Abstract

Purpose The purpose of this paper is to offer new justification for multiskilling practices such as job rotation and extensive training for broad skills, and explain why there appear to exist complementarity between multiskilling and the delegation of decision authority to workers.

Methodology/approach By developing a new model of incomplete contracting where workers make noncontractable investments in multiple skills, we obtain the key insight that worker investments in firm-specific human capital become strategic substitutes when their skills overlap each other.

Findings The "skill substitution effect" analyzed in this paper induces the following three major results, unless specialization offers a substantial technological advantage: (1) workers' incentives to invest in firm-specific human capital tend to be stronger; (2) the
optimal level of delegation is typically higher; and (3) firms’ ex post profits tend to be higher with multiskilling than with specialization.

**Originality/value of paper** The novel implication of the paper is that multiskilling may be desirable from a firm’s viewpoint even if there are no technological or informational task complementarities among the combined skills, which have been believed to be primary reasons for multiskilling in prior works.

Key words: multiskilling, task complementarities, delegation, job design, wage bargaining, human capital investment

JEL codes: J24, J31, M53, M54
1 Introduction

One of the most drastic changes in economists’ views on job design in the past few decades is their recognition of the gains from multiskilling vis-a-vis specialization.\textsuperscript{1} The idea that specialization and division of labor allow more output from a given set of inputs has been embraced by economists because numerous anecdotes (including Adam Smith’s famous description of a pin factory) and historical productivity data supported the proposition. Obviously, a number of economists, including Adam Smith, have discussed the factors that ultimately limit specialization (e.g. size of markets, complementarity among tasks, etc.).\textsuperscript{2} However, scrutinizing tradeoffs affecting the optimal division of labor have become more important recently due to a current trend toward job enlargement.

A number of authors have attempted to explain basic tradeoffs determining job design. Becker and Murphy [6] assert that the degree of specialization is constrained by various costs of coordinating specialized workers who perform complementary tasks and the amount of general knowledge available for each task. A similar view is presented by Bolton and Dewatripont [10], who argue that the benefits of greater specialization in information processing by having more agents team up within the same organizations are partly (and sometimes entirely) offset by the increased costs of communication within the enlarged group of agents. These theories, however, cannot explain why we are observing more workplaces adopting multiskilling practices.

\textsuperscript{1}Other terms such as cross-training, multitasking, job enrichment, and job enlargement are similarly used in the literature. Although these words have slightly different meanings, they are used almost interchangeably to describe a recent trend in job design toward a broader set of tasks and responsibilities assigned and a broader set of skills required for an individual job.

\textsuperscript{2}The way complementarity among tasks determines the degree of specialization has been discussed by authors in the job assignment literature. See Roy [44], MacDonald [37], and Rosen [43] for example.
recently. For example, they imply that falling costs of coordination and communication due to advancement in information technology should encourage specialization, not multiskilling.

Koike [32][33] is perhaps the first author to emphasize the improvement of problem-solving skills as the most important benefit of multiskilling. According to his extensive research of Japanese automobile plants, job rotation and other multiskilling practices prevalent in those plants help workers to understand the whole process and acquire capabilities to respond to productivity and quality issues as they arise in the workplace.\(^3\)  Lindbeck and Snower [36] also focus on a difference in learning patterns between “Tayloristic” (characterized by specialization) and “Holistic” (characterized by multiskilling practices) work organizations. They distinguish two types of learning, “intratask” and “intertask” learning, where the former is traditional learning-by-doing best attained by performing a narrow task, and the latter arises when a worker can use the information and skills acquired at one task to improve his performance at other tasks. Employers then face a tradeoff between returns to specialization, which enhances intratask learning, and returns from task complementarities, which accumulate through intertask learning. They argue that a shift toward Holistic organizations has been driven by four forces, including advances in production technologies promoting technological task complementarities, advances in information technologies promoting informational task complementarities, changes in worker preferences in favor of versatile work, and advances in human capital that make workers more versatile.

Some benefits of multitasking are also mentioned as part of the discussions on complementarities supporting team-based high-performance work systems. Firms adopting a certain

\(^3\)The emphasis on broad skills and decentralization of responsibilities in large Japanese firms have been also noted by other authors, including Cole [13], Aoki [2], Lincoln and Kalleberg [35] and Kagono et al. [29].
bundle of human resource and work practices typically including autonomous teams, contingent compensation, job rotation, extensive training, and worker involvement for quality improvement are found to have experienced substantial improvement in productivity, as well as product and service quality. Common features seen in these workplaces are an emphasis on the development of multiskilled workers, the sharing of information, and the delegation of responsibilities to teams. Milgrom and Roberts [39],[40] offer a coherent theory of complementarities among the firm’s choices of technologies and practices, using the framework of monotone comparative statics. They show that a fall in the costs of flexible manufacturing equipment or of computer-aided design equipment lead to systematic responses including more frequent product reden designs and improvements, speedier delivery, more efforts to reduce setup and changeover costs, etc. These changes in the firm’s incentives are expected to encourage investment in process innovations and to increase the returns to cross training and greater autonomy for workers because the latter two practices are assumed to lower the cost of process innovations. The relative optimality of teamwork or tasksharing has also been extensively analyzed by Holmstrom and Milgrom [22] and Itoh [25], [26], [27].

In this paper, we offer another justification for multiskilling practices, which is distinct from the existing literature in two aspects. First, according to our theory, skill complementarities are not necessary for multiskilling to arise as the optimal practice for firms. In other words, multiskilling may be desirable from a firm’s viewpoint even if there are no technological or informational task complementarities among the combined skills. Second, our framework can

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4See, for example, Ichniowski, Shaw and Prennushi [24]; Cappelli and Neumark [12]; Hamilton, Nickerson and Owan [20]; Boning, Ichniowski, and Shaw [11]; Black and Lynch [8][9]; Bartel [4]; Kato and Morishima [31]; DeVaro [14]; Eriksson [17]; Bayo-Moriones, et. al. [5]; and Zwick [52].
explain why there appear to exist complementarity between multiskilling and the delegation of decision authority to workers, two essential elements in the high-performance work systems as discussed above.

We use the Grossman-Hart-Moore framework of incomplete contracting where neither job design consisting of tasks, decision authority, and skill sets, nor human capital investment are contractible and wages are determined by ex post bargaining. The solution concept we use is the Shapley value. Unlike Grossman and Hart [19] and Hart and Moore [21], the ownership structure is not our concern here.

We show that an organization with a job design that relies on multiskilled workers (henceforth, an $M$-organization) significantly weakens workers’ bargaining power but somewhat paradoxically raises their incentive to acquire firm-specific skills. The key insight provided by the model is that worker investments in firm-specific human capital become strategic substitutes when their skills overlap each other as a result of multiskilling. With this substitutability, it is intuitive that workers’ bargaining power relative to the owner-manager is weaker in the $M$-organization than in one with a specialized work force (henceforth, an $S$-organization), other things being equal. Less intuitive is that workers are more motivated to invest in firm-specific skills in the $M$-organization. This incentive comes from the fact that a worker’s broad skills in the $M$-organization become more valuable when other workers whose skills overlap with the first one are absent. Note that the Shapley value of worker $i$, our solution concept of bargaining outcome, can be expressed as the weighted average of marginal contribution of worker $i$ in all possible subgroups. With skill substitutability, a worker’s broad skills in the $M$-organization tend to be more valuable in small subgroups containing the owner of the firm than in the $S$-organization. As a result, a worker’s wage expressed as the Shapley value tend
to be more sensitive to the accumulation of firm-specific human capital in the M-organization than in the S-organization. To sum up this argument, human capital substitutability in the M-organization lowers the return to bargaining, but raises the elasticity of bargaining returns with respect to human capital investment. Intuitively, workers compete for bargaining power more intensely when their skills overlap than when they don’t.\textsuperscript{56}

One question that needs to be addressed concerning the setup of our theory is whether skill overlapping is in fact what we observe in those organizations that have adopted multiskilling practices. Given the fixed numbers of workers and skills needed, multiskilling seems to require a greater degree of overlapping. One notable example that demonstrates the prevalence of increasingly overlapping skills is autonomous work teams that are perceived as an essential element of the flexible work systems discussed earlier. In a typical autonomous work team, workers make decisions together and coordinate activities, and in order to facilitate such a high level of coordination, team members need to know each other’s job very well and share information. Job rotation is used to make members learn each other’s job. Here, overlapping skills are not just a consequence of multiskilling. Quite the contrary, the latter is introduced to achieve the former. In our theory, whether overlapping skills enhance productivity or not does not matter, but they do generate a “skill substitution effect” which drives all of our results. We believe that many accounts of flexible work systems (see footnote 4 for references) suffice

\textsuperscript{5}One analogy is Bertrand versus Cournot competition. In the former, the sale (wage) is more sensitive to price cuts (human capital investments), but the profit margin (wage level) is lower.

\textsuperscript{6}The work by Rajan and Zingales [47] is also relevant to our research. Their work considers the effects of potential market “competition” between individuals with substitutable human capital on organizational choice, while our analysis looks at the effects of within-firm “competition” among individuals with substitutable human capital.
as evidence of a prevailing tendency toward skill overlapping.

Although the mechanism we find is innovative as an explanation for the rationale for multiskilling practices, a similar mechanism has been identified in other contexts. For example, Edlin and Hermalin [16] analyze the situation where both the principal and the agent invest in an asset that has greater value if owned by the principal than by the agent. They show that, when the principal and agent’s efforts are substitutes, the possibility of renegotiation encourages the agent to overinvest in order to strengthen his bargaining position.

This research is also closely related to that of Stole and Zwiebel [50], which studied how organizational design and technology choice by a firm with no binding employment contracts differ from those of a neoclassical firm with no \textit{ex post} wage bargaining. Our work enriches their model by endogenizing investment in firm-specific human capital and examines how organizational design affects the workers’ skill formation in a firm with no binding employment contracts.

We further extend our framework to analyze managers’ decisions on how much authority they should delegate to the workers. Aghion and Tirole [1] have developed a theory of the allocation of decision rights (formal authority) in situations where the decision-maker, if uninformed, can communicate with the informed party, who in such a case has effective control over decisions (real authority). In their model, the principal can provide more incentives to the agent by delegating formal authority to him (at the cost of losing control) because it raises the agent’s chance of gaining effective real control and thus more private benefit. Similarly, in our model, the delegation of more decision authority motivates workers to invest more because capabilities to make good decisions become more valuable if the workers have more decision rights.
Our “incomplete contract” assumption induces our key insight that the owner-manager typically delegates a less than optimal amount of responsibilities to the workers. Results similar to this have been obtained by Freeman and Lazear [18] and Prendergast [46]. Our novel finding is that the substitutability of worker skills in the M-organization encourages the manager to delegate more decision rights because the marginal wage increase due to delegation is smaller but an increase in the workers’ incentives to acquire skills is greater in the M-organization. For a large set of production technology, the optimal level of delegation is typically higher in the M-organization.

Since our basic model assumes individual bargaining and individual decision making on skill investment, it is natural to ask how collective bargaining and jointly choosing skill investment might affect our results. As Horn and Wolinsky [23] and Stole and Zwiebel [50] have already proved, workers gain by forming a union and engaging in collective bargaining when their human capital stocks are substitutable. So the workers in the M-organization can expropriate more surplus by unionizing \textit{ex post}. However, unionization harms the workers’ incentive to acquire skills because union wage as defined as an outcome of collective bargaining is less sensitive to individual human capital investment. Worker cooperation in choosing skill investment should be encouraged in a unionized firm because it mitigates free-riding, while it should be discouraged in a non-unionized firm because cooperation eliminates the “competition” for bargaining power in the skill investment stage discussed earlier. This implies that workers should not be involved in planning training and should be rotated between teams to discourage cooperation in skill investment in a non-unionized setting, but the converse is true in a unionized firm.

We begin Section 2 by introducing the simple model in which two workers solve two differ-
ent decision problems that require distinct skill sets. Workers make noncontractable efforts to acquire skill sets that enhance the probability of finding the best solutions for respective decision problems. We show that both specialization and multiskilling could appear in the equilibrium. In Section 3, we provide the basic findings of examining the effect of multiskilling on workers’ wages and the levels of their skill investment. In Section 4, we extend the model so that the owner-manager of the firm allocates the set of decision rights between herself and the workers to see the effect of multiskilling on the optimal allocation of decision authorities. In Section 5, we consider the effect of collective bargaining and worker cooperation in choosing skill investment on the equilibrium level of human capital, which offer a number of implications about unionization, worker training and job rotation. Section 6 provides a general discussion of what factors affect the firm’s choice of organizational form and Section 7 offers concluding remarks.

2 Basic Model

This study deals with two distinct policies of job design: one under which workers are specialized in one task and encouraged to acquire deep, narrow skills; and one under which workers are multitasking and motivated to learn broad skills that overlap with others’. We call the former organization the S-organization, and the latter the M-organization. Unlike Grossman and Hart [19] and Hart and Moore [21], ownership structure is not our concern. Hence, we simply assume that an owner-manager owns assets for production and hires two homogeneous workers in the market.\(^7\) The owner-manager and the workers are denoted by \(M\), and \(i (i = 1, 2)\), respectively. Both the manager and the workers are risk-neutral.

\(^7\)For a more general \(n\) worker case, see Owan [42].
2.1 Technology

Suppose the firm needs to solve two decision problems denoted by $k$ where $k = 1, 2$. The outcome of each decision is either success or failure and the firm’s output from a successful decision is $\mu$, while a wrong decision generates no output. Each decision problem $k$ requires a different firm-specific and problem-specific skill set $A_k$. A worker who invested in $A_k$ can solve problem $k$ better. Let $x_{i,k}$ denote worker $i$’s investment in skill set $k$, and let $x_i = (x_{i,1}, x_{i,2})$ and $X = (x_1, x_2)$. The personal cost of investment is $c(x_i)$. Worker $i$ with investment $x_{i,k}$ can find a right solution for problem $k$ with probability $P(x_{i,k})$. $P$ is concave and twice continuously differentiable, and $P(0) = 0$. We assume that the discovery of a solution is stochastically independent across workers. In other words, workers obtain solutions based on their idiosyncratic private information observed in the workplace. Let $v$ denote the value the owner-manager can create using her assets and workers with no skills (i.e., $x_{i,k} = 0$ for all $i$ and $k$). We can set $v = 0$ for the moment but later assume that $v$ depends on the allocation of decision rights.

The probability that either worker finds a right solution for problem $k$ is $1 - (1 - P(x_{1,k}))(1 - P(x_{2,k}))$. Then, the expected joint output is

$$Y(X) = v + \mu \sum_{k=1}^{2} [1 - (1 - P(x_{1,k}))(1 - P(x_{2,k}))],$$  \hspace{1cm} (1)

The manager owns the firm in the sense of Hart and Moore [21], and thus the workers cannot produce anything without management. A worker with no firm-specific human capital produces nothing (i.e., $P(0) = 0$), and the worker’s outside option value is assumed to be zero. When a worker leaves the firm after investment in firm-specific skills, he will be replaced by a new hire who has no firm-specific skills. The expected output when one or two workers leave
can be easy derived. With only worker \( i \) remaining, the output is \( v + \mu(P(x_{i,1}) + P(x_{i,2})) \) (i.e. \( x_{i'} = (0, 0) \) for \( i' \neq i \)). With both workers replaced, the surplus is \( v \).

To rule out asymmetric Nash equilibria, we impose the following assumptions:

(A.1) \( \frac{P'(x)}{3-2P(x)} \) is decreasing in \( x \).

(A.2) \( c(x_{i,1}, x_{i,2}) = c(x_{i,1} + x_{i,2}) \).

(A.1) requires that \( P(x) \) does not converge to 1 too quickly as \( x \) increases. In other words, it ensures that increased investment by one worker does not make the returns to the other’s investment fall too quickly. When (A.1) is violated, it could be efficient to assign both decision problems to one worker and let him alone invest substantially in skills. But this case is not of much interest in light of our motivation because in such asymmetric equilibrium, there is no tradeoff in specialization and multiskilling. It should also be noted that (A.1) is sufficient to rule out any equilibria other than S-organization and M-organization as Proposition 1 shows.\(^8\) (A.2) assumes perfect cost substitution. By imposing (A.2), we can simplify our comparison of specialization and multiskilling in determining bargaining power and human capital investment. Another possibility is the cost function with skill complementarity under which acquiring one skill set helps workers to learn another skill set. Skill complementarity, however, substantially favors multiskilling, obscuring the role of human capital substitutability in multiskilling organizations.

Additionally, we assume that \( c \) is convex and twice continuously differentiable and that

\(^8\) (A.1) does not ensure that either the S-organization or the M-organization is an efficient form of skill investment. Therefore, it is quite possible that an efficient form is one in which both workers invest in both types of skills, but differentiate their investments in the two types of skills. We need more restrictive conditions to derive the result that either the S-organization or the M-organization is efficient.
\( c''(x)/c'(x) \) is non-increasing with \( c(0) = 0 \) and \( \lim_{x \to -\infty} c(x) = +\infty \). To ensure the equilibrium with positive investment, we assume

\[(A.3) \quad \frac{\#}{2} P'(0) > c'(0).\]

One example of \( P \) satisfying (A.3) is \( P(x) = 1 - e^{-x} \), which will be frequently used throughout the paper.

### 2.2 Wage Bargaining

We assume that \( X \) is observable, but that neither \( X \) nor the actual outputs are verifiable. Hence, the manager cannot offer a contract contingent on any of these variables including the “sell the job” contract under which the workers pay a fixed amount to the owner-manager in exchange for the income stream from their decisions.

The timing of decision making is as follows. The workers choose the level of investment \( x_1 \) and \( x_2 \). After the profile of investment \( X \) is observed by all, the owner-manager and the workers negotiate wages. Finally, after wages are determined, the owner-manager and the workers make decisions and generate surplus. We assume that the wages are determined by the Shapley value. The Shapley value for worker \( i \) is the weighted average of his marginal contribution in all possible subgroups. The weights are calculated based on the number of all possible sequence combinations that form the subgroup.\(^9\) A non-cooperative game theoretical justification of the Shapley value is provided by Stole and Zwiebel [49]. In their model, the manager and the

\[^{9}\text{More formally, the Shapley value is defined as}
\]

\[
w_i(X) = \frac{1}{|N|!} \sum_{S \subseteq N \setminus \{i\}} |S|! |(|N| - |S| - 1)! [Y(S \cup \{i\}, X) - Y(S, X)] |
\]

where \( N \) is the set of all agents including the owner and the workers, \( S \) is an arbitrary subset, and \( Y(S, X) \) is the expected output by the subgroup \( S \) given the investment profile \( X \).
workers bargain pairwise sequentially and, in each session, play the alternating-offer bargaining game of Binmore, Rubinstein and Wolinsky [7], in which there is an exogenous probability of breakdown. The solution for this game is the Shapley value for the corresponding cooperative game in the limit. Later, we will also consider collective bargaining in which the union bargains with the owner-manager over the total wage.

Under the bargaining structure explained above, worker $i$’s wage is determined by

$$w_i(X) = \frac{\mu}{3} P(x_{i,1})(1 - P(x_{j,1})) + \frac{\mu}{3} P(x_{i,2})(1 - P(x_{j,2})) + \frac{\mu}{6} (P(x_{i,1}) + P(x_{i,2})). \quad (2)$$

Note that, since the workers’ human capital investment is firm-specific, the subgroup without the owner ($i.e.$ workers who leave the firm and form a new group) cannot produce any outputs. As a result, the bargaining return to his investment is less than the total return to the investment. This is the famous hold-up problem.

The profit the owner-manager earns is

$$\pi(X) = Y(X) - w_1(X) - w_2(X)$$

$$= v + \frac{\mu}{2} (P(x_{1,1}) + P(x_{1,2}) + P(x_{2,1}) + P(x_{2,2})) - \frac{\mu}{3} (P(x_{1,1})P(x_{2,1}) + P(x_{1,2})P(x_{2,2}))$$

2.3 Nash Equilibrium in the Investment Game

First, we show that both specialization and multiskilling could arise endogenously when workers optimally choose investment in skill sets. In the equilibrium, the following first-order conditions have to be satisfied:
\[
\frac{\partial w_i}{\partial x_{i,1}} = \frac{\mu}{3} P'(x_{i,1})(1 - P(x_{j,1})) + \frac{\mu}{6} P'(x_{i,1}) \leq c'(x_{i,1} + x_{i,2});
\]
\[
\frac{\partial w_i}{\partial x_{i,2}} = \frac{\mu}{3} P'(x_{i,2})(1 - P(x_{j,2})) + \frac{\mu}{6} P'(x_{i,2}) \leq c'(x_{i,1} + x_{i,2})
\]
(4)

where \(i = 1, 2\).

The following proposition proves that there could appear only two different Nash equilibria under (A.1): symmetric specialization and symmetric multiskilling.

**Proposition 1** There could be at most two Nash equilibria in the stage game where two workers choose their investment profiles. In one equilibrium \(x_{i,1}^* = x_{12}^* = x_{21}^* = x_{22}^*\). When \(\frac{\mu}{6} P'(0)(3 - 2P(x^*)) \leq c'(x^*)\) for the solution \(x^*\) to the equation \(\frac{\mu}{6} P'(x^*)(3 - 2P(0)) = c'(x^*)\), there is another equilibrium, in which \(x_{i,1}^* = x_{j,2}^* = x^*\) and \(x_{i,2}^* = x_{j,1}^* = 0\).

**Proof:** See the Appendix.

Proposition 1 ensures that workers choose the same investment level and invest either uniformly between the skill sets or specialize in one skill set. There is no asymmetric equilibrium where workers choose different investment levels or invest in both skill sets but do so asymmetrically. Although "multiskilling" equilibrium always exists, "specialization" equilibrium may not exist unless there is some gain from specialization. To make this point clear, consider \(P(x) = 1 - e^{-x^k}\) where \(k\) is a parameter of gains from specialization and \(k > 0\). The higher the value of \(k\), the more likely is specialization to be efficient. We can easily show that "specialization" equilibrium exists if \(k > 1\) but does not if \(k \leq 1\).
### 2.4 Firm’s Choice of Job Design

Proposition 1 allows us to focus on the two types of job design: specialization and multiskilling. In the rest of our analyses, we assume that the owner-manager can first choose either type of job design. Such assumption is reasonable for two reasons. First, when both equilibria in Proposition 1 exist (i.e. there are some gains from specialization), the owner-manager should be able to induce the equilibrium with more profitable outcome to realize by guiding workers’ beliefs. For example, management can express its expectation and offer training opportunities to encourage a certain learning behavior. Second, the owner-manager can directly control the skill sets that workers acquire by offering specific training programs or complementary practices (e.g. team activities, job rotation, evaluation, etc.) designed for either specialization or multiskilling. We call organizations with specialized skill investment *S-organization* and those with multiskilling practices *M-organization*.

Let \( x_i \) be the total investment made by worker \( i \). Namely, \( x_{ii} = x_i \) in the S-organization and \( x_{i1} = x_{i2} = \frac{x_i}{2} \) in the M-organization. Then, by substituting these investment choices into Equation 1, the expected outputs in the S-organization and M-organization, \( Y_S \) and \( Y_M \) respectively, are expressed as follows:

\[
Y_S(x_1, x_2) = v + \mu(P(x_1) + P(x_2));
\]

\[
Y_M(x_1, x_2) = v + 2\mu[1 - (1 - P(\frac{x_1}{2}))(1 - P(\frac{x_2}{2}))].
\]

Likewise, we can compare the wage functions in S-organizations and M-organizations. Let \( w_i^S(x_1, x_2) \) and \( w_i^M(x_1, x_2) \) be the worker \( i \)'s wage in the S- and M-organizations, respectively. Then, from Equation 2, we get
\[ w_i^S(x_1, x_2) = \frac{1}{2} \mu P(x_i) \]
\[ w_i^M(x_1, x_2) = \mu P(\frac{x_i}{2}) (1 - \frac{2}{3} P(\frac{x_j}{2})) \] (7)

The key difference between these two wage functions is that there is no interaction between \( x_1 \) and \( x_2 \) in \( w_i^S \), while \( x_1 \) and \( x_2 \) are Edgeworth substitutes in \( w_i^M \) (i.e., \( \frac{\partial^2 w_i^S}{\partial x_1 \partial x_2} < 0 \)).\(^{10}\) This feature drives most of our results that follow.

3 Basic Results

As a first step to see what factors affect the relative efficiency of the S-organization and the M-organization, we compare the production frontiers of the two organizations. By substituting \( x_1 = x_2 = x \) into Eqs. 5 and 6, we obtain

\[ Y^S > Y^M \text{ if } (1 - P(\frac{x}{2}))^2 > 1 - P(x). \] (8)

The condition requires that the marginal increase of \( P \) does not decrease too quickly. When it is satisfied, there are gains from specialization. Again, let us assume \( P(x) = 1 - e^{-x^k} \). Then, Inequality 8 holds if and only if \( k > 1 \) and \( Y^M = Y^S \) for all \( x \) when \( k = 1 \). In many results in the paper, we assume this specific function of \( P(x) = 1 - e^{-x^k} \), with which an increase in \( k \) raises the relative efficiency of the S-organization.\(^{10}\)

\(^{10}\)It may be often more realistic to assume Edgeworth complementarity between \( x_1 \) and \( x_2 \) in the S-organization. Most qualitative results in this paper hold for such a case. See Owan [42] for discussions.
The next proposition investigates how an organizational difference affects the workers’ bargaining power.

**Proposition 2**

\[
\begin{align*}
  w_i^S(x, x) &= \frac{1}{4}(Y^S(x, x) - Y^S(0, 0)) \\
  w_i^M(x, x) &= \frac{1}{4}(Y^M(x, x) - Y^M(0, 0)) - \frac{\mu}{6}P\left(\frac{x}{2}\right)^2.
\end{align*}
\]

The proof is omitted because it is straightforward from Eqs. 4-7.

In the S-organization, the owner-manager and the workers split the quasi-rent by half and each worker receives one quarter. Hence, the wage in the S-organization is the same as the union wage if collective bargaining leads to a Nash bargaining solution. In the M-organization, a worker receives less than one quarter of the quasi-rent because of his weaker bargaining power. Namely, in the M-organization, when one worker quits, the output does not drop as sharply as in the S-organization because of the overlapping investment in the same skill set made by the other worker. Put differently, the loss of human capital caused by the separation is partly offset by the more efficient use of the other worker’s broad skills. Because worker turnover is less costly for the firm as a result, the M-organization should give its workers lower wages, given the same amount of investment. The difference in the bargaining power is captured by the last term \(\frac{\mu}{6}P\left(\frac{x}{2}\right)^2\).

Propositions similar to this have been proven by Horn and Wolinsky [23] and Stole and Zwiebel [50]. They find that workers bargaining with the employer gain by forming a union when they are substitutable to each other, and lose when they are complementary. In our
model, workers in the M-organization will receive \( \frac{1}{4}(Y^M(x, x) - Y^M(0, 0)) \) when collective bargaining is introduced and therefore, the union wage is higher by \( \frac{\delta}{4} P(\frac{x}{2})^2 \) in the M-organization.

Let \( \bar{x}_S \) and \( \bar{x}_M \) be the efficient total investment in the S- and M-organizations, respectively.\(^\text{11}\) Also, denote the equilibrium investment for the S and M-organizations by \( x^*_S \) and \( x^*_M \), respectively. Since the owner-manager can capture a share of the surplus created by the workers’ investment (i.e. the hold-up problem), the workers underinvest in skills in the S-organization. Namely \( \bar{x}_S > x^*_S \). In the M-organization, however, the investments are substitutes, and thus subject to a countervailing effect: a worker’s investment increases his marginal contribution to a subgroup containing only him and the owner more than his marginal contribution to the total output because his broad skills are more valuable without a co-worker whose skills overlap with his. A mechanism working behind the Shapley value formula is that a worker’s human capital investment weakens the other worker’s bargaining position, which in turn generates additional negotiation surplus for the former. More intuitively, an increase in one worker’s investment makes it more likely that the other’s discovery of the solution is redundant, reducing the value of the other’s skills. I will call this the “skill substitution effect.” In an extreme case, the workers could overinvest in skills in the M-organization.

To see this point, compare the first-order conditions for \( \bar{x}_M \) and \( x^*_M \). The efficient investment \( \bar{x}_M \) is obtained by solving

\[
\frac{\partial Y^M}{\partial x}(x, x) - c'(x) = \mu P'\left(\frac{x}{2}\right)(1 - P\left(\frac{x}{2}\right)) - c'(x) = 0.
\]

\(^{11}\)As we made clear earlier, the current assumptions do not ensure that either the S or the M-organization is efficient. Thus, we mean constrained efficiency here: no deviation from the specified investment profile gives a better payoff to anyone without negatively affecting others within the set of investment profiles called the S or the M-organization.
\[ x^*_M \text{ solves} \]
\[
\frac{\partial w^M_i(x, x)}{\partial x_i} - c'(x) = \frac{\mu}{3} P'\left(\frac{x}{2}\right)(1 - P(x)) + \frac{\mu}{6} P'\left(\frac{x}{2}\right) - c'(x) = 0. \tag{10}
\]

Let me rewrite (10) as follows:
\[
\frac{\partial w^M_i(x, x)}{\partial x_i} - c'(x) = \frac{\mu}{2} P'\left(\frac{x}{2}\right)(1 - P(x)) - c'(x) + \frac{1}{6} \mu P'\left(\frac{x}{2}\right) P\left(\frac{x}{2}\right) - c'(x) + \frac{1}{2} \frac{\partial Y^M}{\partial x_i} - c'(x) + \frac{1}{2} \frac{\partial Y^M}{\partial x_i} + \frac{1}{6} \mu P'\left(\frac{x}{2}\right) P\left(\frac{x}{2}\right) \cdot \tag{11}
\]

In the M-organization, when the skill substitution effect is greater than the hold-up effect, the workers overinvest in skills.\(^{12}\) As we discussed in the introduction, Edlin and Hermelin [16] find a similar effect that offsets the holdup effect in a model with substitutable investments made by the buyer and the seller of an asset.

Because of the skill substitution effect discussed earlier, the M-organization tends to give the workers stronger incentives to acquire skills if the individual bargaining procedure is adopted. This comparison is more clearly stated when we assume \( P(x) = 1 - e^{-x} \). With this production technology, \( Y^S = Y^M \) for any symmetric investment \( x_1 = x_2 = x \). Therefore, \( \bar{x}_S = \bar{x}_M \).

Despite the fact that the wage is lower in the M-organization than in the S-organization, the former outperforms the latter in terms of productivity as shown in the next proposition:

**Proposition 3** When \( P(x) = 1 - e^{-x} \), \( x^*_M > x^*_S \).

**Proof:** Suppose \( x_1 = x_2 = x \). Then,
\[
\frac{\partial w^M_i(x, x)}{\partial x_i} - \frac{\partial w^S_i(x, x)}{\partial x_i} = \frac{\mu}{6} e^{-\frac{x}{2}} (1 - e^{-\frac{x}{2}}) > 0
\]

\(^{12}\)For example, suppose \( c(x_{i,1}, x_{i,2}) = \frac{1}{2} c(x_{i,1} + x_{i,2}) \). Then, the workers overinvest when the cost parameter \( c \) is sufficiently small. The necessary and sufficient condition for this to be true is \( p(x_0) > \frac{2}{3} \).
for all $x > 0$. Hence, $x_M^* > x_S^*$. ■

Propositions 2-3 imply that, when the two organizational forms have the same production frontier, firms should choose an M-organization because it induces higher investment and gives the owner-manager a larger share of the economic rent earned.

4 Allocation of Decision Rights

In the previous sections, the manager has played only a limited role in determining the firm’s output because $v$ is constant. In this section, we assume that the owner-manager allocates decision problems to the workers. In so doing, a manager has to decide how many decision rights she should delegate or, in other words, how much the workers should be “empowered.”

Let $S$ be the set of all decision problems. There exists a partition $S = S_1 \cup S_2$ where skill set $A_k$ is necessary to solve problems in $S_k$. Decision problems in $S$ are ordered according to the relative advantage of the manager to the workers in making right decisions. The decision problems that are high in this ordering are more strategic decisions, and the manager’s ability to coordinate decisions between $S_1$ and $S_2$ gives her relatively high productivity. The decision problems that are low in this ordering are more operational decisions, and the workers’ engagement in the production process enables them to create relatively high value on these lower-order problems. The manager’s problem is simply to choose the set of decision rights she will delegate to the workers. This set is $S_r = S_{1,r} \cup S_{2,r}$, where $r \in [0, 1]$ is the delegation parameter that represents how much the workers are empowered and $S_{k,r} \subset S_k$. We assume that there is a continuum of decision problems and $r$ is continuous. $r = 0$ indicates that no decision rights are delegated to the workers; and $r = 1$ means all decision problems are assigned.
to the workers. $S_r$ is non-decreasing in $r$ in the set order.

Let $\zeta(r)$ denote the incremental value created by a worker from a successful decision on $s \in S_r$ and $\eta(r)$ denote the incremental average value created by the manager for $s \in S \setminus S_r$.

The size of the allocated responsibility affects the quality of implementation and thus the value created by successful decisions: $\zeta(r)$ is decreasing in $r$, and $\eta(r)$ is increasing in $r$. As before, $P(x_{i,k})$ is the probability that worker $i$ with investment $(x_{i,1}, x_{i,2})$ will find a right solution for $s \in S_{k,r}$, and we assume the same properties for $P$ as in the previous sections. The firm’s expected joint output is

$$Y(X, r) = \#(S \setminus S_r)\eta(r) + \sum_{k=1}^2 \#(S_{k,r})[1 - (1 - P(x_{1,k}))(1 - P(x_{2,k}))]\zeta(r),$$

where $\#(Z)$ denotes the number of decision problems in $Z$. Assume $\#(S_{1,r}) = \#(S_{2,r})$, and redefine $v(r) = \#(S \setminus S_r)\eta(r)$ and $\mu(r) = \#(S_{k,r})\zeta(r)$. Then, the output function looks similar to (1) except that the productivity coefficients are parameterized by $r$ as follows:

$$Y(X, r) = v(r) + \mu(r)\sum_{k=1}^2 [1 - (1 - P(x_{1,k}))(1 - P(x_{2,k}))].$$

(12)

We assume that $r$ is not contractible. Otherwise, *ex ante* transfers can be made contingent on the decision rights delegated to the workers and the firm can achieve the efficient delegation by simply “selling” decision rights to the workers. Here, the owner-manager is expected to choose $r$ so as to maximize her *ex post* bargaining surplus. We also assume that, once the owner-manager delegates the set of decision rights $S_r$ to the workers, she is unable to solve any problems in $S \setminus S_r$ after the skill investment is made.\textsuperscript{13} The interpretation is that the owner-

\textsuperscript{13}This assumption also implies the owner-manager’s ability to commit to her delegation decision. Since “worker empowerment” encourages workers’ skill investment, the owner-manager may promise to delegate large
manager loses access to the opportunities to learn problem-specific knowledge and information which the workers acquire after delegation. Since the owner-manager cannot take over any subset of delegated decision rights \textit{ex post} when one or two workers leave the firm, the profit function is identical to (3) except for the parameterized coefficients $v(r)$ and $\mu(r)$. 

To facilitate mathematical derivation, let $v$ and $\mu$ be twice continuously differentiable. To ensure unique interior solution, we assume $v'' \leq 0$, $v'(0) > 0$, $v'(1) < 0$, $\mu'' \leq 0$, $\mu'(0) > 0$ and $\mu'(1) < 0$. The concavity of $v$ and $\mu$ also makes it suboptimal for the owner-manager and the workers to share authority and exchange information.

Now we ask how increased allocation of decision authority affects the workers’ incentives to acquire skills. Consider the S-organization as before. The workers solve

$$\max_x w_i^S(r, x_1, x_2) - c(x_i) = \frac{1}{2} \mu(r) P(x_i) - c(x_i).$$

From the first-order condition

$$\frac{1}{2} \mu(r) P'(x_i) = c'(x_i) \quad (13)$$

we get

$$\frac{dx_i^*}{dr} = \frac{\mu'(r) P'(x_i^*)}{2c''(x_i^*) - \mu(r) P''(x_i^*)}. \quad (14)$$

Similarly,

$$\frac{dx_M^*}{dr} = \frac{\mu'(r) P'(x_M^*) (3 - 2P(x_M^*))}{6c''(x_M^*) - \mu(r) P''(x_M^*) (3 - 2P(x_M^*)) + \mu(r) P'(x_M^*)^2}. \quad (15)$$

Thus, $\frac{dx_i^*}{dr} > 0$ and $\frac{dx_M^*}{dr} > 0$ if and only if $\mu'(r) > 0$. This assumption rules out such possible reneging by the owner-manager.
The owner-manager will optimize with respect to \( r \), assuming that workers will choose investment optimally. Let \( \pi_S(r, x^*_S) \) and let \( \pi_M(r, x^*_M) \) denote the profit functions for the owner-manager in the S- and M-organizations, respectively. Then,

\[
\begin{align*}
\pi_S(r, x^*_S) & = v(r) + \mu(r)P(x^*_S) ; \\
\pi_M(r, x^*_M) & = v(r) + 2\mu(r)(P\left(\frac{x^*_M}{2}\right) - \frac{1}{3}P\left(\frac{x^*_M}{2}\right)^2).
\end{align*}
\]

\( v' > 0 \) implies that the owner-manager’s productivity increases as his responsibilities decrease. This means that the owner-manager is overloaded in the range where \( v' > 0 \). Similarly, the workers are overloaded when \( \mu'(r) < 0 \). In (A.4), we assume that the owner-manager and the workers cannot be overloaded at the same time. In order words, the set of decision rights \( S \) should not be too large for three people to handle.

(A.4) If \( \mu'(r) \leq 0, v'(r) < 0 \).

The owner-manager solves \( \max_r \pi_l(r) \) where \( l = S, M \). The first-order condition take the following form:

\[
\frac{d\pi_l}{dr} = \frac{\partial \pi_l}{\partial r} + \frac{\partial \pi_l}{\partial x^*_l} \frac{dx^*_l}{dr} = 0.
\]

There are two channels through which an increase in \( r \) affects the owner-manager’s profit: (1) through a direct impact on productivity and bargaining power; and (2) through an indirect impact via a change in worker incentives. Let \( r^*_l \) be the optimal degree of delegation for the \( l \)-organization.

The next lemma is used in the following results.

**Lemma 1** \( \mu'(r^*_l) > 0 \) for \( l = S, M \).
Proof: We prove only for the S-organization. The proof is basically the same for the M-organization.

\[
\frac{d\pi_S}{dr} = v'(r) + \frac{1}{2} \mu'(r) P(x^*_S) + \frac{1}{2} \mu(r) P'(x^*_S) \frac{dx^*_S}{dr} = 0.
\]  
(17)

By substituting in (13) and (14),

\[
\frac{d\pi_S}{dr} = v'(r) + \frac{1}{2} \mu'(r) [P(x^*_S) + \frac{2}{\mu(r)} \frac{c'(x^*_S)^2}{c'(x^*_S) - \frac{1}{2} \mu(r) P''(x^*_S)}].
\]  
(18)

Suppose \(\mu'(r^*_S) \leq 0\). The term in the last brackets is positive. Then, (A,4) implies that \(\frac{d\pi_S}{dr}(r^*_M) < 0\), leading to contradiction. This concludes the proof.

Now we compare the owner-manager’s optimal choice with the efficient allocation \(\tilde{r}_l\) that maximizes the total surplus created in the firm, \(Y_l(r, x^*_l(r)) - 2c(x^*_l(r))\). Note that the efficient allocation discussed here does not assume efficient investment in skills. Thus, its efficiency is constrained by the workers’ self-interested choice of skill investment.

**Proposition 4** The owner-manager always underdelegates decision rights to the workers in the S-organization. Underdelegation also appears in the M-organization if the cost function is well-behaved.

\(\tilde{r}_S > r^*_S\).

When \(c(X) = \frac{1}{2}cx^2\), \(\tilde{r}_M > r^*_M\).

Proof: See the Appendix.

Prendergast [46] similarly argues that managers delegate less responsibilities than would be efficient.\(^{14}\) In his work, underdelegation arises because the firm or the manager cannot capture all of the intrinsic benefits of implementing tasks (e.g., only the worker acquires skills

\(^{14}\)Freeman and Lazear derive a similar result in a different context where the firm decides whether it should
by “learning-by-doing”) in the face of the liquidity constraint imposed on workers. In the framework presented here, the manager underdelegates from the fear of increasing the worker’s bargaining power.

From $\pi_l(r, x^*_l(r)) = Y^l(r, x^*_l(r)) - w^l_1(x^*_l(r), x^*_i(r)) - w^l_2(x^*_l(r), x^*_i(r))$ and $\frac{\partial w^M}{\partial x_i}(x^*_l(r)) - c'(x^*_l(r)) = 0$,

$$d\pi^l_{I,k} = \frac{d}{dr}(Y^l(r, x^*_l(r)) - 2c(x^*_l(r))) - \frac{\partial w^l_1}{\partial r} - \frac{\partial w^l_2}{\partial r} - \frac{\partial w^l_1}{\partial x^*_i} \frac{dx^*_i(r)}{dr} - \frac{\partial w^l_2}{\partial x^*_i} \frac{dx^*_i(r)}{dr}.$$

(19)

The owner-manager tends to underdelegate because the workers also capture some of the rent directly created by delegation (i.e. $\frac{\partial w^l_1}{\partial r} > 0$). Let us call this the hold-up effect. In the $M$-organization though, there is an offsetting effect: an increase in a worker’s skills in response to larger responsibilities weakens his co-worker’s bargaining return (i.e. $\frac{\partial w^l_1}{\partial x^*_j} \frac{dx^*_j(r)}{dr} < 0$). We call this the skill substitution effect, although it is now used to capture the impact of skill substitution on the firm owner’s incentive to delegate decisions, whereas the term was earlier used to refer to the impact on the worker’s incentive to invest in skills. (19) implies that the distortion in the allocation of decision rights will be smaller in the M-organization unless the skill substitution effect is too large.$^{15}$

We will now demonstrate that the optimal set of decision rights delegated to the workers tends to be larger in the M-organization.

create a works council to empower workers or not. They argue that, even if setting up a works council is efficient, the employer may not be better off by doing so because the empowered workers will likely capture a significant part of the efficiency gain.

$^{15}$There may be some pairs of production functions and cost functions that induce overdelegation in the M-organization, although we haven’t found any such simple functions. Overdelegation may arise if a greater allocation of decision rights increases the substitutability of the workers’ skills so significantly that further delegation weakens the workers’ relative bargaining power.
**Proposition 5** When $P(x) = 1 - e^{-x}$, $r_S^* < r_M^*$.

**Proof:** See the Appendix. ■

The role of *ex post* bargaining in getting this result is essential for two reasons. First, it is only under *ex post* bargaining that the workers with substitutable skills have greater incentive to invest in human capital. Since additional delegation tends to induce a greater increase in human capital investment in the M-organization than in the S-organization, the efficient allocation of decision rights is typically more decentralized in the former than in the latter. Second, it is only under *ex post* bargaining that workers with substitutable skills have weaker bargaining power. Note that the owner-manager usually distorts the allocation of decision rights because she cannot capture all the rents created by the efficient allocation. This is similar to the classic hold-up problem. But this under-delegation problem is much less severe in the M-organization where the owner-manager receives a larger share of the efficiency gain due to her stronger bargaining power in the M-organization.

Under the assumption of identical production frontier, the M-organization gives a higher profit to the owner-manager for two reasons: (1) the owner-manager has stronger bargaining power in the M-organization (Proposition 2); and (2) the workers are better motivated to acquire skills in the M-organization (Proposition 3). More formally,

**Corollary 1** When $P(x) = 1 - e^{-x}$, the M-organization gives the owner a higher profit *ex post* than the S-organization.

**Proof:**

$$
\pi_M(r_M^*, x_M^*(r_M^*)) > \pi_M(r_S^*, x_M^*(r_S^*)) > \pi_S(r_S^*, x_S^*(r_S^*)) > \pi_S(r_S^*, x_S^*(r_S^*))
$$
where the first inequality is derived by the fact that $r^{I,M}$ is the optimal choice in the M-organization, the second is immediate from Proposition 2 and the third from Proposition 3.

It is not clear whether workers’ wages will be higher or lower in the M-organization even with the same assumptions as in Corollary 1. Although the workers are given more responsibilities and are more motivated to invest in firm-specific human capital, which strengthens their bargaining power, they may not receive a higher wage, simply because their share of the rent is smaller in the M-organization (Proposition 2).

5 Collective Bargaining and Cooperation

Suppose the workers collectively negotiate their wages by forming a union and thus receive an equal union wage. Horn and Wolinsky [23] and Stole and Zwiebel [50] find that workers bargaining with an indispensable firm gain by forming a union when they are substitutable to each other, and lose when they are complementary.\footnote{Segal [48] shows a very general result to this effect concerning the desirability of coalitions under the random-order value, which gives each player his expected marginal contribution to the set of preceding players in various orderings of players, according to some probability distribution over orderings. The random-order value in which all orderings are equally likely is the Shapley value.} We restate their result without the proof. The total union wage is defined as the Nash bargaining solution between the owner-manager and the workers, as is assumed in the earlier works.

\textbf{Proposition 6 (Horn and Wolinsky [23] and Stole and Zwiebel [50])}

\textit{Given the fixed investment by the workers, collective bargaining increases the workers’ wages in the M-organization, while the workers in the S-organization do not benefit from collective}
bargaining.

With collective bargaining, the workers’ share of the rent created by their skills is always half, regardless of the organizational form. In contrast, the workers’ share of the rent obtained through individual bargaining is higher in the S-organization, where the share is half, than in the \textit{M-organization}, where the share is less than half. \footnote{This result may be consistent with the fact that enterprise unions are rare in the U.S., where traditional firms have maintained a specialized job structure. A typical union’s goal of increasing the workers’ bargaining power probably necessitated the use of monopoly power in the industry-wide labor market. On the contrary, in Japan, where large firms have adopted many multiskilling practices, most unions are enterprise unions.}

As you can easily see, collective bargaining reduces the workers’ skill investment because it encourages free-riding. Lower skill investment also decreases the benefit of delegation for the owner-manager. Hence, the following proposition is straightforward, and thus the proof is omitted.

\textbf{Proposition 7} Collective bargaining gives a lower incentive to acquire skills and induces the allocation of fewer decision rights to the workers in both organizations.

Since the workers in the S-organization will be worse off by forming a union, I will focus on the M-organization for now. So far, we have assumed that the workers choose their investment in skills non-cooperatively even when they are unionized. When the workers work in teams, they may be able to cooperate (or collude) in choosing their investment level if each worker’s investment is observable to the other. When the workers cooperate, they jointly optimize their total payoff: \(w_1(x_1, x_2) + w_2(x_1, x_2) - c(x_1) - c(x_2)\). We consider the four possible cases: (UC) form a union and cooperate in investment; (NC) not form a union but cooperate in investment; (UN) form a union but not cooperate in investment; and (NN) not form a
union and not cooperate in investment. Let \( x_{M}^{UC}, x_{M}^{NC}, x_{M}^{UN}, \) and \( x_{M}^{NN} \) be the workers’ skill investments in each of the above cases.

**Proposition 8** The workers’ cooperation in setting their investment in skills benefits the owner-manager under collective bargaining but hurts the firm’s profit under individual bargaining.

\[
x_{M}^{NN} > x_{M}^{UC} > \max\{x_{M}^{NC}, x_{M}^{UN}\}.
\]

**Proof:** See the Appendix.

Cooperation is beneficial under collective bargaining because it eliminates free-riding. Under individual bargaining, however, cooperation and autonomy in setting skill standards in the M-organization could substantially reduce efficiency. This is because the strategic substitutability of workers’ investments creates negative externality on their utilities, and internalizing this externality while neglecting the positive externality on the owner-manager’s payoff could cause significant underinvestment in skills. This cooperation in skill investment is less likely if there are many teams competing with each other. Also, frequent job rotation among teams working on similar tasks should alleviate this problem because the possibility of moving to another team, or of a worker from another team coming to your team, reduces the incentive to collude. This may partly explain why many Japanese firms have adopted job rotation.

**5.1 Discussion**

When the two organizational forms generate the same production frontier, the firm should choose the M-organization because it induces higher investment and gives the owner-manager stronger bargaining power. The M-organization is also more efficient unless it induces suf-
iciently excessive investment, which is very unlikely in a team with more than two workers and with sufficiently costly investment. This benefit of multiskilling practices has never been recognized in the literature. If there exist gains from specialization as we normally expect (e.g. $p(x) = 1 - e^{-x^k}$ for $k > 1$ in our model), the manager has to make tradeoffs between the incentive efficiency from multiskilling and the technical efficiency from specialization. Eventually, the efficient job design should prevail.$^\text{18}$

The difference between the two types of job design becomes remarkable with individual bargaining but not with collective bargaining. Therefore, the M-organization will be favored in workplaces that are not unionized and in those that have more promotion prospects (so that there is more differentiation in lifetime income based on skill levels).

One legitimate critique to our theory may be that, in many industries and occupations, especially manufacturing plants, wage bargaining is highly centralized, or a wage formula is typically standardized, even if the plant is not unionized, so that individual bargaining or the Shapley value as the wage bargaining outcome is not realistic. Our reaction to this critique is twofold.

First, wages in our model should be interpreted as the lifetime wage income rather than as short-term wages. Even if workers cannot directly bargain over wages in the short run, those with better skills may influence the managers’ decisions, which affect their income in the

$^\text{18}$Suppose the owner-manager can commit to a job design at the time of hiring. Then, by adopting the efficient job design, the owner-manager should be able to make the largest profit if she only needs to guarantee young unskilled workers their reservation utility by offering an appropriate upfront wage (i.e. the reservation wage minus the ex post bargaining surplus), or the owner-manager should be able to offer the highest wage if firms compete for workers in the labor market.
long run (e.g., promotion, job assignment, training, etc.). Therefore, the bargaining process formalized in our model captures a worker’s ability to make his supervisors’ decisions reflect his voice over a long period of time.

Second, although our study was first motivated by a recent trend for reorganization toward job enlargement, the application of the framework should not be restricted to the work organization of lower-level workers. For example, the model may be more suitable to explain differences in job design across hierarchical levels. Pay for managers are determined by individual bargaining, much broader cross-functional knowledge/skills are required of managers, and much more decision authority is assigned to managers. Our theory may predict that job design consisting of skill requirement and decision authority assignment should be much closer to the efficient one for managers than for lower-level positions. The model may be also applicable to a comparison among different organizational forms where the relationship between human capital in different units varies. For example, compare M-form and U-form organizations. It may be the case that firm-specific human capital across functional units in the U-form organizations are complementary while those across business units in the M-organizations are substitutes if there is a lot of duplication of practices among the units. Then, the model predicts that human capital investment is larger and decision-making is more decentralized in the M-form than in the U-form organizations.

6 Conclusion

This work makes an important contribution in two areas. First, it offers another rationale for multiskilling practices increasingly observed in industries worldwide. Multiskilling can re-
duce the distortion in investment and the allocation of responsibilities created by the hold-up problem because multiskilling makes “bargaining returns” more sensitive to skill acquisition and also mitigates the manager’s fear of giving away too much bargaining power to the workers. Therefore, choosing multiskilling practices will enhance productivity unless specialization offers a substantial technical advantage. This idea that multiskilling practices mitigate the distortion in human capital investment and delegation decisions has never been discussed in the literature.

Second, we have demonstrated that the multiskilling form of organization could arise as the optimal form even if there are no technological or informational task complementarities among the combined skills. Prior works typically argued that task complementarities are primary reason for many firms adopting multiskilling practices (for example, see Lindbeck and Snower [36].).

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Appendix

A Proof of Proposition 1

We consider four cases: (1) $x_{i,k}^* > 0$ for all $i$ and $k$; (2) $x_{i,1}^* = 0$ but $x_{i,2}^* > 0$ and $x_{j,2}^* > 0$; (3) $x_{i,1}^* = x_{i,2}^* = 0$; and (4) $x_{i,1}^* = x_{j,2}^* = 0$ but $x_{i,2}^* > 0$ and $x_{j,1}^* > 0$ without loss of generality.

Case 1

In this case, all first-order conditions hold with equality and

\[
\frac{\mu}{6} P'(x_{i,1}^*)(3 - 2P(x_{j,1}^*)) = \frac{\mu}{6} P'(x_{i,2}^*)(3 - 2P(x_{j,2}^*)) = c'(x_{i,1}^* + x_{i,2}^*)
\]

\[
\frac{\mu}{6} P'(x_{j,1}^*)(3 - 2P(x_{i,1}^*)) = \frac{\mu}{6} P'(x_{j,2}^*)(3 - 2P(x_{i,2}^*)) = c'(x_{j,1}^* + x_{j,2}^*)
\] (20)

If $\frac{\mu}{6} P'(x_{i,1}^*)(3 - 2P(x_{j,1}^*)) > \frac{\mu}{6} P'(x_{j,1}^*)(3 - 2P(x_{i,1}^*))$, then $\frac{\mu}{6} P'(x_{i,2}^*)(3 - 2P(x_{j,2}^*)) > \frac{\mu}{6} P'(x_{j,2}^*)(3 - 2P(x_{i,2}^*))$ from (20) and (A.1) implies $x_{i,1}^* < x_{j,1}^*$ and $x_{i,2}^* < x_{j,2}^*$. But they contradict $c'(x_{i,1}^* + x_{i,2}^*) > c'(x_{j,1}^* + x_{j,2}^*)$, the other implication from (20). Similarly, assuming $\frac{\mu}{6} P'(x_{i,1}^*)(3 - 2P(x_{j,1}^*)) < \frac{\mu}{6} P'(x_{j,1}^*)(3 - 2P(x_{i,1}^*))$ leads to contradiction. Therefore, $\frac{\mu}{6} P'(x_{i,1}^*)(3 - 2P(x_{j,1}^*)) = \frac{\mu}{6} P'(x_{j,1}^*)(3 - 2P(x_{i,1}^*))$. Then $\frac{\mu}{6} P'(x_{i,2}^*)(3 - 2P(x_{j,2}^*)) = \frac{\mu}{6} P'(x_{j,2}^*)(3 - 2P(x_{i,2}^*))$ from (20) and (A.1) implies $x_{i,1}^* = x_{j,1}^*$ and $x_{i,2}^* = x_{j,2}^*$. If $x_{i,1}^* = x_{j,1}^*$, $x_{i,2}^* = x_{j,2}^*$, $\frac{\mu}{6} P'(x_{i,1}^*)(3 - 2P(x_{j,1}^*)) > \frac{\mu}{6} P'(x_{j,1}^*)(3 - 2P(x_{i,1}^*))$, contradicting (20). Hence, $x_{i,1}^* = x_{j,1}^*$, $x_{i,2}^* = x_{j,2}^*$. It is easily seen that there exists the unique interior solution for (20) from (A.3) and the concavity of the objective function.

Case 2

The first-order conditions are,
\[
\frac{\mu}{6} P'(0)(3 - 2P(x_{i,1}^*)) \leq \frac{\mu}{6} P'(x_{i,2}^*)(3 - 2P(x_{j,2}^*)) = c'(x_{i,2}^*)
\]

\[
\frac{\mu}{6} P'(x_{j,1}^*)(3 - 2P(0)) \leq \frac{\mu}{6} P'(x_{j,2}^*)(3 - 2P(x_{i,2}^*)) = c'(x_{j,1}^* + x_{j,2}^*)
\]

(21)

If \( \frac{\mu}{6} P'(x_{i,2}^*)(3 - 2P(x_{j,2}^*)) > \frac{\mu}{6} P'(x_{j,2}^*)(3 - 2P(x_{i,2}^*)) \), (A.1) suggests \( x_{i,2}^* < x_{j,2}^* \). But (21) also indicates \( c'(x_{i,2}^*) > c'(x_{j,1}^* + x_{j,2}^*) \) contradicting \( x_{i,2}^* < x_{j,2}^* \). Thus \( \frac{\mu}{6} P'(x_{i,2}^*)(3 - 2P(x_{j,2}^*)) \leq \frac{\mu}{6} P'(x_{j,2}^*)(3 - 2P(x_{i,2}^*)) \). If \( x_{j,1}^* > 0 \), this combined with (21) implies \( \frac{\mu}{6} P'(0)(3 - 2P(x_{j,1}^*)) \leq \frac{\mu}{6} P'(x_{j,1}^*)(3 - 2P(0)) \), which suggests \( x_{j,1}^* = 0 \) from (A.1). Since \( \frac{\mu}{6} P'(0)(3 - 2P(0)) > \frac{\mu}{6} P'(x)(3 - 2P(x)) \) for any \( x \), this result contradicts (21).

**Case 3**

The first-order conditions are,

\[
\frac{\mu}{6} P'(0)(3 - 2P(x_{i,1}^*)) \leq c'(0), \quad \frac{\mu}{6} P'(0)(3 - 2P(x_{j,2}^*)) \leq c'(0)
\]

\[
\frac{\mu}{6} P'(x_{j,k}^*)(3 - 2P(0)) = c'(x_{j,1}^* + x_{j,2}^*) \text{ if } x_{j,k}^* > 0.
\]

(22)

If \( x_{j,k}^* > 0 \), \( c'(x_{j,1}^* + x_{j,2}^*) \geq c'(0) \) and \( \frac{\mu}{6} P'(x_{j,k}^*)(3 - 2P(0)) > \frac{\mu}{6} P'(0)(3 - 2P(x_{j,1}^*)) \). The last inequality contradicts (A.1). Therefore, \( x_{i,1}^* = x_{j,1}^* = x_{i,2}^* = x_{j,2}^* = 0 \). But this case is ruled out by (A.2).

**Case 4**

The first-order conditions are,

\[
\frac{\mu}{6} P'(0)(3 - 2P(x_{j,1}^*)) \leq \frac{\mu}{6} P'(x_{i,2}^*)(3 - 2P(0)) = c'(x_{i,2}^*)
\]

\[
\frac{\mu}{6} P'(0)(3 - 2P(x_{i,2}^*)) \leq \frac{\mu}{6} P'(x_{j,1}^*)(3 - 2P(0)) = c'(x_{j,1}^*)
\]

(23)
(23) indicates $x_{i,2}^* = x_{j,1}^*$. So, there exists an equilibrium when $\frac{\mu}{6} P'(0)(3-2P(x^*)) \leq c'(x^*)$ for the solution $x^*$ for $\frac{\mu}{6} P'(x^*)(3 - 2P(0)) = c'(x^*)$.

**B Proof of Proposition 4**

Let $\tau$ be the number such that $\mu'(\tau) = 0$. Then, $\mu'(r) > 0$ if and only if $0 < r < \tau$. From Lemma 24, $0 < r_1^* < \tau$.

$r_1$ solves

$$\frac{dY}{dr} = \frac{d\pi_1}{dr} + \frac{\partial w_1^l}{\partial r} + \frac{\partial w_2^l}{\partial r} + (\frac{\partial w_1^l}{\partial x_1} + \frac{\partial w_2^l}{\partial x_1} + \frac{\partial w_2^l}{\partial x_2}) \frac{dx_1^*}{dr} = 0.$$  

For $\forall r < \tau$, $\frac{\partial w_i^l}{\partial r} > 0$ and $\frac{dx_1^*}{dr} > 0$ from (14), (15) and $\mu'(r) > 0$.

For the S-organization, $\frac{\partial w_S^i}{\partial x_i} > 0$ and $\frac{\partial w_S^i}{\partial x_j} = 0$ holds additionally. Therefore, $\frac{dY_S}{dr} > \frac{dx_S}{dr}$ for $\forall r < \tau$. This implies that $\frac{dY_S}{dr} > \frac{dx_S}{dr} > 0$ for $\forall r < r_S$ leading to $\tilde{r}_s > r_S^*$. For the M-organization,

$$\frac{\partial w_M^i}{\partial x_i} + \frac{\partial w_M^j}{\partial x_j} = \frac{1}{2} \mu(r) P'(\frac{x_M^*}{2}) - \frac{2}{3} \mu(r) P'(\frac{x_M^*}{2}) P(\frac{x_M^*}{2})$$

$$= \mu(r) P'(\frac{x_M^*}{2}) (\frac{1}{2} - \frac{2}{3} P(\frac{x_M^*}{2})) > 0$$

if and only if $P(\frac{x_M^*}{2}) < \frac{3}{4}$. Hence, it is not clear if $\frac{dY_M}{dr} > \frac{dx_M}{dr}$ holds for $\forall r < \tau$ in general.

Now assume $c(X) = \frac{1}{2} cx^2$. Then,

$$\frac{dx_M^*}{dr} = \frac{\mu'(r) P'(\frac{x_M^*}{2})(3 - 2P(\frac{x_M^*}{2}))}{6 \mu'(\frac{x_M^*}{2}) - \mu(r) P''(\frac{x_M^*}{2})(\frac{3}{2} - P(\frac{x_M^*}{2})) + \mu(r) P'(\frac{x_M^*}{2})^2}$$

$$< \frac{\mu'(r) c'(\frac{x_M^*}{2})}{\mu(r) c''(\frac{x_M^*}{2})} = \frac{\mu'(r) x_M^*}{\mu(r) \frac{1}{2}} \quad (24)$$

where the inequality is derived from the first-order condition $\mu(r) P'(\frac{x_M^*}{2})(\frac{1}{2} - \frac{1}{3} P(\frac{x_M^*}{2})) = c'(x_M^*)$ and $P'' < 0$. 

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In order to show that \( \frac{\partial w_i^M}{\partial r} + \left( \frac{\partial w_i^M}{\partial x_i} + \frac{\partial w_i^M}{\partial x_j} \right) \frac{dx_M^*}{dr} > 0 \) always holds, we assume \( P(\frac{x_M^*}{2}) > \frac{3}{4} \).

Then,

\[
\frac{\partial w_i^M}{\partial r} + \left( \frac{\partial w_i^M}{\partial x_i} + \frac{\partial w_i^M}{\partial x_j} \right) \frac{dx_M^*}{dr} > \mu'(r)P(\frac{x_M^*}{2})(1 - \frac{2}{3}P(\frac{x_M^*}{2})) + \mu'(r) \frac{x_M^*}{2} P'(\frac{x_M^*}{2})(\frac{1}{2} - \frac{2}{3}P(\frac{x_M^*}{2}))
\]

from (24)

\[
> \mu'(r)P(\frac{x_M^*}{2})(1 - \frac{2}{3}P(\frac{x_M^*}{2})) + \mu'(r)P(\frac{x_M^*}{2})(\frac{1}{2} - \frac{2}{3}P(\frac{x_M^*}{2}))
\]

\[
= \mu'(r)P(\frac{x_M^*}{2})(\frac{3}{2} - \frac{4}{3}P(\frac{x_M^*}{2})) > 0
\]

where the second inequality is obtained from \( P(x) > xP'(x) \), a property of concave functions with \( P(0) = 0 \) and \( P'(x) > 0 \).

This leads to \( \frac{dY^M}{dr} > 0 \) for \( 0 \leq \forall r < \tau \) implying that \( \frac{dY^M}{dr} > 0 \) for \( 0 \leq \forall r \leq r_M^* \).

Therefore, \( \tilde{r}_M > r_M^* \).

C  Proof of Proposition 5

By substituting \( P(x) = 1 - e^{-x} \) into (18), we get

\[
\frac{d\pi_S}{dr} = v'(r) + \mu'(r) \left[ \frac{1}{2} P'(x_S^*) + \frac{1}{\mu(r) e^\eta(x_S^*)} - \frac{1}{2} \mu(r) P''(x_S^*) \right]
\]

\[
= v'(r) + \mu'(r) \left[ \frac{1}{2} P'(x_S^*) + \frac{1}{\mu(r) e^\eta(x_S^*)} + \frac{1}{2} \mu(r) e^{-x_S^*} \right]
\]

\[
= v'(r) + \mu'(r) \left[ \frac{1}{2} P'(x_S^*) + \frac{c'(x_S^*) \left( \frac{1}{\mu(r) e^\eta(x_S^*)} + \frac{c'(x_S^*)}{c'(x_S^*)} + 1 \right)}{\mu(r) e^\eta(x_S^*) / c'(x_S^*) + 1} \right]
\]

(25)

where the last line is derived by using the first-order condition \( \frac{\partial w_S^i}{\partial x_i} = \frac{1}{2} \mu(r) P'(x_S^*) = \frac{1}{2} \mu(r) e^{-x_S^*} = c'(x_S^*) \).

Similarly,
\[
\frac{d\pi_M}{dr} = v'(r) + \mu'(r)\left[2P\left(\frac{x_M^*}{2}\right) - \frac{2}{3}P\left(\frac{x_M^*}{2}\right)^2\right]
+ \frac{2}{\mu(r)} c''(x_M^*) - \frac{1}{2}\mu(r)\left\{P''\left(\frac{x_M^*}{2}\right)\left(\frac{1}{2} - \frac{1}{3}P\left(\frac{x_M^*}{2}\right) - \frac{1}{3}P''\left(\frac{x_M^*}{2}\right)^2\right)\right\}
\]
\[
= v'(r) + \mu'(r)\left[2P\left(\frac{x_M^*}{2}\right) - \frac{2}{3}P\left(\frac{x_M^*}{2}\right)^2\right] + \frac{2}{\mu(r)} c''(x_M^*) - \frac{1}{2}\mu(r)\left(c''(x_M^*) + \mu(r)\left(\frac{1}{3}e^{-x_M^*} + \frac{1}{12}e^{-\frac{x_M^*}{2}}\right)\right)
\]
\[
> v'(r) + \mu'(r)\left[2P\left(\frac{x_M^*}{2}\right) - \frac{2}{3}P\left(\frac{x_M^*}{2}\right)^2\right] + \frac{c'(x_M^*)}{\mu(r)} \left(\frac{1}{c''(x_M^*)/c'(x_M^*) + 1}\right)
\] (26)

where the last line is derived by using the first-order condition 
\[
\frac{\partial w}{\partial x_i} = \frac{\mu(r)}{3} P''\left(\frac{x_M^*}{2}\right)\left(1 - P\left(\frac{x_M^*}{2}\right)\right) + \frac{\mu(r)}{6} e^{-x_M^*} + \frac{\mu(r)}{6} e^{-\frac{x_M^*}{2}} = c'(x_M^*).$

Compare (25) and (26) term by term. From \(x_M^* > x_S^*\), the result in Proposition 3,
\[
\frac{1}{2} P\left(x_S^*\right) < \frac{1}{2} P\left(x_M^*\right) = \frac{1}{2} e^{-x_M^*} < \frac{4}{3} + \frac{1}{3} e^{-\frac{x_M^*}{2}} - \frac{2}{3} e^{-x_M^*} = 2P\left(\frac{x_M^*}{2}\right) - \frac{2}{3} P\left(\frac{x_M^*}{2}\right)^2
\]
\[
c'(x_S^*) < c'(x_M^*), \text{ and}
\]
\[
\frac{1}{c''(x_S^*)/c'(x_S^*) + 1} < \frac{1}{c''(x_M^*)/c'(x_M^*) + 1}
\]

where the last inequality is derived from the assumption that \(c''(x)/c'(x)\) is non-increasing.

Hence, \(\frac{d\pi_M}{dr} < \frac{d\pi_S}{dr}\) for all \(r\) such that \(\mu'(r) > 0\). This concludes the proof.


References


