_L^d, p_H^d\}. \quad (18)$$

Increasing  $b_L$  while reducing  $b_H$  by the same amount improves disclosure by worker  $L$  ( $p_L^d$  decreases) but deteriorates disclosure of worker  $H$  ( $p_H^d$  increases). The set of parameters for which full disclosure is an equilibrium becomes maximal when disclosure incentives are equalized, i.e. when  $(b_L, b_H)$  is such that  $p_L^d = p_H^d$ . Solving this equation together with (6) gives us the following:

**Observation 1.** *Amongst all compensation policies  $(b_L, b_H)$  that satisfy the firm's zero-profit constraint (6) and induce efforts from both workers  $(b_L, b_H > 0)$ ,  $(b_L^d, b_H^d) = (\frac{1}{1+\gamma^2}, \frac{\gamma^2}{1+\gamma^2})$*

guarantees full disclosure in the widest range of parameters by minimizing  $p^d$ . In self-managed work teams, effort incentives and disclosure incentives are diametrically opposed in the sense that  $b_L^d = b_H^{st}$  and  $b_H^d = b_L^{st}$ .

*Proof:* See Appendix.

Observation 1 has an important implication for the relation between pay dispersion and firm performance. It shows that rewarding more decisive/productive tasks with higher bonuses ( $b_H > b_L$ ) can be detrimental for information sharing and hence decision-making. Our theory thus explains the precise mechanism (information sharing) through which team cooperation may suffer from pay dispersion.

Observation 1 further suggests that in SMWTs, the provision of incentives to share information (adaptation) and incentives to exert effort (motivation) stand in conflict with each other. In particular, in a firm with a SMWT a trade-off between motivation and adaptation may exist not only at the individual but also at the institutional level. In the following we consider how the firm will resolve this trade-off optimally.

## 4.2 Compensation

Having determined the probabilities  $a_L^*$  and  $a_H^*$  with which workers disclose their private information in a SMWT, we are now ready to characterize the firm's profit-maximizing compensation scheme  $(b_L^*, b_H^*)$  as the solution to (13). A question of particular interest is whether the firm will sacrifice adaptation for motivation by choosing a compensation scheme that induces less than full information sharing. For this question to be sensible, project  $P$ 's quality must be sufficiently high for full adaptation to be attainable, i.e. it must hold that

$$p \geq p_L^d(b_L^d, b_H^d) = \sqrt{\frac{q(q+2)}{3}} \equiv \underline{p} \in (q, E[x_Q]). \quad (19)$$

If this inequality was reversed, full disclosure could not be induced by any compensation policy. The following proposition characterizes the firm's profit-maximizing compensation policy for all  $p \in [\underline{p}, E[x_Q])$  and in the limit where  $p \rightarrow q$ , before we comment on the remaining cases  $p \in (q, \underline{p})$  below.

**Proposition 2.** *A firm employing a self-managed work team will choose its compensation policy  $(b_L^*, b_H^*)$  as follows:*

- *If  $p \geq \sqrt{\frac{q(\gamma^4 q + 2)}{\gamma^4 + 2}} \equiv \bar{p}$  then  $(b_L^*, b_H^*) = (b_L^{st}, b_H^{st})$ , inducing full adaptation,  $a_L^* = a_H^* = 1$ .*
- *If  $p \in [\bar{p}, \tilde{p})$  then  $(b_L^*, b_H^*) = (\frac{2(q-p^2)}{2(q-p^2)+\gamma^2(p^2-q^2)}, \frac{\gamma^2(p^2-q^2)}{2(q-p^2)+\gamma^2(p^2-q^2)})$ , inducing full adaptation,  $a_L^* = a_H^* = 1$ .*
- *If  $p \in [\underline{p}, \tilde{p})$  then  $b_L^* = 1 - b_H^* \in (b_L^{st}, \frac{2(p^2-q)}{2(p^2-q)-\gamma^2(p^2-q^2)})$ , inducing only partial adaptation,  $a_L^* < a_H^* = 1$ .*
- *If  $p \rightarrow q$  then  $(b_L^*, b_H^*) \rightarrow (b_L^{st}, b_H^{st})$ , inducing no adaptation at all,  $a_L^* = a_H^* = 0$ .*

*The threshold  $\tilde{p}$  is strictly larger than  $\underline{p}$  if and only if  $\gamma < \underline{\gamma}(q) \equiv \sqrt{\frac{2(q^2+3q+2)}{q^2+4q+7}}$ , i.e. when tasks are sufficiently heterogeneous, the firm will induce only partial adaptation (for some  $p$ ) even though full adaptation is attainable.*

*Proof:* See Appendix.

Figure 2 visualizes Proposition 2 with a focus on the extent of adaptation induced by the firm's profit-maximizing compensation policy. When project  $P$  is of very high quality, the workers' incentives for concealment are rather weak and the firm is able to induce full adaptation by offering the same compensation policy as in the case of a standard team. This happens when even under  $(b_L^{st}, b_H^{st})$ , worker  $L$  chooses full disclosure  $a_L^* = 1$ , i.e. for  $p \geq p_L^d(b_L^{st}, b_H^{st}) = \bar{p}$ . In this range, inducing full information aggregation comes at zero cost, that is, from an institutional viewpoint, the trade-off between adaptation and motivation is absent.

More interestingly, for intermediate project qualities  $p \in (\underline{p}, \bar{p})$  the trade-off between adaptation and motivation causes the firm to compromise between the policy optimal for motivation,  $(b_L^{st}, b_H^{st})$ , and the policy optimal for adaptation,  $(b_L^d, b_H^d)$ . Inducing full adaptation turns out to be optimal for  $p \in [\bar{p}, \tilde{p})$  while for  $p \in [\underline{p}, \tilde{p})$  full adaptation becomes too costly. The fact that partial adaptation can be optimal might seem surprising because it entails the possibility that the team works on a project even in the presence of evidence of its inferior quality. This is due to the fact that, by the nature of team-production, efforts are inefficiently low. As a consequence, boosting motivation by inducing uninformed workers

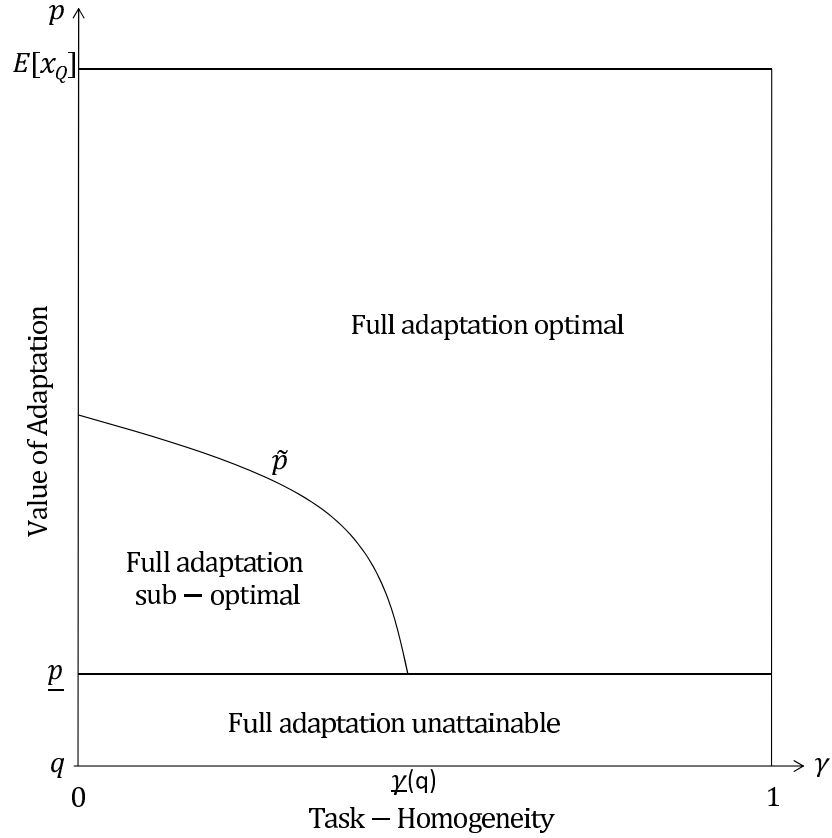


Figure 2: **Adaptation.** Characterization of the self-managed work team’s degree of adaptation under the firm’s profit-maximizing compensation policy  $(b_L^*, b_H^*)$  in dependence of the value of adaptation,  $p - q$  (for  $q$  held fixed), and the degree of homogeneity of team production,  $\gamma$ .

to have unreasonably high expectations can be optimal not only from the viewpoint of an individual worker but also for the firm as a whole.

Finally, when project  $P$ ’s quality drops below  $\underline{p}$ , full disclosure becomes unattainable for the firm. In the limit where  $p \rightarrow q$ , adaptation ceases to have any value and the firm will resort to the compensation-policy that minimizes the efficiency losses from free-riding, i.e.  $(b_L^*, b_H^*) \rightarrow (b_L^{st}, b_H^{st})$ , inducing zero adaptation,  $a_L^* = a_H^* = 0$ . For values of  $p \in (q, \underline{p})$ , the firm will induce partial adaptation or none. In this range, a closed form solution for the firm’s optimal compensation policy cannot be obtained but we contemplate (and have

confirmed numerically) that  $(b_L^*, b_H^*)$  must lie in between  $(b_L^{st}, b_H^{st})$  and  $(b_L^d, b_H^d)$ .

Comparing the firm's profit-maximizing compensation scheme in Proposition 2 with the benchmark in Proposition 1, we obtain the following corollary:

**Corollary 1.** *In a firm with a self-managed work team, the profit-maximizing compensation policy exhibits pay compression relative to the benchmark of a firm with a standard team. In particular:*

$$|b_H^* - b_L^*| \leq b_H^{st} - b_L^{st} \quad (20)$$

for all  $p \in [\underline{p}, E[x_Q]]$  with strict inequality for all  $p \in (\underline{p}, \bar{p})$ .

*Proof:* See Appendix.

The intuition for this result is as follows. When self-managed team production entails tasks that differ in their productivity, optimal motivation and optimal adaptation stand in conflict with each other. Motivation is maximized when the more productive task is offered a larger bonus. In contrast, adaptation is optimized when the more productive task is given a smaller bonus. A firm employing a SMWT chooses its compensation policy to balance these two effects, making bonuses become more equalized relative to a firm with a standard team.

Note that in (20) we have accounted for the possibility that  $b_L^* > b_H^*$ , i.e. in a firm with a SMWT, the less productive task might be offered a higher bonus. This happens when the value of adaptation  $p - q$  is high enough for full adaptation to be desirable from the firm's viewpoint but too low for worker  $L$  to be induced to share his information by the prospect of a bonus of  $b_L \leq \frac{1}{2}$ .

Our analysis in this section has shown that in SMWTs information aggregation might be a problem and that a profit-maximizing firm might choose to mitigate its workers' tendency to conceal private information by offering a more balanced compensation scheme. However, due to its negative effect on motivation, pay compression is costly for the firm and it is therefore not clear whether the firm would like to use a SMWT or instead opt for standard team production. This issue will be the subject of the following section.

## 5 Empowerment

Consider a firm's choice between standard team production and employing a SMWT. Delegating decision-making authority to the team is beneficial because, on aggregate, the team is able to make a more informed decision. However, as we have shown in the previous section, information aggregation may not come for free but can be costly when it requires the firm to compress its compensation scheme.

When team production involves tasks that are strongly heterogeneous, inducing information aggregation requires a large degree of pay compression and is too costly for delegation to be optimal. For the remainder we therefore restrict attention to the non-trivial case where tasks are not too heterogeneous. In particular, we restrict attention to the case where  $\gamma \geq \underline{\gamma}(q)$ , which allows us to express the workers' expected utilities in closed form.

Proposition 2 has shown that for sufficiently high values of adaptation,  $p \geq \bar{p}$ , workers will share their private information even in the absence of pay compression. In this case, SMWTs dominate standard teams trivially, due to their informational advantage. In contrast, for  $p < \bar{p}$  it follows from Proposition 2 (and  $\gamma \geq \underline{\gamma}(q)$ ) that the firm would induce a SMWT to fully adapt by compressing workers' pay to

$$(b_L^*, b_H^*) = \left( \frac{2(q - p^2)}{2(q - p^2) + \gamma^2(p^2 - q^2)}, \frac{\gamma^2(p^2 - q^2)}{2(q - p^2) + \gamma^2(p^2 - q^2)} \right) \quad (21)$$

and the workers' expected utility in a SMWT would be given by

$$E[U_L] + E[U_H] = \left[ \frac{1}{2} + \frac{1}{2}p^2 \right] \left[ \gamma^2 b_L^* + b_H^* - \frac{1}{2}(\gamma b_L^*)^2 - \frac{1}{2}(b_H^*)^2 \right]. \quad (22)$$

If the firm employed standard team production instead, it would offer

$$(b_L^{st}, b_H^{st}) = \left( \frac{\gamma^2}{1 + \gamma^2}, \frac{1}{1 + \gamma^2} \right) \quad (23)$$

and the workers' expected utility would be given by

$$E^{st}[U_L] + E^{st}[U_H] = \left[ \frac{[1 + (1 - \phi)q]^2}{2(2 - \phi)} + \frac{\phi}{2}p^2 \right] \left[ \gamma^2 b_L^{st} + b_H^{st} - \frac{1}{2}(\gamma b_L^{st})^2 - \frac{1}{2}(b_H^{st})^2 \right]. \quad (24)$$

The comparison between (22) and (24) reveals that the choice between a SMWT and a standard team is again driven by a trade-off between adaptation and motivation. The firm employing a SMWT achieves better project choices (the first term in (22) is larger than the first term in (24)) at the cost of sub-optimal effort-incentives (the second term in (22) is smaller than the second term in (24)). Empowerment is optimal when the loss in effort-incentives that results from the pay compression necessary for information aggregation is small compared to the gain from using the team's superior (aggregate) information.

Our next result summarizes the conditions under which firms should empower their teams by delegating decision-making authority downwards in their hierarchy. In order to render the firm's delegation-problem non-trivial, Proposition 3 requires that the owner's informedness  $\phi$  is above some threshold  $\underline{\phi}(q)$  (characterized in the proof in the Appendix). This guarantees that the team's informational advantage is not so large as to rule out the use of a standard team all together.

**Proposition 3.** *Suppose that  $\phi > \underline{\phi}(q)$ . There exists a threshold  $\gamma^* \in (\underline{\gamma}(q), 1)$  such that the following holds:*

1. *The firm will employ a self managed work team when tasks are rather homogeneous, i.e.  $\gamma \in [\gamma^*, 1)$  but use a standard team when tasks are rather heterogeneous, i.e.  $\gamma \in [\underline{\gamma}(q), \gamma^*)$ .*
2. *The threshold  $\gamma^*$  is decreasing in  $p$  and increasing in  $\phi$ , i.e. environments where adaptation is important and where the team's informational advantage is large allow for self managed work teams with a larger degree of task heterogeneity.*

*Proof:* See Appendix.

The firm's optimal choice between a standard team and a SMWT is depicted in Figure 3. As can be seen from the figure, SMWTs are optimal when the degree of task-heterogeneity is relatively low and the value of adaptation is relatively high. If team production involves tasks with diverging influence on the team's project-success, then incentives that are optimal for motivation differ strongly from incentives that are optimal for information aggregation. Inducing information sharing within a SMWT then becomes rather costly and the firm may refrain from empowerment and use a standard team instead.



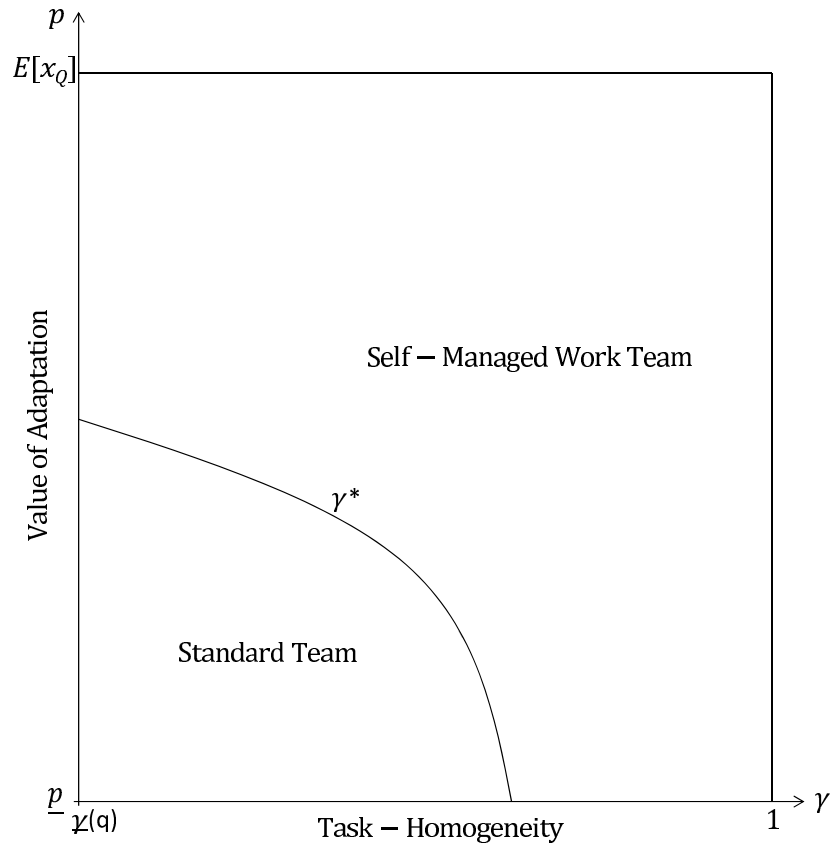


Figure 3: **Empowerment.** Characterization of the firm’s optimal choice between a standard team and a self-managed work team in dependence of the value of adaptation,  $p - q$  (for  $q$  held fixed), and the degree of homogeneity of team production,  $\gamma$ .

Note that our model allows for the interpretation of task-heterogeneity as differences in workers’ productivity/ability. In light of this interpretation, our finding that team-heterogeneity constitutes a challenge for (self-directed) team production contrasts with the view that heterogeneity can be beneficial as it allows low ability workers to learn from their high ability peers (Hamilton et al., 2003).

## 6 Conclusions

In this article we have developed a stylized model of a self-managed work team that helped us to uncover a novel mechanism – information sharing – through which pay dispersion can have a detrimental effect on organizational performance. Before we summarize our main results we briefly discuss the robustness of this mechanism with respect to the model’s assumptions about market structure, information, and the functional relation between effort and success. Details can be found in the Online Appendix.

Our analysis was simplified by the assumption that project-success depends linearly on individual efforts which implied that efforts were independent. A natural question to ask is whether motivation and information sharing continue to conflict with each other when efforts are interdependent. In order to investigate this issue we have generalized (2) to  $R(e_L, e_H, x_n) = \frac{1}{2}r(\gamma e_L + e_H)x_n$  with  $r(\cdot)$  being an increasing and concave function. Although a closed form solution for the firm’s optimal compensation scheme  $(b_L^*, b_H^*)$  is unavailable in this case, we have been able to show that  $b_L^{st} < b_H^{st}$  and  $b_L^d > b_H^d$ , i.e. optimal effort incentives and optimal disclosure incentives continue to be opposed. For more general functional forms the comparative statics of the equilibrium efforts become ambiguous and the tension between motivation and information sharing might become mitigated. In particular, when tasks are strongly complementary it might be optimal to provide balanced compensation even from a purely motivational perspective, because incentivizing one task without incentivizing the other makes no sense. Understanding how effort-complementary affects a team’s incentives to share information is an important issue for future research.

Regarding our model’s information structure, we have assumed that team members are equally likely to become informed and can merely conceal but never misrepresent their information. A practically relevant extension is to allow the worker in charge of the more decisive task to also be better informed. We have confirmed that Observation 1 continues to hold in such a scenario. Similarly, allowing team members’ information to consist of unverifiable signals rather than verifiable evidence leaves this result intact. This is reassuring because in a model with signals, workers have a propensity to agree (Prendergast, 1993), which, given that signals are more likely to coincide with each other, reinforces their incentives to reveal the truth. Correlation between signals would augment the propensity to agree

and we therefore expect the workers' disclosure incentives to be increasing in the degree of signal correlation. Hence, as information sharing ceases to be necessary it also ceases to be a problem, or in other words, information sharing is most problematic when it is most vital.

Finally, while our results extend beyond the simple technology and information structure of our model, the presence of perfect competition in the labor market turns out to be crucial as it makes the team's surplus coincide with the firm's objective. Alternatively, we may consider the firm as a principal, maximizing revenue net of compensation, subject to the workers' participation constraints. In our setting, it then becomes optimal for motivation to induce effort from the more decisive worker only, and hence, as noted in Section 4.1, information sharing is no longer an issue. While in standard teams, a principal (budget-breaker) helps to overcome the free-riding problem, in self-managed work teams a principal can remove the conflict between motivation and adaptation.

In summary, this paper contributes to our understanding of the relationship between pay dispersion and organizational performance, by showing that pay dispersion may deteriorate information sharing in self managed work teams. The practical implications are that the delegation of authority to a team should go hand in hand with pay compression and empowerment should be avoided when team production involves strongly heterogeneous tasks.

## Appendix: Proofs

*Proof of Proposition 1.* Substituting the constraint  $b_H = 1 - b_L$  and using the definitions

$$A(\phi) \equiv \frac{[1 + (1 - \phi)q]^2}{2(2 - \phi)} + \frac{\phi}{2}p^2, \quad (25)$$

$$M(b_L) \equiv \gamma^2 b_L + 1 - b_L - \frac{1}{2}(\gamma b_L)^2 - \frac{1}{2}(1 - b_L)^2 = \frac{1}{2} + \gamma^2 b_L - \frac{1}{2}(1 + \gamma^2)b_L^2 \quad (26)$$

the firm's maximization program can be written as

$$\max_{a, b_L \in [0, 1]} A(a\phi)M(b_L). \quad (27)$$

Note that  $\frac{dA}{d\phi} > 0$  because from  $p > q$  it follows that

$$\frac{dA}{d\phi} = \frac{(1 + q - \phi q)(1 - 3q + \phi q)}{2(2 - \phi)^2} + \frac{p^2}{2} > \frac{(1 + q - \phi q)(1 - 3q + \phi q)}{2(2 - \phi)^2} + \frac{q^2}{2} = \frac{(1 - q)^2}{2(2 - \phi)^2}. \quad (28)$$

Hence the firm's objective is maximized by setting  $a^{st} = 1$ . Moreover,

$$\frac{dM}{db_L} = \gamma^2 - (1 + \gamma^2)b_L \quad \text{and} \quad \frac{d^2M}{db_L^2} = -1 - \gamma^2 < 0 \quad (29)$$

imply that the firm's objective is maximized by setting  $b_L^{st} = \frac{\gamma^2}{1+\gamma^2}$  and hence  $b_H^{st} = \frac{1}{1+\gamma^2}$ .  $\square$

*Proof of Lemma 1.* Consider worker  $L$ . Substitute equilibrium efforts (4) into (14) and (15). Note that  $a_L$  influences  $U_L^c$  via its effect on worker  $H$ 's beliefs  $\hat{x}_Q^H$ . Now solve  $U_L^d = U_L^c$  for  $a_L$  to determine the  $a_L^* \in (0, 1)$  that makes worker  $L$  indifferent between disclosure and concealment. A solution  $a_L^* \in (0, 1)$  exists and is given by (17) if and only if  $p \in (p_L^c, p_L^d)$ . For worker  $H$ ,  $a_H^*$  can be derived analogously.

To see that  $p_i^d$  and  $p_i^c$  are decreasing in worker  $i$ 's own bonus  $b_i$  and increasing in his co-worker's bonus  $b_j$  note that

$$\frac{d(p_i^d)^2}{db_i} = -\frac{2\gamma_i^2\gamma_j^2b_jq(1-q)}{(\gamma_i^2b_i + 2\gamma_j^2b_j)^2} = -\frac{b_i}{b_j} \frac{d(p_i^d)^2}{db_j} < 0, \quad (30)$$

$$\frac{\partial(p_i^c)^2}{db_i} = -\frac{12\gamma_i^2\gamma_j^2b_jq(1-q)}{(3\gamma_i^2b_i + 6\gamma_j^2b_j)^2} = -\frac{b_i}{b_j} \frac{d(p_i^c)^2}{db_j} < 0. \quad (31)$$

For  $p \in (p_i^c, p_i^d)$  we have

$$\frac{da_i}{db_i} = \frac{4\gamma_i^2\gamma_j^2b_jq(1-q)}{(\gamma_i^2b_i + 2\gamma_j^2b_j)^2(p^2 - q^2)} = -\frac{b_i}{b_j} \frac{da_i}{db_j} > 0. \quad (32)$$

Finally, consider the case where bonuses are equal, i.e.  $b_L = b_H$ . With  $\gamma_L = \gamma$  and  $\gamma_H = 1$  we have  $p_L^d - p_H^d > 0$  if and only if

$$\frac{\gamma^2q^2 + 2q}{\gamma^2 + 2} - \frac{q^2 + 2\gamma^2q}{1 + 2\gamma^2} > 0 \Leftrightarrow 2(1 - \gamma^4)(1 - q)q > 0 \quad (33)$$

and  $p_L^c - p_H^c > 0$  if and only if

$$\frac{3\gamma^2q^2 + 2q(2 + q)}{3\gamma^2 + 6} - \frac{3q^2 + 2\gamma^2q(1 + q)}{3 + 6\gamma^2} > 0 \Leftrightarrow 12(1 - \gamma^4)(1 - q)q > 0. \quad (34)$$

Moreover, for  $a_L^*, a_H^* \in (0, 1)$  we get

$$a_H^* - a_L^* = \frac{4(1 - \gamma^4)q(1 - q)}{(1 + 2\gamma^2)(2 + \gamma^2)(p^2 - q^2)} > 0. \quad (35)$$

This proves that for  $b_L = b_H$ ,  $a_L^*$  and  $a_H^*$  look as depicted in Figure 1.  $\square$

*Proof of Observation 1.* Let  $b_L = b \in [0, 1]$  and  $b_H = 1 - b$  so that  $(b_L, b_H)$  satisfies the zero profit constraint (6). From Lemma 1 we know that for  $b = \frac{1}{2}$ , it holds that  $p_L^d > p_H^d$  and that increasing  $b$  reduces  $p_L^d$  but increases  $p_H^d$ , leading to an increase in  $p^d = \max\{p_L^d, p_H^d\}$ .  $p^d$  is maximized when the two thresholds become identical. From  $p_L^d = p_H^d$  it follows that  $b = \frac{1}{1+\gamma^2}$ .  $\square$

*Proof of Proposition 2.* Let  $b_L = b \in [0, 1]$  and  $b_H = 1 - b$  so that  $(b_L, b_H)$  satisfies the zero profit constraint (6). For  $p \geq \underline{p}$ , equilibrium disclosure probabilities are as follows:  $0 < a_L^* < a_H^* = 1$  for  $b \in (0, \bar{b})$ ,  $a_L^* = a_H^* = 1$  for  $b \in [\underline{b}, \bar{b}]$ , and  $0 < a_H^* < a_L^* = 1$  for  $b \in (\bar{b}, 1)$ . To see this note that for  $b = 0$ ,  $p_L^c = \underline{p}$  and  $\frac{dp_L^c}{db} < 0$  imply that  $a_L^* > 0$  for all  $b \in (0, 1]$ . Similarly, for  $b = 1$ ,  $p_H^c = \underline{p}$  and  $\frac{dp_H^c}{db} > 0$  imply that  $a_H^* > 0$  for all  $b \in [0, 1)$ . The thresholds  $\underline{b}$  and  $\bar{b}$  follow from solving  $a_L^* = 1$  and  $a_H^* = 1$  for  $b$  and are given by

$$\underline{b} = \frac{2(q - p^2)}{2(q - p^2) + \gamma^2(p^2 - q^2)} < \frac{p^2 - q^2}{p^2 - q^2 + 2\gamma^2(q - p^2)} = \bar{b}. \quad (36)$$

Note that  $0 < \underline{b} < \bar{b} < 1$  if and only if  $p < \sqrt{q}$ . For  $p \geq \sqrt{q}$ ,  $\underline{b} = 0$  and  $\bar{b} = 1$ , i.e. full disclosure is an equilibrium independently of the firm's compensation scheme. Our proof consists of three steps. First, we show that, out of all compensation schemes that induce full disclosure, the firm's objective is maximized by the one that minimizes the bonus given to worker  $L$ . Second, we show that for any compensation scheme that induces worker  $H$  to mix between disclosure and concealment there exists a compensation scheme that induces worker  $L$  to mix while increasing the firm's objective. Finally, we determine the conditions under which the firm prefers to induce full disclosure rather than allowing worker  $L$  to mix.

*Step 1:*  $\underline{b} = \arg \max_{b \in [\underline{b}, \bar{b}]} E[U_L] + E[U_H]$ . To see this, note that for  $b \in [\underline{b}, \bar{b}]$ ,  $(a_L^*, a_H^*) = (1, 1)$  and  $E[U_L] + E[U_H] = \frac{1}{2}(1 + p^2)M(b)$  with  $M$  as defined in (26) in the proof of Proposition 1. There we have shown that  $M$  is strictly concave and maximized at  $b = b_L^{st}$ . As  $b_L^{st} < \underline{b}$  for all  $p < \bar{p}$ , it follows that  $E[U_L] + E[U_H]$  is strictly decreasing in  $[\underline{b}, \bar{b}]$ .

*Step 2:* For every  $b \in (\bar{b}, 1]$  there exists  $b' \in [0, \underline{b})$  such that  $E[U_L] + E[U_H]$  is strictly larger under policy  $(b', 1 - b')$  than under policy  $(b, 1 - b)$ . To see this, note that we can choose  $b'$  such that  $a_L^*(b') = a_H^*(b)$  by setting  $b' = \frac{1-b}{1-b+b\gamma^4}$ . Inducing mixing by worker  $L$  rather than worker  $H$  raises the workers' aggregate utility,  $E[U_L] + E[U_H]$ , because it comes

at the same loss of project quality, but leads to a greater gain in terms of motivation, because the more productive worker's effort is more reactive with respect to his beliefs about project quality.

*Step 3:* Suppose that  $p < \sqrt{q}$  so that  $0 < \underline{b} < \bar{b} < 1$ . Then there exists a  $\hat{p} \in (\underline{p}, \bar{p})$  such that  $\underline{b} = \arg \max_{b \in [0, \underline{b}]} E[U_L] + E[U_H]$  if and only if  $p \geq \hat{p}$ . To prove this we substitute  $a_H^* = 1$  and  $a_L^* = \frac{3\gamma^2 b + 2(1-b)[1-2\frac{q-p^2}{p^2-q}]}{\gamma^2 b + 2(1-b)}$  into (11) and show that the resulting function  $E[U_L] + E[U_H]$  is concave in  $b$  and non-decreasing in  $b$  at  $b = \underline{b}$  if and only if  $p \geq \hat{p}$ . For concavity, note that at  $p = \underline{p}$ ,

$$\frac{\partial^2 E[U_L] + E[U_H]}{\partial b^2} = \frac{5T_1(b)}{4q[b\gamma^2 + 2(1-b)]^3} \quad (37)$$

where

$$T_1(1) = -\frac{4}{15}q\gamma^6[(3\gamma^2 - 4q + 6)q + \gamma^2(1 - q^2) + 1] < 0 \quad (38)$$

$$\frac{\partial T_1}{\partial b}\Big|_{b=1} = \frac{4}{5}q\gamma^4(\gamma^2 + 1)[(\gamma^2 + 1)q^2 + 3(1 - \gamma^2)q + 2 - \gamma^2] > 0 \quad (39)$$

and

$$\frac{\partial^2 T_1}{\partial b^2} = -\frac{8}{5}[b\gamma^2 + 2(1-b)]q(2 - \gamma^2)(\gamma^2 + 1)[(1 + \gamma^2)q^2 + 3q(1 - \gamma^2) + 2 - \gamma^2] \quad (40)$$

is negative for all  $b \in [0, 1]$ . Moreover,

$$\frac{\partial^3 E[U_L] + E[U_H]}{\partial b^2 \partial p} = -\frac{5p[2 - (2 - \gamma^2)b]^3[(\gamma^2 + \frac{2}{5})q + \frac{1}{5}(2 - \gamma^2)]}{2q[b\gamma^2 + 2(1-b)]^3} < 0. \quad (41)$$

Hence we have shown that  $\frac{\partial^2 E[U_L] + E[U_H]}{\partial b^2}$  is negative at  $p = \underline{p}$  and strictly decreasing in  $p$  which implies that  $\frac{\partial^2 E[U_L] + E[U_H]}{\partial b^2} < 0$  for all  $p \geq \underline{p}$ . To see that  $E[U_L] + E[U_H]$  is non-decreasing in  $b$  at  $b = \underline{b}$  if and only if  $p \geq \hat{p}$ , define:

$$T_2(z) \equiv 8q(1 - q)[2(q - z) + \gamma^2(z - q^2)] \frac{\partial E[U_L] + E[U_H]}{\partial b}\Big|_{b=\underline{b}} \quad (42)$$

with  $z = p^2$ . Since  $z \in [\underline{p}^2, q]$ ,  $\frac{\partial E[U_L] + E[U_H]}{\partial b}\Big|_{b=\underline{b}}$  is positive if and only if  $T_2(z)$  is positive. Note that  $T_2(z)$  is increasing in  $z$  for  $z \geq \underline{p}$  because its first derivative is convex,

$$\frac{\partial^3 T_2(z)}{\partial z^3} = 18\gamma^2(2 - \gamma^2) > 0, \quad (43)$$

and already increasing and positive at  $z = \underline{p}^2$ ,

$$\frac{\partial^2 T_2(\underline{p}^2)}{\partial z^2} = 2(1-q)[(8+\gamma^4)(1+q) - 6\gamma^2] > 0 \quad (44)$$

$$\frac{\partial T_2(\underline{p}^2)}{\partial z} = \frac{4}{3}q(1-q^2)[(4-\gamma^4)q + 4\gamma^4 + 2 - \frac{3}{2}\gamma^2(1-q)] > 0. \quad (45)$$

Also note that for  $p = \bar{p}$ ,

$$T_2(\bar{p}^2) = \frac{8q^2(1-q)^3(1+\gamma^2)\gamma^4[1+2\gamma^2+\gamma^6+\frac{1}{2}\gamma^4(1+3q)]}{(\gamma^4+2)^3} > 0 \quad (46)$$

and that for  $p = \underline{p}$ ,

$$T_2(\underline{p}^2) = \frac{4}{9}(1+\gamma^2)q^2(1-q)^2[7\gamma^2-4-(2-\gamma^2)q^2-(6-4\gamma^2)q] \geq 0 \quad (47)$$

if and only if  $\gamma \geq \underline{\gamma}(q)$ . Hence, there exists a  $\hat{p} < \bar{p}$  such that  $\frac{\partial E[U_L]+E[U_H]}{\partial b}|_{b=\underline{b}} > 0$  and hence  $\arg \max_{b \in [0, \underline{b}]} E[U_L] + E[U_H] = \underline{b}$  for all  $p \in (\hat{p}, \bar{p})$  whereas  $\frac{\partial E[U_L]+E[U_H]}{\partial b}|_{b=\underline{b}} < 0$  and hence  $\arg \max_{b \in [0, \underline{b}]} E[U_L] + E[U_H] < \underline{b}$  for all  $p \in [\underline{p}, \hat{p})$ . If  $\gamma \geq \underline{\gamma}(q)$  then  $\hat{p} = \underline{p}$ , otherwise  $\hat{p} \in (\underline{p}, \bar{p})$ .  $\square$

*Proof of Corollary 1.* The result follows from the fact that  $b_H^*$  is increasing in  $p$  and becomes identical to  $b_H^{st}$  for  $p = \bar{p}$ .  $\square$

*Proof of Proposition 3.* Using the functions  $A$  and  $M$  defined in the proof of Proposition 1, the difference  $F \equiv E[U_L] + E[U_H] - E^{st}[U_L] - E^{st}[U_H]$  can be written as

$$F = A(1)M(b_L^*) - A(\phi)M(b_L^{st}). \quad (48)$$

The proof uses the Implicit Function Theorem and proceeds in four steps.

Step 1: Show that  $\frac{dF}{d\phi} < 0$  and that  $F = 0$  implies that  $\frac{dF}{dp} > 0$ . The first part is immediate from the fact that  $\frac{dA}{d\phi} > 0$  (see 28). To see the second part, first note that

$$\frac{dF}{dp} = M(b_L^*)p + \frac{1}{2}(1+p^2)\frac{dM(b_L^*)}{db_L}\frac{db_L^*}{dp} - M(b_L^{st})\phi p > M(b_L^*)p - M(b_L^{st})\phi p \quad (49)$$



because  $M$  is a strictly concave function that is maximized at  $b_L^{st} < b_L^*$  and

$$\frac{db_L^*}{dp} = -\frac{4\gamma^2 pq(1-q)}{[2(p^2 - q) - \gamma^2(p^2 - q^2)]^2} < 0. \quad (50)$$

From  $F(p) = 0$  we can then substitute to obtain

$$M(b_L^*)p - M(b_L^{st})\phi p = M(b_L^{st})\frac{p}{1+p^2} \left[ \frac{[1 + (1-\phi)q]^2}{(2-\phi)} - \phi \right] > 0 \quad (51)$$

where the last inequality follows from  $q > 0$  and  $\phi \in (0, 1)$ .

Step 2: Show that  $\frac{dF}{d\gamma} > 0$ . To see this note that  $\frac{dM(b_L^*)}{db_L} < 0$  and  $\frac{db_L^*}{d\gamma} < 0$  imply that

$$\frac{dM(b_L^*)}{d\gamma} = \frac{dM(b_L^*)}{db_L} \frac{db_L^*}{d\gamma} + \frac{\partial M(b_L^*)}{\partial \gamma} > 2\gamma b_L^*(1 - b_L^*) \quad (52)$$

whereas

$$\frac{dM(b_L^{st})}{d\gamma} = \frac{\partial M(b_L^{st})}{\partial \gamma} = 2\gamma b_L^{st}(1 - b_L^{st}). \quad (53)$$

From Corollary 1 we thus get  $\frac{dM(b_L^*)}{d\gamma} > \frac{dM(b_L^{st})}{d\gamma}$ .  $\frac{dF}{d\gamma} > 0$  then follows from  $A(1) > A(\phi)$ .

Step 3: Show that  $F > 0$  for  $\gamma \rightarrow 1$ . For  $\gamma \rightarrow 1$ ,  $b_L^* \rightarrow b_L^{st}$ . Hence  $F > 0$  follows from  $A(1) > A(\phi)$ .

Step 4: Show that at  $\gamma = \underline{\gamma}$ ,  $F < 0$  if and only if  $\phi > \underline{\phi}$ . To see this, set  $\gamma = \underline{\gamma}$  and  $p = \underline{p}$  and let

$$\underline{\phi} \equiv A^{-1} \left( A(1) \frac{M(b_L^*)}{M(b_L^{st})} \right). \quad (54)$$

Note that because  $\frac{dA}{d\phi} > 0$ ,  $\underline{\phi}$  is well defined. Also note that because  $\gamma = \underline{\gamma}(q)$  and  $p = \underline{p}(q)$  have been substituted,  $\underline{\phi}$  depends on  $q$  only.

□

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