Abstract. In this paper, considering an agency framework, we compare benefits and costs related to a hierarchical organization with those deriving from a decentralized one. In the first system projects selected by the agent are submitted to the principal’s judgement, while the second is characterized by the delegation of the decisional power to the agent, who is able to autonomously decide which projects to implement. With perfect information, the optimal level of the agent’s effort is lower in hierarchy compared to delegation, then the organizational choice is influenced by the possibility to compensate the further check offered by the principal under hierarchy with the higher effort provided by the agent under delegation. Moreover, we show that the relative efficiency of the hierarchical system worsens with imperfect information. When effort is not observable, encouraging the agent to work hard requires the adoption of performance based compensation systems. We show that, with risk-averse agents, the use of these systems is more costly under hierarchical systems rather than under decentralization. From the comparison of the hierarchical and decentralized systems, it emerges a trade-off between the advantages deriving from the principal’s screening activity and the costs that this induces in terms of higher agency costs. A hierarchical structure tends to prevail the higher are the costs deriving from the implementation of bad projects (Type-II errors), the lower are expected profits from good projects, the higher is the principal’s screening ability.

JEL classification: D23; L22; J330.

1. Introduction

A growing body of research shows that the allocation of decisional rights among agents influences the performance of the economic organizations in which they operate. Even if decisional rights and property rights are formally strictly related, the entrepreneur may decide to delegate some decisional power to other subjects inside the organization. This decision modifies agents’ incentives, their use of the available information, the communication costs, the errors entailed in the decisional process, etc. Firms are usually interested in conferring decisional power to their employees because better decisions can be made thanks to their contribution, since they are able to collect raw information directly from the production floor and possess unique knowledge due to their work experience.

A number of recent empirical studies (Caroli, Greenan and Guellec, 2001; Batt, 1996; Osterman, 1994) shows that while until the early Seventies the prevailing organizational system
in industrialized countries was characterized by a strong centralization of decisional rights, in recent years many companies have adopted an organizational structure with a highly decentralized decision making process. Emphasis is placed on the so-called “employees’ empowerment”, which refers both to workers’ participation in management and to greater autonomy of workers who are expected to work without the direction of managers.

The recent literature on organizational systems and on the allocation of authority in organizations provides interesting insights for the interpretation of this phenomenon. Some authors refer to technological change that favoring the transmission and acquisition of information has allowed to substitute the superiors’ activity with the direct interaction between workers (Bolton and Dewatripont, 1994; Garicano, 2000). Other works relate the organizational change to the need to adapt to the increased competition and to the higher variability of demand (Aoki, 1986). In face of the increased uncertainty of economic contexts the principal, being unable to evaluate the agent’s choice, allows him autonomy and uses incentive contracts to prevent his opportunistic behavior (Prendergast, 2002).

In this paper, we analyze the choice of the organizational structure in an agency context, focusing on the impact of different organizational structures on the agent’s incentives to provide effort. We assume that in the decentralized system the agent acquires information on a range of projects, evaluates them and independently decides which to implement. On the contrary, in case of hierarchy all projects are proposed to the principal and only those approved are implemented. A project may be represented by an idea for the introduction of a new product, a change in the production process, an opening of a new branch, etc.

We suppose that in both structures the expected quality of the project is positively related to the agent’s effort. Moreover, under hierarchy the probability of implementing a good project also depends on the manager’s screening abilities, that we assume as exogenously given.

Firstly, assuming perfect observability of effort, we show that the optimal level of the agent’s effort under delegation is higher compared to hierarchy. Therefore, the choice between hierarchy and delegation in terms of welfare depends not only on the relative relevance of costs deriving from the rejection of profitable projects (Type-I errors) and from the implementation of bad projects (Type-II errors), but it is strictly related to the principal screening abilities and to the cost of the agent’s effort. Delegation is more efficient than hierarchy when the higher effort provided by the agent is able to compensate for the check offered under hierarchy by the principal, which reduces the probability of implementing bad projects. However, when the principal’s screening ability is low, the relevance of this advantage is scarce and it results convenient to increase the agent’s effort (if it is not too costly) in order to reduce Type-II errors.

In the second part of the paper we consider that the agent’s effort is not observable, which gives rise to moral hazard problems. We assume that in order to encourage the agent to provide
effort, the firm - both in the decentralized and in the centralized organizational structure - adopts a performance related pay contract, in which the agent’s wage is directly related to the gross profits deriving from the implemented projects\(^1\). On the basis of this contract, we compare the benefits and costs deriving from hierarchy and delegation, showing the effects that the organizational structure produces on incentives.

We point out that under a hierarchical structure inducing the agent to provide a high level of effort might be more costly for the firm for two related reasons. Firstly, under hierarchy the agent’s effort in selecting a good project will produce a positive result only as long as the principal is able to recognize the true nature of the proposed project. On the other hand, proposing bad projects will not result in a lower wage when the principal correctly evaluates the project and refuses it. As a consequence, to induce the agent to provide effort, it is necessary to pay him a higher wage when good results are obtained and punish him more harshly in case of bad outcomes. However, if the agent is risk-averse and it is not possible to force him to pay a fine to the firm in case a bad project is implemented, providing higher incentives will be costly for the firm, because of the payment of a higher average wage.

In this framework, a high principal’s screening ability has a positive effect not only, as discussed above, on the gains deriving from avoiding Type-I and Type-II errors, but also on the costs related to the incentive system.

The importance of the superior’s performance in evaluating his subordinate’s suggestions emerges in all the systems known as “total quality management”, “continuous improvement”, “suggestion box” which ask for the employees’ involvement aimed at increasing firm’s productivity or the quality of its products. Since employees’ suggestions are implemented only if approved by a superior, a key factor for the success of these plans is the superior’s ability in recognizing good and bad projects. On the other hand, stimulating workers participation is very costly and does not produce positive results when the superior is not interested in carefully reviewing the employees suggestions and in implementing those that have merit.

Many scholars in management techniques stress that ignoring workers’ suggestions is worse that not asking for employees’ suggestions at all. Roxanne Emmerich, a successful business consultant, writes “According to an Employee Involvement Association study, the average employee in Japan submits 32 ideas for improvement per year, compared to the average employee in the United States who submits 0.17–a ratio of 188-1. The root of this problem stems from the fact that only 33 percent of U.S. employees' ideas are adopted–compared to 87 percent from Japanese workers.”

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\(^1\) In a preliminary version of this paper, consistently with empirical evidence, we assumed two different incentive system: while in decentralized systems firms use a performance related pay, in a hierarchical
Workers will hardly be motivated in looking for new ideas when there is a high probability that their suggestions will be refused by the superior. Even when refusals do not depend on the scarce interest of the superior in evaluating proposals, a high percentage of rejections may produce negative effects. Since it is not easy to prove to workers that their proposals would have been unsuccessful, a high number of rejections may harm the workers’ morale and induce them to operate for the failure of projects selected by the management (see Akerlof and Kranton, 2000). Then, before implementing a suggestion system it is useful to consider if workers are really able to provide sound proposals.

The paper is organized in the following way. Section 2 discusses briefly the related literature on the allocation of power inside organizations. Section 3 presents the main hypothesis of our analysis and, assuming perfect information, examines the optimal level of effort under hierarchy and delegation. Section 4 considers the existence of asymmetric information and analyses the effects produced by the compensation system adopted on the optimal level of effort under the two organizational structure, showing that eliciting a high level of effort is more costly under hierarchy. In Section 5 this aspect is emphasized considering discrete levels of effort, which allows to simplify the comparison between the two organizational structures. Section 6 offers some concluding remarks.

2. Related works

The organizational choice has been analyzed following two different approaches, one focuses on the organization of knowledge in production and the other emphasizes the influence of incentive problems on the allocation of decisional right.

In the first one, leaving aside incentive problems, the choice between centralization or decentralization emerges from the trade-off between the optimal use of information available at lower level, allowed by a decentralized decision-making process, and the advantages of coordination and control, allowed by a centralized one. The organizational structure is aimed to solve co-ordination problems taking into account the costs of acquisition, processing and communication of information, delays and errors in decision making, advantages from specialization (Aoki, 1986; Sah and Stiglitz, 1986; Radner, 1993; Van Zand, 1988; Bolton and Dewatripont, 1994; Garicano, 2001).

In some of these analysis authority defines a communication network, while in others authority corresponds to the right to choose among different alternatives. Aoki (1986) considers the selection of the production level and shows that the delegation of decisional power to system, the agent is compensated on the basis of subjective performance evaluation by the principal. However, the qualitative results do not change with these different assumptions.
agents, directly involved in the production process, allowing a better use of local information, tends to prevail on the hierarchical organization when the economic context is characterized by a high uncertainty.

In the Sah and Stiglitz’s (1986) paper authority corresponds to the right to choose which projects to undertake, among a wide set. These authors, assuming that individuals’ judgements entail errors, in that sometimes good projects get rejected (Type-I errors) and bad projects get accepted (Type-II errors), show that the delegation of authority to the agent influences the type of errors that more frequently characterize the decision making process. This view of hierarchical system is similar to that adopted in this paper. However, while Sah and Stiglitz assume an exogenously given projects’ portfolio, in our approach the probability of discovering good projects depends on the agent’s effort. The trade-off we study is related to Type-I and Type-II errors in which organizations incur, but focuses on the impact that these errors produce on the incentives to provide effort.

Incentive problems, left aside in the previously cited papers, become crucial in the second approach, initially proposed by Aghion and Tirole (1997) and based on the hypothesis that the agent has private objectives diverging from those of the principal. In this work, the allocation of authority inside the organization influences the solution of agency problems. The delegation of authority to the agent, allowing him to choose projects that maximize his private benefits, enhances his effort in the acquisition of information concerning projects to be implemented. However, this higher effort can be obtained only suffering a cost in terms of loss of control, since the implemented projects do not maximize the principal’s payoff.

Baker, Gibbons and Murphy (1999) develop Aghion and Tirole’s analysis in a dynamic framework focusing on the credibility of delegation. They argue that the delegation of decisional rights to the agent can only be informal (the principal is always able to overturn subordinates’ decisions) and based on self-enforcing implicit contracts.

Following Aghion and Tirole (1997), we do not consider the problem of the principal’s commitment in giving delegation, that is, we assume that delegation is contractible. However, while Aghion and Tirole assume that the agent can pursue his own opportunistic objective if he gets delegation, without any possibility for the principal to use incentive contracts or other mechanisms to prevent agent’s moral hazard, we use the standard formulation of agency contracts in which the agent’s opportunistic behavior can be restrained by the principal through performance related compensation schemes.

A similar assumption is adopted by Zabojnik (2002). In his paper, under the centralized system the agent does not make proposals, but has the task to implement the project selected by his superior. The author shows that it might be more costly to induce an employee to work on the project selected by the superior rather than on a project selected by himself. In fact, if the agent
believes that the project selected by his superior has a low probability of success, he will be discouraged in putting high effort to implement that project. On the contrary, if the agent is free to implement the project that, in his opinion, has more probability of success, stimulating his effort will be less costly, since its expected rewards are higher.

In our paper we obtain similar results due to the fact that under the hierarchical system the agent’s effort will produce the implementation of a project conditioned to the principal approval. The principal screening activity reduces both the probability of incurring in loss, since some of the negative projects erroneously proposed by the agent will be recognized and rejected, and the probability of obtaining positive results, since the principal will erroneously refuse some of the positive projects proposed by the agent. Then, in order to stimulate the agent’s effort it is necessary to provide higher incentives that will translate in higher costs for the firm when the agent is risk-adverse.

As in the above cited papers, in our work decisional right can be disjoined from property rights. We do not consider problems analyzed in the property rights school (Grossman and Hart, 1986 and Hart and Moore, 1990), in which authority (that is, the residual rights of control) deriving from ownership of physical assets is a device useful to protect specific investments from hold-up. In our analysis specific investment are absent.

3. The model

We assume that the agent’s task consists in acquiring information in order to evaluate the profitability of alternatives projects. Under the decentralized organizational structure (delegation), the agent has the right to implement the selected project while in hierarchy he makes a proposal to the principal who evaluates it and decides for approval or rejection.

Both the agent and the principal could make errors of judgement, in that sometimes bad projects are erroneously evaluated as good projects, actually determining a negative payoff, and sometimes good projects are erroneously evaluated as unprofitable. The communication process between the agent and the principal is imperfect and only the judgements they express about projects can be communicated.

The agent

The task of the agent (he) is to acquire information in order to develop a project $X$. The project’s payoff can take only two values: $X_G > 0$ (“good project”) and $X_B < 0$ (“bad project”).

The probability $p$ of developing a good project depends positively on the effort $e$ provided by the agent in searching profitable projects and in analyzing their optimal
implementation in the relevant economic environment. In order to keep the analysis simple we assume \( p(e) = e \).

The agent is risk-averse and, for the sake of simplicity, we assume that his utility function takes the following form: \( u = W^\alpha - \gamma e^2 / 2 \), where \( W \) is the compensation received by the agent, \( \alpha \) is a parameter which takes into account the worker’s risk aversion \((0 < \alpha < 1)\), where the degree of risk-aversion is decreasing in \( \alpha \) and \( \gamma e^2 / 2 \) represents the disutility of his effort. The agent’s reservation utility level is denoted by \( d \).

**The principal and the organizational structure**

The principal (she) is risk-neutral and her utility is given by the revenues from projects less the wage paid to the agent. She has the possibility to choose between two organizational structures: delegation and hierarchy.

As argued above, in the delegation system, projects are selected autonomously by the agent who decides to implement any project he considers profitable, without any control by the principal. Therefore, with probability \( e \), the agent selects and implements a project, whose payoff is equal to \( X_G \), while with probability \( (1 - e) \) a bad project is realized, determining a payoff \( X_B \).

On the contrary, under the hierarchical structure, the principal actively participates in the selection process, by independently acquiring information and evaluating projects proposed by the agent. She has the right to approve or reject the proposal made by the agent, and only projects proposed by the agent and approved by the principal are implemented.

On the one hand, the principal’s activity may reduce losses deriving from the selection of bad projects, but, on the other hand, it may have a negative effect on welfare if she erroneously rejects good projects proposed by the agent.

The principal is able to recognize with a certain probability the true nature of the project, understanding if the effective payoff is positive or negative. The screening ability of the principal is exogenously given and indicated by \( s \). We assume that the cost of the principal’s activity is equal to zero. With probability \( s \) the principal discovers the real nature of the project, approving good projects and rejecting the bad ones, while with probability \( (1 - s) \) she takes a wrong decision, approving a bad project (Type-II error) or refusing a positive project (Type-I errors). Table 1 shows the four possible cases with the relative probabilities.

**Table 1. Probabilities of project’s approval or rejection under hierarchy**
<table>
<thead>
<tr>
<th>Quality of the project</th>
<th>Principal’s decision</th>
<th>Probability</th>
<th>Errors’ Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>Approved</td>
<td>$se$</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>Rejected</td>
<td>$(1 - s)e$</td>
<td>Type-I errors</td>
</tr>
<tr>
<td>Bad</td>
<td>Rejected</td>
<td>$s(1 - e)$</td>
<td></td>
</tr>
<tr>
<td>Bad</td>
<td>Approved</td>
<td>$(1 - s)(1 - e)$</td>
<td>Type-II errors</td>
</tr>
</tbody>
</table>

### 3.1. Perfect information and first best levels of effort

Assuming that the agent’s effort is observable and verifiable and a complete contract can be written and enforced, we determine the first best level of effort under both the organizational structures. A constant wage is paid to the agent as compensation for his effort.

#### Optimal effort under delegation

Under delegation, it is possible to obtain a positive payoff equal to $X_G$ when the agent chooses, with probability $e$, a good project, and a negative payoff $X_B$ when the agent, with probability $(1 - e)$, implements a bad project. The joint expected welfare of the boss and her subordinate, $S^D$, is equal to the firm’s expected profits plus the agent’s utility, that is:

\[
S^D = eX_G + (1 - e)X_B - \frac{\gamma e^2}{2}
\]

since the wage paid by the firm elides with the wage certainty equivalent.

From the first order condition we obtain the optimal effort:\(^2\)

\[
\frac{\partial S^D}{\partial e} = X_G - X_B - \gamma e = 0
\]

\[
e^*_D = \frac{X_G - X_B}{\gamma}
\]

Expression (3) defines the efficient level of effort under the organizational structure that delegates authority to the agent. It is possible to see that the efficient level of effort is:

1) increasing in the positive payoff $X_G$, that is, when good projects are more profitable;

---

\(^2\) Given our assumptions, second-order conditions for a maximum are respected.
2) increasing in the negative payoff $|X_B|$ resulting from the implementation of bad projects: if losses from bad projects are large, it is efficient to increase effort to avoid them;

3) decreasing in $\gamma$, since effort is more costly in terms of disutility.

Optimal effort under hierarchy

Under centralization, it is possible to obtain a positive payoff $X_G$ when the agent proposes a good project which is recognized as good by the principal, and a negative payoff $X_B$ when the agent proposes a bad project which is implemented since the principal does not find out its true nature (see Table 1 for probabilities). The projects proposed by the agent and refused by the principal are not implemented leading to a payoff equal to zero. As a consequence, the total expected welfare is equal to:

$$S^H = s e X_G + (1 - e)(1 - s) X_B - \frac{\gamma e z}{2}$$

The first order condition is the following:

$$\frac{\partial S^H}{\partial e} = s X_G - (1 - s) X_B - \gamma e = 0$$

from which the agent’s optimal level of effort results:

$$e_{FB}^H = \frac{s X_G - (1 - s) X_B}{\gamma}$$

Similarly to the results obtained under decentralization, the agent’s optimal effort results increasing in $X_G$ and in $|X_B|$, while is decreasing in $\gamma$.

Moreover, under hierarchy the agent’s effort is increasing in $s$, that is the principal’s ability is complementary to the agent’s effort, if $(X_G + X_B) > 0$, and decreasing in $s$, that is the principal’s ability is a substitute for the agent’s effort, if $(X_G + X_B) < 0$.

To explain this result, it is helpful to consider that if $(X_G + X_B) > 0$, this implies that $X_G$ is greater compared to $|X_B|$, that is gains from good projects are more relevant than losses deriving from bad projects. Since under the hierarchical system, good projects need a double approval to be implemented, it results optimal to encourage high effort when the principal has high ability. On the one hand, the agent effort in selecting good projects would be lost if the principal is not able to recognize that the selected projects are good; on the other hand, a high ability principal is not able to implement good projects if the agent does not propose them. As discussed by Jacobs (1981, p. 687) and Thompson (1967) the agent’s effort is input for the
principal’s activity and can produce a positive result only if the principal’s screening ability is sufficiently high.

On the contrary, when \( X_G \) is lower than \( |X_B| \), it means that it is more important to avoid big losses arising from bad projects, rather than selecting good projects. However, to reject bad projects it is sufficient that only one of the two subjects involved in the selection process is able to recognize them: bad projects are refused whenever the agent or the principal expects a negative payoff and, therefore, in this case the principal’s abilities and agent’s effort are substitute. Therefore, when the principal screening ability is high, stimulating a high agent’s effort is not convenient, as in this case the main role is played by the principal who is able to recognize bad projects. Only if the principal’s screening ability is low, it is worthwhile to require a high level of the agent’s effort, in order to compensate for losses that might derive from the principal activity.

As a consequence, the efficient level of the agent effort could be high because the principal ability is high and \( X_G > |X_B| \), or because the principal ability is low and \( X_G < |X_B| \).

This result can be useful to analyses the relationship existing between the incentives offered by firms respectively to managers and subordinates. In fact, in more general contexts the principal’s screening activity depends on the principal’s effort. According to our results, when the main objective is to avoid Type-I errors, it is optimal to stimulate both the manager and the subordinate effort. Giving high incentives to the manager (in order to increase \( s \)) will not produce desirable results when adequate incentives for his subordinates are missing. On the contrary, when the main objective is to avoid big losses (Type-II errors) it is possible to offer good incentives only to one of the subjects involved in the selection process (the subject who suffers a lower cost from effort).

### 3.2. An efficiency comparison between hierarchy and delegation

In the previous Section, we have obtained the first best levels of effort under the two alternative organizational structures. It is immediate to show, comparing expression (3) with expression (6), that the efficient level of effort under delegation is higher than under hierarchy:

\[
\frac{X_G - X_B}{\gamma} > \frac{sX_G - (1-s)X_B}{\gamma}
\]

which, given our assumptions, is always true.

Let us compare the expected welfare obtained under the two organizational systems, to determine their relative efficiency, by substituting the corresponding optimal levels of effort in equations (1) and (4).
The welfare obtained under delegation is equal to:

\[ S^D = \frac{[X_G - X_B] F}{2\gamma} + X_B \]  

The welfare realized under hierarchy is equal to:

\[ S^H = \frac{[sX_G - (1-s)X_B] F}{2\gamma} + (1-s)X_B \]

While the traditional approach based on exogenous levels of effort (Sah and Stiglitz, 1986) considers hierarchy more effective in minimizing Type-II errors and delegation more suitable to avoid Type-I errors, in our case it is also necessary to consider both the principal’s ability and those variables determining the agent’s optimal effort. As in Sah and Stiglitz paper it emerges that the relative advantage of hierarchy respect to delegation reduces as \( X_G \) increases, while an increase in \( X_s \) positively affects the relative advantage of hierarchy only when \( s \) is sufficiently high.\(^3\) In fact, the negative output deriving from the implementation of bad projects is lower in hierarchy compared to delegation only when the greater effort provided by the agent under delegation is not able to compensate for the principal’s activity, given the lower effort provided by the agent in the hierarchical system.\(^4\)

Principal’s screening ability plays a central role in determining the efficient organizational structure. The relative advantage of hierarchy respect to delegation is increasing in the principal’s abilities\(^5\), since a higher \( s \) increases the probability of approving good projects and rejecting bad ones.

Finally, the relative advantage of the hierarchical system, which requires a lower level of the agent’s effort, increases when the cost of the agent’s effort increases. Since generally the cost of the agent’s effort in developing new ideas and project reduces with his ability, this result is consistent with the literature emphasizing the role of worker’s education in defining the allocation of decisional right (Marsden e Ryan, 1991; Soskice, 1993).

\(^3\) Defining \( F = (S^H - S^D) \), the first derivative of \( F \) respect to \( X_G \) is negative, \( \frac{\partial F}{\partial X_G} = X_G (s^2 - 1) - X_B [s(1-s) - 1] < 0 \), while the derivative of \( F \) respect to \( X_B \) has an ambiguous sign depending on \( s \), \( \frac{\partial F}{\partial X_B} = X_G [1 - s(1-s)] - s(2-s)X_B - \gamma s \).

\(^4\) In our framework the principal’s screening ability can be substituted by the agent’s effort. In more complex analysis the degree of substitution depends on variables such as the agent’s information and ability. On this point see Puga and Trefler (2003).

\(^5\) \[ \frac{\partial S^H}{\partial s} = \frac{[sX_G - (1-s)X_B](X_G - X_B)}{\gamma} - X_B > 0 \]
4. Moral hazard, incentives, and organizational structure

In Section 3 it has been shown, assuming perfect observability of effort, that under delegation it is optimal to require a higher level of effort to the agent compared to hierarchy. However, as evidenced by the wide literature on asymmetric information, in many situations the agent’s effort is hardly observable by the principal or verifiable by an external authority. In these cases, the agent is tempted to shirk and he is encouraged to provide effort only through the stipulation of appropriate incentive contracts.

We assume that the compensation system used by the firm to encourage the agent to provide effort consists in paying a wage related to the revenues realized through the implementation of projects, which we assume fully verifiable.

Since workers are risk adverse this compensation system does not allow for efficient solutions. This assumption is crucial for our results because it makes costly to provide incentives. Moreover, in order to simplify the analysis, we assume that the firm cannot receive any kind of payment from workers. This means that a wage equal to zero represents the severest punishment for workers’ shirking behavior. The exclusion of penalties is quite realistic since workers are usually liquidity constrained (because of imperfect capital markets), and, moreover, because there exist legal constraints on the possibility to impose a negative wage to workers.\(^6\)

We show that when the risk-averse worker cannot be forced to pay any fine to the firm in case of unsatisfactory performance or negative results, it is more costly to elicit a given amount of effort under hierarchy rather than under delegation.

**Incentive contracts under decentralized decision-making**

Under delegation, the principal gives to the agent the authority to choose and implement any project he considers profitable. We assume that the compensation scheme offered by the firm consists in the payment of a bonus \(w_D\) when a positive result is obtained and a wage equal to zero when a bad project is implemented.\(^7\)

As a consequence, the worker’s utility is given by the utility deriving from obtaining the bonus \(w_D\), which occurs with probability \(e\) (the probability that under delegation a good project is realized), minus the cost deriving from the disutility of effort:

\[
U_A = e(w_D)^2 - \frac{\gamma e^2}{2}
\]

---

\(^6\) More generally, the same results are obtained imposing a lower bound on wages.

\(^7\) It can be shown that this contract is equivalent to a performance related pay contract where the wage is determined as a percentage \(\beta\) of the realized output.
Maximizing the utility function with respect to the effort $e$, we obtain
\[
\frac{\partial U_A}{\partial e} = (w_D)^\alpha - \gamma e = 0
\]
from which the worker’s reaction function is derived:
\[
(11) \quad e = \frac{(w_D)^\alpha}{\gamma}
\]
Given the assumption that it is not possible to impose any penalty on the agent (the wage must always be non-negative), it follows that the participation constraint is not binding and can be ignored.\(^8\)

The firm’s profit function is the following:
\[
(12) \quad \Pi^D = eX_G + (1-e)X_B - ew_D,
\]
where $ew_D$ represents the worker’s expected wage. By substituting in $\Pi^D$, $w_D = \left[e\right]^{\beta \alpha}$, we get:
\[
(13) \quad \Pi^D = eX_G + (1-e)X_B - e[\gamma]^{\beta \alpha}
\]
From the first order condition:
\[
\frac{\partial \Pi^D}{\partial e} = X_G - X_B - \frac{1+\alpha}{\alpha} \gamma^{\beta \alpha} e^{\beta \alpha} = 0,
\]
the optimal level of effort required by the firm results equal to:
\[
(14) \quad e^D = \frac{1}{\gamma} \left[ \frac{\alpha(X_G - X_B)}{1+\alpha} \right]^{\gamma \alpha}
\]
Because of the greater cost deriving from the compensation system, this level of effort (second best), is below the first-best level (equation 3). In fact, $e^D$ can now be reached paying a bonus: $w_D = \frac{\alpha(X_G - X_B)}{1+\alpha}$

**Incentive contracts under centralization of authority**

Under centralization the agent receives a bonus $w_H$ when the project he proposes is implemented with positive results and a wage equal to zero both in case of negative results and rejection by the manager.

The worker’s utility is equal to:
\[
(15) \quad U_A = se(w_H)^\alpha - \frac{\gamma^2}{2}
\]
where the first term represents the expected wage and the latter indicates the disutility deriving from effort.

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\(^8\) This is a typical result of the efficiency wage approach (see, for example, Tirole, 1989, p.68).
From the first order condition, the optimal choice of effort for the agent is obtained:

\[ e = s \left( \frac{w_H}{\gamma} \right)^{\psi_a} \]  

(16)

It is important to note that the effort that the agent decides to provide is increasing in the principal’s ability \( s \): given \( w_H \), the effort is greater the higher the principal’s ability. Since, the bonus that the firm has to pay to get the effort \( e \) is equal to \( w_H = \left( \frac{\gamma e}{s} \right)^{\psi_a} \), a low-ability principal must pay a higher bonus to stimulate the agent’s effort.

Comparing this bonus with that obtained under delegation, it follows that, under a hierarchical system, in order to elicit a given amount of effort, it is necessary to pay a higher bonus compared to delegation:

\[ w_H > w_D \rightarrow \left( \frac{\gamma e}{s} \right)^{\psi_a} > (\gamma e)^{\psi_a} \]  

since \( s < 1^9 \).

Taking into account \( w_H = \left( \frac{\gamma e}{s} \right)^{\psi_a} \), which is paid with probability \( se \), the firm’s profits are equal to:

\[ \Pi^H = se(X_G) + (1 - e)(1 - s)(X_B) - se\left( \frac{\gamma e}{s} \right)^{\psi_a} \]  

(17)

The level of effort desired by the firm is derived from the condition:

\[ \frac{\partial \Pi^H}{\partial e} = sX_G - (1 - s)X_B - \frac{1 + \alpha}{\alpha} \gamma^{\psi_a} s^{\psi_a - 1} e^{\psi_a} = 0 \]  

and \( e^H \) is equal to:

\[ e^H = \frac{1}{\gamma} s^{1-\alpha} \left[ \frac{\alpha sX_G - (1 - s)X_B}{1 + \alpha} \right]^{\psi_a} \]  

(18)

It clearly emerges that the effort required by the firm is below the first-best level: \( e^H < e^H_{FB} \). The level of effort \( e^H \) can be obtained paying a bonus equal to

\[ w_H = \frac{\alpha [sX_G - (1 - s)X_B]}{s(1 + \alpha)} \]  

This bonus results higher than that paid under delegation when \( s \leq 1/2 \).

Moreover, the level of agent’s effort required by the hierarchical system is lower compared to delegation:

---

9 The bonus would result equal only if \( s=1 \).
\begin{equation}
e^D > e^H \quad \Rightarrow \quad \frac{1}{\gamma} \left[ \frac{\alpha(X_G - X_B)}{1 + \alpha} \right]^\alpha > \frac{1}{\gamma} s^{-\alpha} \left[ \frac{\alpha(sX_G - (1-s)X_B)}{1 + \alpha} \right]^\alpha
\end{equation}

\[ X_G \left( 1 - s^\alpha \right) > X_B \left( 1 - (1-s)^\alpha \right) \]
which is always true since \( X_B \) is negative.

The principal’s ability influences the optimal effort required by the firm in the following way:

\begin{equation}
\frac{\partial e^H}{\partial s} = \frac{1 - \alpha}{\gamma} s^{-\alpha} \left[ \frac{\alpha(sX_G - (1-s)X_B)}{1 + \alpha} \right]^\alpha + \frac{\alpha}{\gamma} s^{-\alpha} \left[ \frac{\alpha(sX_G - (1-s)X_B)}{1 + \alpha} \right]^{\alpha-1} \frac{\alpha[X_G + X_B]}{1 + \alpha}
\end{equation}

Analogously to the case of verifiability, the agent’s effort and the principal’s screening ability can be substitutes or complements. However, when opportunistic behavior is taken into account, the relationship between these variables does not depend only on the sign of \((X_G + X_B)\). Independently on the relative importance of Type-I and Type-II errors, the principal’s screening ability produces a positive effect on the agent’s incentives to provide effort. Then, a substitution effect emerges less frequently compared to the case characterized by perfect information.

5. Optimal organizational structure with discrete levels of effort

The efficiency comparison between delegation and hierarchy is complex because of two different choices of effort. In this Section, we aim to compare the benefits and costs deriving from the organizational choice, neutralizing effects arising from the different choice of effort in the two systems. This can be done by assuming that the agent chooses between only two levels of effort.

The agent’s choice is between a high level of effort \( e_H \) and a low level \( e_L \), where \( e_H > e_L \). When the agent offers a high effort the probability of discovering a good project, \( X_G \), is equal to \( p_H \), while with probability \((1-p_H)\) the selected project determines a negative output \( X_B \). If the agent’s effort is low, the probability of selecting a good project, \( X_G \), is equal to \( p_L \), while with probability \((1-p_L)\) a bad project is selected. The cost of providing a high effort is equal to \( c_H \) and the cost of a low effort is equal to \( c_L \). We assume that the agent’s reservation utility is equal to \( d \).
Incentive contracts under delegation

When the agent provides a high level of effort, with probability \( p_H \) a good project is selected determining a payoff equal to \( X_G \). In this case the agent obtains a wage equal to \( w \), while if the project, with probability \( 1 - p_H \), is unsuccessful he obtains a wage equal to zero.

The participation constraint for the agent is equal to:

\[
(19) \quad p_H w^H - c_H \geq d
\]

The agent will decide to provide the high level of effort only when the incentive compatibility condition is satisfied, that is, when the utility deriving from a high effort is higher than the utility deriving from a low effort:

\[
(20) \quad p_H w^H - c_H \geq p_L w^L - c_L
\]

The incentive compatibility condition implies a bonus \( w \) equal to:

\[
(21) \quad w = \left[ \frac{c_H - c_L}{p_H - p_L} \right]^{\frac{1}{\alpha}}
\]

Note that when the worker’s degree of risk-aversion increases, that is, when \( \alpha \) becomes greater, the level of the bonus decreases.

As explained above, we suppose that, given the impossibility to impose a negative wage, the utility the individual obtains providing a high effort is higher than his reservation utility. This means that the participation constraint is not binding.

The profits obtained by the firm are equal to:

\[
(22) \quad \Pi^H = p_H X_G + (1 - p_H) X_H - p_H \left[ \frac{c_H - c_L}{p_H - p_L} \right]^{\frac{1}{\alpha}}
\]

Incentive contracts under hierarchy

Under the hierarchical system, projects selected by the agent are implemented only if approved by the principal. Proposing good projects does not yield any positive payoff for the agent if the principal does not approve them. Then, given the compensation scheme, the agent’s expected payoff depends on the principal ability in finding out the true nature of the project he proposes. Then, the incentive compatibility constraint is equal to:

\[
(23) \quad p_H w^H - c_H > p_L w^L - c_L
\]
From [23], the bonus $G$ paid by the firm is equal to:

$$w = \left[ \frac{c_H - c_L}{s(p_H - p_L)} \right]^\alpha$$

(24)

$w$ is decreasing in $s$ and it is greater than the optimal bonus under delegation (if $s < 1$).

Moreover, the worker’s expected wage results higher in hierarchy than under delegation:

$$sp_H \left[ \frac{c_H - c_L}{s(p_H - p_L)} \right]^\alpha \geq \left[ \frac{c_H - c_L}{p_H - p_L} \right]^\alpha p_H$$

(25)

since $(1/s) \geq 1$

The firm’s profits under hierarchy are equal to:

$$\Pi^H = p_H sX_G + (1 - p_H)(1 - s)X_B - sp_H \left[ \frac{c_H - c_L}{s(p_H - p_L)} \right]^\alpha - c_H$$

(26)

5.1. Social welfare and the choice of the organizational form

The choice between the two organizational structures depends on the total surplus deriving from each of them. Since under the two organizational structure, the worker’s obtains the same certainty equivalent, identical results emerge comparing the firm’s profits.

The social surplus under hierarchy, equal to the firm’s expected profits plus the worker’s certainty equivalent, is the following:

$$S^H = p_H sX_G + (1 - p_H)(1 - s)X_B - p_H \left[ \frac{c_H - c_L}{s(p_H - p_L)} \right]^\alpha + \left( p_H s \right) \left[ \frac{c_H - c_L}{s(p_H - p_L)} \right]^\alpha - c_H$$

(27)

Similarly, under delegation the total surplus is given by:

$$S^D = p_H X_G + (1 - p_H)X_B - p_H \left[ \frac{c_H - c_L}{p_H - p_L} \right]^\alpha + \left( p_H \right) \left[ \frac{c_H - c_L}{p_H - p_L} \right]^\alpha - c_H$$

(28)

In order to compare the efficiency of the two systems it is useful to give a graphical representation of the combinations of $X_G$ and $s$ which equalize the surplus produced under the two systems. Therefore, we find out the threshold values of $X_G$ as a function of $s$:

\[\text{We assume that the profits obtained when the worker provides a high level of effort are higher than those realized with a low level of effort.}\]
\[
\hat{X}_G = -s(1 - P_H) X_B - \frac{1}{(1-s)P_H} \left[ \frac{c_H - c_L}{c_H - c_L} \right]^{1/\alpha} 
\]

The relative advantages of hierarchy increase when the principal’s screening ability is higher, both because of the improvement of the projects selection process and because the agent’s effort becomes less costly (when \( s \) is near 1, the cost of obtaining a high level of effort by the agent is almost equal to the cost sustained under delegation). Therefore, an increase in the principal’s screening ability requires a higher value of \( X_G \), in order to maintain the indifference between the two systems: a higher \( X_G \), increasing the relative importance of type-I errors, especially favors the surplus generated under delegation. Moreover, it can be shown that when \( s \) tends to 1, \( \hat{X}_G \) tends to \(+ \infty\) and for \( s \) which goes to 0, \( \hat{X}_G \) tends to \(- \infty\).

Since \( \frac{\partial X_G}{\partial s} > 0 \) and the sign of \( \frac{\partial^2 X_G}{\partial s^2} \) depends on the value of \( s \) (see appendix) (for high values of \( s \) it is positive, which means that the function is convex, while for low level of \( s \) it could become negative describing a concave function) it is possible to draw the organizational indifference curve” (OIC thereafter) in figure 1.

This figure shows how the relative efficiency of hierarchy and delegation changes with \( X_G \) and \( s \). The OIC represents the threshold values of \( \hat{X}_G \). All the combinations of \( X_G \) and \( s \) lying above the OIC belong to the delegation region since \( S^D > S^H \), while below the OIC are included all those combinations yielding \( S^D < S^H \) and thus defining the hierarchy region.\(^{11}\)

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\(^{11}\) Figure 1 is drawn assuming \( X_B = -500 \); \( P_H = 0.8 \); \( P_L = 0.1 \); \( c_H = 4 \); \( c_L = 1 \); \( \alpha = 0.4 \)
Figure 1. A comparison between hierarchy and delegation as a function of $s$ and $X_G$

The combinations of $X_G$ and $s$ which lays above OIC (a higher $X_G$ or a lower $s$) represent situations in which delegation generates a higher surplus than hierarchy. On the contrary, the area below OIC represents combinations of $X_G$ and $s$ which determines a higher performance of the hierarchical system.

The position of OIC depends, among others variables, on the values of $|X_B|$, $c_H$ and $\alpha$. When $|X_B|$ increases, since the relative advantage of delegation reduces, the curve OIC moves upward, enlarging the region in which hierarchy is more efficient.

An opposite result derives when $c_H$ increases. Since the agent’s effort is more costly, higher incentives are required increasing the costs of the hierarchical system.

Moreover, the relative performance of the hierarchical system worsens when the agent’s risk-aversion is higher, because providing incentives becomes more costly: $\frac{\partial X_G}{\partial \alpha} > 0$ (see appendix).
Organizational performance under perfect and imperfect information

In order to compare the moral hazard case with the perfect information system let us calculate the total surplus obtained under perfect information. Total surpluses under the two organizational structures are respectively equal to:

\[ S^H = p_H s X_G + (1 - p_H)(1 - s)X_B - c_H \]

\[ S^D = p_H X_G + (1 - p_H)X_B - c_H \]

From the condition \( S^H = S^D \) we can find out the value of \( X_G \) that makes the firm indifferent between the two systems. This value is equal to:

\[ \hat{X}_G = \frac{s(1 - p_H)}{p_H (1 - s)} X_B \]

Comparing the OIC curves with perfect and imperfect information, it is possible to show that the existence of imperfect information determines an enlargement of the delegation region, that is \( \hat{X}_G > \tilde{X}_G \) (always).

The OIC approaches the curve under perfect information for high values of \( s \), or when \( \alpha \) is close to 1 (that is, when the agent is risk-neutral).\(^{12}\)

\(^{12}\) Figure 2 is drawn assuming \( X_B = -500 \); \( p_H = 0.7 \); \( p_L = 0.3 \); \( c_H = 5 \); \( c_L = 1 \); \( \alpha = 0.4 \)
6. Concluding remarks

Firms can choose to establish different kinds of authoritarian relationships among subjects participating in the productive process. In flatter organizational structures individuals have the authority on which projects to accept and reject. On the contrary, in hierarchical systems the superior has the ability to veto decisions made by his subordinates. Sah e Stiglitz (1986) show that the choice between these two structures depends on the cost of rejecting good projects (Type-I errors) relative to the cost of accepting poor ones. This result is obtained assuming an exogenously given projects’ portfolio and agents with identical screening ability (the superior and the subordinate have the some probability to discover good projects).

In this paper in a framework similar to that proposed by Sah and Stiglitz we compare hierarchical and delegation systems under the hypothesis that the agent’s probability of discovering good projects depends on his effort (while the principal screening ability is left exogenous). In the first part of the paper, considering perfect observability of the agent’s choice, we show that under delegation the efficient level of effort is higher. Comparing the total surplus obtained under the two organizational systems, we demonstrate that the relative efficiency of each system is related not only to the importance of Type-I and Type-II errors, but also to the principal’s screening ability and to the marginal disutility of the agent’s effort.

In the second part of the paper we abandon the hypothesis of perfect observability of the agent’s effort. In order to encourage effort, firms have to offer adequate incentives to the agent. We consider a compensation system based on the results deriving from the implemented projects. Under hierarchy this system requires higher bonus and higher penalties to elicit the agent’s effort. In fact, the principal’s activity reduces both the probability of implementing bad project (and then the agent’s probability of receiving a negative payoff) and the probability of implementing good projects (and then the agent’s probability to be rewarded). However, with risk-adverse workers this implies more costly incentives in hierarchy compared to delegation. Then, we show that given the principal screening ability the performance of the hierarchical systems may worsens if the agent’s effort is not observable. This result is similar to that obtained by Zabojnik (2002), but in our case it is not related to the agent’s belief on the principal’s information, but is due to the principal’s imperfect screening on projects proposed by the agent. The performance of the hierarchical system improves when the principal’s screening ability increases and when the agent’s risk-aversion decreases. In our framework the principal’s activity introduces additional uncertainty, since the result obtained by the agent depends not only on his effort but also on the principal interest and ability in evaluating the agent’s proposals. The superior might not be interested in carefully reviewing the employees
suggestions and in implementing those that have merit, or he might not have enough information or be endowed with low abilities that does not allow him to recognise good suggestions. In this case, the probability for the agent to be rewarded for his effort is very low and then it is possible to encourage the development of new idea and projects only paying high bonus.

According to our results the recent diffusion in many firms of new work practices that allow greater autonomy to workers may be related to an increased relevance of costs deriving from the refusal of profitable projects. In economic systems characterised by frequent changes the ability to innovate represents a key factor for the firm’s success and then costs deriving from conservative behaviours may be extremely relevant. On the contrary, in more stable economics environment, in which the treat of entrance of new innovative firms is low, it may be important to avoid the implementation of poor projects (Lazear 1998, Aoki, 1986).

Moreover, our analysis confirms the view according to which the delegation system might have been favoured by an increase in the workforces’ skills (Caroli and Greenan, 2001; Soskice, 1993). A low cost of the agent’s effort allows an easy substitution of the screening device offered by the principal in hierarchical systems.

Finally, in our analysis an important role in explaining the delegation of decisional rights to employees is played by the effect that this choice produces on the cost of incentive systems: delegation allows for cheaper incentives. Changes in the type of tasks assigned to workers and difficulties in monitoring their effort, increasing the relevance of incentives systems, may have favoured the diffusion of organizational forms presenting advantages in motivating workers.

**Appendix**

It is possible to see that $\hat{X}_G$ increases when $s$ takes higher values. In fact, using the implicit-function theorem, we have:

$$\frac{\partial X_G}{\partial s} = -\frac{\partial F/\partial s}{\partial F/\partial X_G}$$

Since:

$$\frac{\partial F}{\partial s} = p_H X_G - (1 - p_H) X_H + \frac{(1 - \alpha)}{\alpha} p_H \left[ \frac{c_H - c_L}{s(p_H - p_L)} \right]^{1/\alpha} > 0 \quad \text{always true}$$
\[
\frac{\partial F}{\partial X_G} = -(1 - s)p_H < 0 \text{ always true}
\]

we obtain that:

\[
\frac{\partial X_G}{\partial s} = -\frac{\partial F/\partial s}{\partial F/\partial X_G} > 0 \text{ always true}
\]

The second derivative is equal to:

\[
\frac{\partial^2 X_G}{\partial s^2} = \frac{p_H [p_H X_G - (1 - p_H)X_B] + \left\{ p_H^2 \frac{(1 - \alpha)}{\alpha} \left[ \frac{c_H - c_L}{s(p_H - p_L)} \right]^{\frac{1}{\alpha}} \left[ 1 - \frac{(1 - s)p_H}{\alpha} \right] \right\}}{[(1 - s)p_H]^2}
\]

The sign of \( \frac{\partial^2 X_G}{\partial s^2} \) depends on the value of \( s \): for high values of \( s \) it is positive, which means that the function is convex, while for low level of \( s \) it could become negative (concave function).

\[
\frac{\partial X_G}{\partial \alpha} = -\frac{\alpha^2}{1 - s} \left\{ \frac{c_H - c_L}{(p_H - p_L)} \right\}^{\frac{1}{\alpha}} \log \left[ \frac{c_H - c_L}{(p_H - p_L)} \right] + s^{1 - \frac{\alpha}{\alpha_s}} \left\{ \frac{c_H - c_L}{(p_H - p_L)} \right\}^{\frac{1}{\alpha}} \log \left[ \frac{c_H - c_L}{s(p_H - p_L)} \right] - \log s \}
\]

\[
\frac{\alpha^2}{1 - s} \left\{ \frac{c_H - c_L}{(p_H - p_L)} \right\}^{\frac{1}{\alpha}} \log \left[ \frac{c_H - c_L}{(p_H - p_L)} \right] + s^{1 - \frac{\alpha}{\alpha_s}} \left\{ \frac{c_H - c_L}{(p_H - p_L)} \right\}^{\frac{1}{\alpha}} \log \left[ \frac{c_H - c_L}{s(p_H - p_L)} \right] - \log s \}
\]

\[
\frac{\alpha^2}{1 - s} \left\{ \frac{c_H - c_L}{(p_H - p_L)} \right\}^{\frac{1}{\alpha}} \log \left[ \frac{c_H - c_L}{(p_H - p_L)} \right] (s^{1 - \frac{\alpha}{\alpha_s}} - 1) - s^{1 - \frac{\alpha}{\alpha_s}} \log s > 0
\]

References


