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Externalities and the Allocation of Decision Rights in the Theory of the Firm

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Abstract

This paper views authority as the right to undertake decisions that have external effects on other members of the organization. Because of contractual incompleteness, monetary incentives are insufficient to internalize these effects in the decision maker's objective. The optimal assignment of decision rights minimizes the resulting inefficiencies. We illustrate this in a principal–agent model where the principal retains the authority to select 'large' projects but delegates the decision right to the agent to implement 'small' projects. Extensions of the model discuss the role of effort incentives, asymmetric information and multi-stage decisions.

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Key words: Authority, Control Rights, Decision Rights, Delegation, Externalities, Incomplete Contracts, Theory of the Firm

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1 Introduction

The most important decisions in an organization affect not only the decision maker but also other members of the organization. The decision maker therefore exerts an externality on other parties within the organization. As an example, consider the merger or acquisition decision of a firm. When the firm owners are endowed with the right to take such decisions, they probably fail to internalize the full impact of their decision on the benefits and costs of the management. Similarly, when the management decides, it is likely to take the shareholders' concerns only partially into account. Who then should have the authority to decide over mergers and acquisitions?

In this paper we explain the allocation of decision rights as a response to the problem of externalities and contractual incompleteness. In a world of complete contracts, the members of an organization could simply write a comprehensive contract to implement those decisions that maximize their joint surplus. In line with the Coase Theorem, the benefits and costs of the different members would be fully internalized by monetary transfers under the organization's compensation scheme. Yet, as Grossman and Hart (1986), Hart and Moore (1990) and Hart (1995) point out, it is typically impossible to specify all the organization's future decisions in advance in a legally binding way. This is so because the details of different decisions are often not verifiable to outsiders and the courts or prohibitively costly to specify ex ante.

When decisions are not contractible, the party holding the decision right will opportunistically select a decision in its own interest and may fail to maximize the organization's overall surplus.[1] Under the optimal allocation of authority, therefore, the decision right should be given to the party whose behavior minimizes the resulting loss of surplus. Indeed, the transfer of decision rights is perhaps the most important feature that distinguishes transactions within a firm from market transactions (cf. Coase (1937) and Simon (1951)). The employees of a firm not only provide inputs; they also accept and receive authority over different aspects of the firm's activity.

As Aghion and Tirole (1997), we assume that the residual control over decisions in a certain area can be contractually assigned to a specific party. While some decisions or actions cannot be contracted upon, it is possible to specify in a contract who has the authority to undertake them. For ex-

[1] As Simon (1951, p. 302) observes, in the employer–worker relationship "the worker has no assurance that the employer will consider anything but his own profit in deciding what he will ask the worker to do".

ample, a member or a section of the firm may be given the autonomy over financial transactions because it is impractical to specify the optimal financial decisions for all possible contingencies. As Grossman and Hart (1986) and Hart and Moore (1990) emphasize, also the ownership of assets may be a mechanism to allocate control rights within the firm. Rajan and Zingales (1998) argue that the regulation of access to resources may be an alternative mechanism to allocate power. Rather than by an explicit contract, the allocation of authority may also be supported implicitly as a self–enforcing agreement in a repeated interaction (see Baker, Gibbons and Murphy (1999) and Bolton and Rajan (2000)).

The assumption that authority can be contractually allocated has some similarity with the "task assignment" literature (see e.g. Holmstrom and Milgrom (1991)), which considers the optimal assignment of tasks to the members of an organization.[2] Yet, there is an important difference between this literature and our modelling of the assignment of decision rights: In the "task assignment" problem the agent who becomes responsible for a task also bears the cost of performing this task. In contrast, the essence of our model is that the decision maker may affect the *other* agents' payoffs from performing their task. As an example, the tasks of a firm's production workers is to produce output; but the management may affect their disutility of work when it has the right to decide which production technology the firm adopts.

Our analysis considers a principal who hires an agent to implement one out of several feasible projects. Each project generates a verifiable random output for the principal; the agent's cost, however, is non–verifiable. Because projects with a higher expected output are more costly for the agent, the preferences of the two parties over different projects are *a priori* opposed to each other. Therefore, the contractual agreement not only entails a compensation scheme for the agent but also specifies which party has the right to select a project. In principle, the compensation scheme could be used to align the parties' preferences over the choice of a project. But such an alignment requires the agent's compensation to depend on the realisation of output. This implies a loss of surplus in the form of inefficient risk sharing. As a result, monetary incentives only partially resolve the problem of externalities: When the principal retains the authority over project selection, he fails to internalize the impact of his decision on the agent's cost. He is therefore biased towards choosing 'large' projects with high expected output

[2]In this literature, the assignment of tasks interacts with the agents' effort incentives. We consider the role of such incentives for the allocation of authority in Section 3.

and high cost. Conversely, the agent tends to select 'small' projects since he bears the full cost and receives at most a fraction of the output. Because of the biases in the parties' decision behavior, the optimal allocation of control rights will not generally implement the first–best project. The principal is more likely to retain the control right if the second–best project is relatively 'large'; he optimally delegates the authority to the agent if the second–best project is relatively 'small'.

A number of additional factors may influence the externality problem associated with authority. One such factor is moral hazard. We can extend our model to a situation where *after* the choice of a project the agent may increase the project's output by investing effort. We show that there are complementarities between decision rights and effort incentives which favor delegation of control to the agent. Another factor that we can integrate into our model is asymmetric information. It turns out that under an optimal mechanism not only the compensation scheme but also the allocation of the decision right may be contingent on the revelation of private information. Finally, we consider a sequential decision process and show that it may be optimal to divide control rights at different stages of this process.

Our approach to the allocation of power in organizations is not based on ex–ante investment incentives, which distinguishes it from other explanations in the literature. In the theory of vertical integration developed by Grossman and Hart (1986), Hart and Moore (1990) and Hart (1995), the ownership of assets is identified with residual control rights. These rights define the default options when bargaining over transactions or decisions takes place. The party having the residual control right can appropriate a larger share of the bargaining surplus and so has a higher incentive to make *ex ante* relationship–specific investments. It is the efficiency of these investments that determines the optimal allocation of property rights and, henceforth, of authority. In our model there is no hold–up problem of specific investments, even though it could be extended to include such investments. Also, in the property rights approach to the theory of the firm decisions are non–describable *ex ante* at the contracting stage; but they are legally verifiable *ex post* at the bargaining and renegotiation stage.[3] Our analysis sidesteps potential problems with this assumption by considering decisions as neither *ex ante* nor *ex post* verifiable. This also implies that in our model decisions may turn out not be Pareto–optimal because – even *ex post* – inefficiencies cannot be negotiated away.

[3]The consistency of this assumption is discussed in Hart–Moore (1999), Maskin–Tirole (1999a,b) and Segal (1999).

Holmstrom and Hart (2002) also adopt a framework in which decisions are non–contractible not only ex ante but also ex post.[4] They focus on the firm boundaries by investigating whether integration or non–integration is the optimal organisational form. Under non–integration each production unit has a separate manager, which may lead to too little coordination between different units. This inefficiency may be overcome through integration, under which an outside manager receives authority over the production units. While this solves the coordination problem, the outside manager fails to take into account the private benefits of the unit managers. Holmstrom and Hart (2002) show that a first–best outcome can be achieved by selecting the appropriate organisational form.[5]

In Aghion and Tirole (1997) authority affects the incentives to invest in information gathering. The delegation of formal authority entitles the agent to select his preferred project and, therefore, increases his initiative to acquire information about the benefits of different projects. As long as the principal's and the agent's objectives are at least partially aligned, delegation may increase the principal's payoff because extremely poor projects are more likely to be screened out. In our model, the principal and the agent are fully informed about the benefits and costs of all feasible projects. Also their preferences over different projects are *a priori* opposed to each other. They become partially congruent with each other only through monetary incentives, which play a minor role in Aghion and Tirole (1997).

While in Aghion and Tirole (1997) both parties are initially uninformed, Dessein (2002) assumes that the principal deals with a better informed agent. He can either delegate control rights to the agent or keep authority and rely on the agent's willingness to communicate information. As we show in Section 4, asymmetric information of this kind can easily be incorporated in our basic framework. Indeed, it turns out that the allocation of authority itself may be useful as an incentive mechanism for information revelation. Under an efficient contract control rights may depend on private information.

The rest of the paper is organized as follows. In Section 2 we study the allocation of decision rights in a basic framework. Section 3 extends this framework by introducing inalienable private effort incentives. The role of asymmetric information about project characteristics is investigated in Section 4. In Section 5 we analyze the allocation of authority in a sequential decision environment. Finally, Section 6 contains concluding remarks.

[4]Another model with this feature is Aghion, Dewatripont and Rey (2001).

[5]This property of their model seems to rely on the assumption that each production unit faces a binary decision problem; cf. Section 2 of this paper.

2 Authority and Externalities

A principal and an agent can jointly implement a project. The set of available projects is D. If project $d_i \in D$ is selected, the principal receives the output

$$X_i + \varepsilon, \tag{1}$$

with $X_i \geq 0$. The variable ε is random and normally distributed with mean zero and variance $\sigma^2 > 0$. Thus decision d_i determines the mean output X_i and the project risk is measured by σ^2. The agent's cost of implementing project d_i is $C_i \geq 0$.

We assume that the selection of a particular project is not verifiable to outsiders and, hence, not contractible. Only the output generated by a project is publicly observable and hence verifiable. Yet, because of the measurement error ε it is not possible to infer precisely the choice of project from the observation of output. In contrast with output, we assume that the agent's cost of implementing a project is not verifiable. The assumption that all direct benefits for the principal are verifiable is not essential. The model can easily be extended to situations where in addition to the contractible output the principal receives some private benefits from a project. Similarly, some part of the agent's cost or benefit might be verifiable.

In our analysis we have to compare the payoffs from different contractual arrangements. As project decisions are not contractible, the contracting problem involves an incentive restriction for the party maintaining the decision right. From the literature on such problems it is well–known that this is practically impossible unless certain restrictions on the form of contracts are imposed (see e.g. Grossman and Hart (1983)). For this reason, we restrict ourselves to payment schemes that are linear in the observed output. A compensation scheme for the agent consists of a base amount $\alpha \geq 0$ plus a portion $\beta \in [0, 1]$ of the realised output. Thus, depending on the choice of project and the realisation of ε, the agent's wage is

$$\alpha + \beta \, (X_i + \varepsilon) \, . \tag{2}$$

The principal's overall payoff is the project's output minus the compensation paid to the agent. We take the principal to be risk–neutral. Therefore, his expected payoff is

$$V(d_i, \alpha, \beta) \equiv (1 - \beta) X_i - \alpha. \tag{3}$$

The agent's payoff is the difference between his wage income and his cost of implementing a project. We assume that the agent has exponential utility

with a constant rate $\rho > 0$ of absolute risk aversion. Therefore, his expected utility can be written as

$$U(d_i, \alpha, \beta) \equiv \beta\, X_i - \frac{\rho}{2}\,\beta^2\sigma^2 + \alpha - C_i. \tag{4}$$

The agent's reservation utility from his best outside option is zero. In what follows, we assume that the principal has all the bargaining power so that he can make a take–it–or–leave–it offer to the agent. Yet, it is important to notice that the allocation of authority under an optimal contract is independent of the distribution of bargaining power between the principal and the agent. Different divisions of the available bargaining surplus affect only the base amount α in the agent's compensation.

The purpose of our analysis is to study the allocation of decision rights when the selection of projects is not observable to outsiders. Yet, as a bench–mark it may be helpful to consider first the case where the choice of project is verifiable and can be made part of the contract between the principal and his agent. In this case, a contract specifies a project in combination with a payment scheme. The principal's problem is then to maximize his expected payoff subject to the agent's individual rationality constraint, i.e.

$$\max_{d_i,\alpha,\beta} V(d_i, \alpha, \beta) \quad \text{subject to} \quad U(d_i, \alpha, \beta) \geq 0. \tag{5}$$

The solution of this problem is straight–forward: Since only the agent is risk–averse, he should not bear any output risk so that $\beta = 0$. Indeed, the principal is able to appropriate the entire surplus $X_i - C_i$ from project d_i by setting $(\alpha, \beta) = (C_i, 0)$. Therefore, under an optimal contract a project will be selected that maximizes $X_i - C_i$. For what follows, we define $S_i \equiv X_i - C_i$ as the *first–best surplus* from project d_i. We say that project $d_i \in D$ is *first–best efficient* if $S_i \geq S_j$ for all $d_j \in D$.

We now turn to the case where only the allocation of authority, i.e. the right to decide, is contractible. We describe the allocation of the decision right by $h \in \{P, A\}$. Thus, if $h = P$ the principal retains the right to select $d \in D$; if $h = A$ he delegates the selection of a project to the agent. The principal now solves the following problem:

$$\max_{h,d_i,\alpha,\beta} V(d_i, \alpha, \beta) \tag{6}$$

subject to

$$U(d_i, \alpha, \beta) \geq 0, \tag{7}$$

and

$$\begin{aligned} d_i &\in \operatorname{argmax}_d V(d,\alpha,\beta) \qquad \text{if} \qquad h = P, \\ d_i &\in \operatorname{argmax}_d U(d,\alpha,\beta) \qquad \text{if} \qquad h = A. \end{aligned} \tag{8}$$

The difference between this problem and the problem considered previously in (5) are the incentive constraints in (8): When only authority is contractible, project d_i is selected at the discretion of the party who maintains the decision right. In contrast with standard moral–hazard problems, here the allocation of the decision right determines whether an incentive restriction for the principal or the agent becomes relevant.

A simple observation shows that problem (6) induces the implementation of the first–best project whenever the set D of feasible decisions contains only two elements. To see this, suppose that $D = \{d_A, d_B\}$ with $S_A \geq S_B$. Since $S_A = V(d_A,\alpha,0) + U(d_A,\alpha,0) \geq V(d_B,\alpha,0) + U(d_B,\alpha,0) = S_B$, at least one of two parties prefers project d_A over d_B under a contract with $\beta = 0$. Therefore, by the appropriate choice of h the incentive constraint (8) can be made consistent with a contract that otherwise specifies $d_i = d_A, \alpha = C_A$ and $\beta = 0$. It is easy to see that this contract also satisfies the agent's participation constraint (7). As a result, the efficient allocation of authority enables the principal to realise the first–best surplus from the first–best efficient project in any environment where one out of two available projects has to be selected!

To illustrate the distortions that can arise when merely decision rights but not decisions themselves are contractible, it is sufficient to consider the case of three projects. In the remainder of this section we assume that $D = \{d_0, d_L, d_H\}$ and

$$0 \leq X_0 < X_L < X_H, \quad 0 \leq C_0 < C_L < C_H. \tag{9}$$

Thus, the higher a project's expected output the higher is the agent's private cost of implementing the project. Under optimal risk–sharing this creates a natural conflict between the principal and the agent: While the agent prefers a smaller project, the principal prefers a larger project. One possible application is the restructuring decision in a firm that is owned by the principal and managed by the agent. Decision d_0 can be interpreted as maintaining the status quo, while d_L indicates a 'minor' and d_H a 'major' restructuring of the firm.

We further assume that

$$\frac{C_L - C_0}{X_L - X_0} < \frac{C_H - C_L}{X_H - X_L}. \tag{10}$$

This assumption reflects increasing 'marginal' costs, because the change in cost relative to the change in expected output is higher when switching from project d_L to d_H than from d_0 to d_L.

There are two constellations under which the incentive restriction (8) in problem (6) can be satisfied without reducing the principal's payoff:

Proposition 1 *If d_0 is first–best efficient, the agent has the decision right under the optimal contract and the principal receives the first–best surplus from project d_0. If d_H is first–best efficient, the principal retains the decision right under the optimal contract and receives the first–best surplus from project d_H.*

Clearly, under a contract with $\beta = 0$ the agent selects project d_0 to minimize his cost. Hence the principal can extract the entire surplus from project d_0 by setting $h = A$ and $\alpha = C_0$. Similarly, project d_H is the principal's preferred project. Therefore, under a contract with $h = P, \alpha = C_H$ and $\beta = 0$ he can appropriate the surplus S_H.

Under the conditions of Proposition 1, it is possible to allocate the decision right in such a way that implementing the first–best efficient project does not conflict with efficient risk–sharing. This is no longer possible when the intermediate project d_L is first–best efficient. To induce the agent to select project d_L rather than d_0, he has to be compensated by some share of the output. This implies inefficient risk–sharing and prevents the principal from realising the first–best surplus of project d_L. To state our next result, we define a critical level of project risk by

$$\bar{\sigma}^2 \equiv (S_L - \max[S_0,\, S_H])\frac{2}{\rho}\frac{(X_L - X_0)^2}{(C_L - C_0)^2}. \tag{11}$$

Note that $\bar{\sigma}^2 \geq 0$ when project d_L is first–best efficient. In Figure 1, $\bar{\sigma}^2$ represents the borderline between region $\mathcal{I}$ and $\mathcal{II} + \mathcal{III}$.

Proposition 2 *Let project d_L be first–best efficient. If $\sigma^2 < \bar{\sigma}^2$, then under the optimal contract the agent has the decision right and project d_L is implemented. If $\sigma^2 > \bar{\sigma}^2$ and $S_H > S_0$, the principal has the decision right and selects project d_H; if $\sigma^2 > \bar{\sigma}^2$ and $S_0 > S_H$, the agent has the decision right and selects project d_0.*

Proof: Since $d_H = \text{argmax}_d\, V(d, \alpha, \beta)$ project d_L can only be implemented by setting $h = A$. The agent chooses d_L if $\beta\, X_L - C_L \geq \max[\beta X_0 - C_0,\, \beta X_H -$

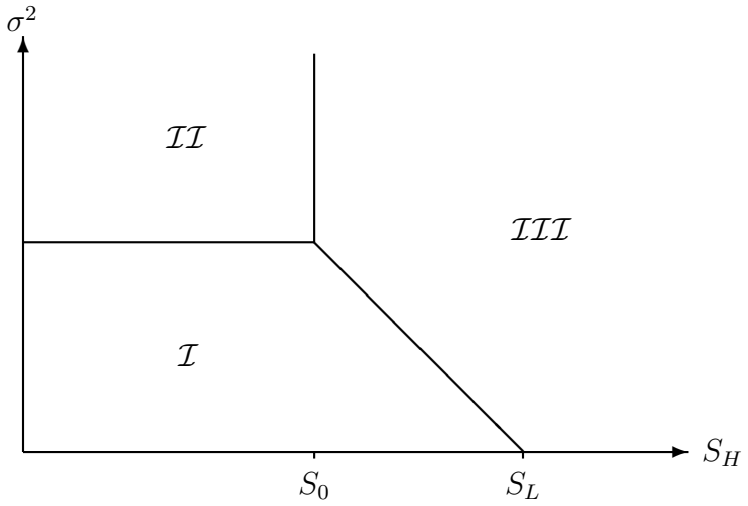

Figure 1: *Decision Rights and Project Risk*

C_H] i.e. if

$$\frac{C_L - C_0}{X_L - X_0} \leq \beta \leq \frac{C_H - C_L}{X_H - X_L}. \tag{12}$$

Accordingly under a contract with $h = A, d = d_L$, $\beta = (C_L - C_0)/(X_L - X_0)$ and $\alpha = C_L - \beta X_L + 0.5\,\rho\,\beta^2\,\sigma^2$ the principal can realise the payoff

$$S_L - \sigma^2\,\frac{\rho}{2}\,\frac{(C_L - C_0)^2}{(X_L - X_0)^2}. \tag{13}$$

Alternatively, he can obtain the payoff S_0 or S_H by setting $(h, d_i, \alpha, \beta) = (A, d_0, C_0, 0)$ or $(h, d_i, \alpha, \beta) = (P, d_H, C_H, 0)$, respectively. Therefore, implementing project d_L is optimal if $\sigma^2 < \bar{\sigma}^2$, where $\bar{\sigma}^2$ is defined in (11). If $\sigma^2 > \bar{\sigma}^2$, then the optimal contract is either $(h, d_i, \alpha, \beta) = (A, d_0, C_0, 0)$ or $(h, d_i, \alpha, \beta) = (P, d_H, C_H, 0)$ depending on whether $S_0 > S_H$ or $S_H > S_0$. Q.E.D.

Figure 1 illustrates our results for the case $S_0 < S_L$:[6] Under the parameter constellations in region $\mathcal{I}$, the agent has the decision right and chooses project d_L, which is also first–best efficient. Yet, his compensation scheme involves some bearing of the project risk and so the principal gets less than the full surplus S_L. Therefore, implementing project d_L is no longer optimal if the risk σ^2 becomes too high. This happens in region $\mathcal{II}$, where again the agent

[6]In the case $S_0 > S_L$ either d_0 or d_H is first–best efficient, and so by Proposition 1 the first–best is implementable.

has the decision right but now selects project d_0. In this region the principal realises the payoff S_0, which is less than the first–best surplus S_L but still higher than S_H. Finally, in region $\mathcal{III}$ the principal retains the authority to choose project d_H. His decision is first–best efficient only in the part of region $\mathcal{III}$ where $S_H \geq S_L$.

The optimal allocation of authority responds to the problem that decisions generate externalities: On the one hand, the agent tends to minimize his cost, thereby neglecting the impact of his decision on the principal's output. On the other hand, the principal favors projects with a high output because he ignores the agent's cost. To internalize these effects by a compensation scheme is costly because this generates inefficiencies in the allocation of risk. As a consequence, the principal delegates the decision right to the agent when it is optimal to implement a project with relatively low costs. When implementing a large–scale project with high output and high cost is optimal, the principal retains the authority to decide. This causes decisions to be biased: Depending on which party holds the decision right, there is a tendency towards a selection of projects that are either too small or too large relative to the first–best.[7]

3 Effort Incentives

While the authority over a wide range of decisions in an organization may contractually allocated, there are also some activities where decision rights are inalienable. A contract may endow the principal with the right to determine on which project the agent has to work; it is however beyond the principal's direct control to determine how much imagination and enthusiasm the agent develops for his job. In this section, we consider the interaction between the allocation of authority and private effort incentives. As an example, a firm's charter may specify whether the firm owner or the manager is entitled to take certain restructuring decisions. But it always remains for the manager to decide how much effort he exerts on restructuring the firm.

In this section project $d_i \in D$ in combination with the agent's effort choice $e_j \in E$ results in the verifiable random output

$$X_i(e_j) + \varepsilon, \tag{14}$$

where, as before, ε is normally distributed with mean zero and variance $\sigma^2 > 0$. The agent's non–contractible cost of spending effort e_j on project d_i

[7] These inefficiencies cannot be negotiated away because decisions are not only *ex ante* but also *ex post* non–verifiable.

is $C_i(e_j)$. Under a linear compensation scheme (α, β) the principal's receives the expected payoff

$$V(d_i, e_j, \alpha, \beta) \equiv (1 - \beta)X_i(e_j) - \alpha; \tag{15}$$

and the agent's expected utility is

$$U(d_i, e_j, \alpha, \beta) \equiv \beta\, X_i(e_j) - \frac{\rho}{2}\,\beta^2\sigma^2 + \alpha - C_i(e_j). \tag{16}$$

The agent chooses his effort after a project has been determined. Even though the decision $d_i \in D$ is not publicly verifiable, we assume that d_i is observed by the agent also when the principal has the decision right. The incentive constraint for the agent's effort choice is therefore

$$e_j(d) \in \operatorname{argmax}_e U(d, e, \alpha, \beta), \tag{17}$$

for all $d \in D$. Depending on the allocation of authority $h \in \{P, A\}$, project $d_i \in D$ is implementable if

$$\begin{aligned} &d_i \in \operatorname{argmax}_d V(d, e_j(d), \alpha, \beta) \qquad \text{if} \qquad h = P, \\ &d_i \in \operatorname{argmax}_d U(d, e_j(d), \alpha, \beta) \qquad \text{if} \qquad h = A. \end{aligned} \tag{18}$$

The principal's problem is to design a contract $(h, d_i, e_j, \alpha, \beta)$ so as to maximize his expected payoff subject to the agent's individual rationality constraint and the incentive constraints (17) and (18).

To investigate the impact of effort incentives on the allocation of authority, we assume that $D = \{d_0, d_R\}$, $E = \{e_L, e_H\}$ and

$$X_0(e_L) = X_0(e_H) = X_0, \quad X_R(e_L) = X_R, \quad X_R(e_H) = X_R + X_E, \tag{19}$$

with $X_E > 0$. Thus the output under the 'status quo' d_0 is independent of the agent's effort. The expected output from project d_R, however, increases by the amount X_E if the agent invests high effort e_H rather than low effort e_L. We denote the agent's effort cost as $K_E > 0$ so that for each project $d_i \in D$:

$$C_i(e_L) = C_i, \quad C_i(e_H) = C_i + K_E. \tag{20}$$

Regarding the selection of projects, the principal and the agent have conflicting interests because

$$0 \leq X_0 < X_R, \quad 0 \leq C_0 < C_R. \tag{21}$$

Finally, to make the problem interesting, we assume that

$$X_E - K_E > 0, \quad X_R + X_E - C_R - K_E > X_0 - C_0. \tag{22}$$

This ensures that project d_R in combination with high effort e_H is first–best efficient. If this were not the case, it would never be optimal to implement high effort and the moral hazard constraint (17) would become irrelevant.

In the previous section we have seen that, in the absence of private effort decisions, the first–best project can be realised when D contains only two elements. Indeed, if effort were contractible, the optimal contract would prescribe high effort e_H and assign the right of control over D to the principal, who would ratify project d_R. Thus under a compensation scheme with $\alpha = C_R + K_E$ and $\beta = 0$, the principal could appropriate the first–best surplus of the first–best efficient project. Of course, this is no longer possible with non–contractible effort, because the agent would not exert high effort under a payment scheme with $\beta = 0$. But it is worth noting that whenever the optimal contract allocates the control right over D to the agent, this is so because of the effort incentive constraint (17).

When working on project d_R, the agent selects high effort e_H only if $U(d_R, e_H, \alpha, \beta) \geq U(d_R, e_L, \alpha, \beta)$, which is equivalent to

$$\beta \geq \frac{K_E}{X_E}. \tag{23}$$

Let $S_0 \equiv X_0 - C_0$ and $S_R \equiv X_R - C_R$. The following lemma shows that the provision of effort incentives makes project d_R more attractive for the agent if the surplus difference $S_R - S_0$ exceeds some critical value.

Lemma 1 *Under a contract with $\beta = K_E/X_E$ the agent prefers project d_R and effort e_H to project d_0 and effort e_L if and only if*

$$S_R - S_0 \geq \bar{S} \equiv (C_R - C_0)\frac{X_E - K_E}{K_E}. \tag{24}$$

Proof: The condition $U(d_R, e_H, \alpha, \beta) \geq U(d_0, e_L, \alpha, \beta)$ is equivalent to

$$\beta(X_R + X_E) - C_R - K_E \geq \beta X_0 - C_0. \tag{25}$$

For $\beta = K_E/X_E$, it is easy to show that this inequality is identical to (24). Q.E.D.

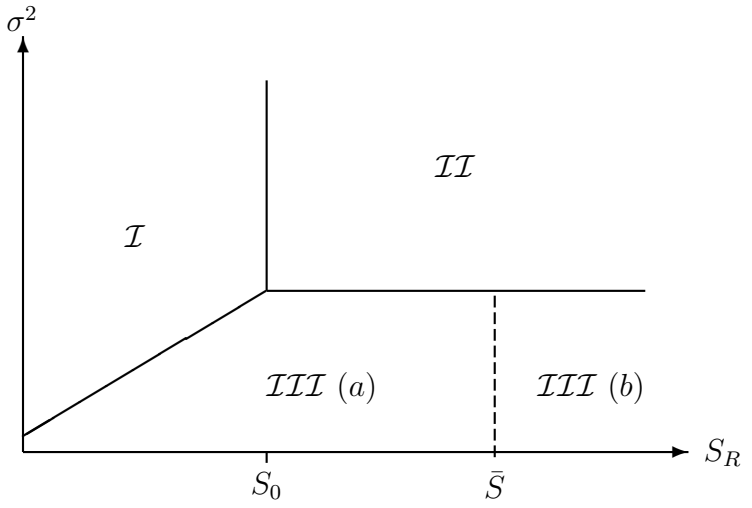

Figure 2: *Effort Incentives*

As in the previous section, it turns out that the level of project risk influences the optimal allocation of control rights. Here the critical value of risk is

$$\hat{\sigma}^2 \equiv (X_E - K_E - \max[S_0 - S_R,\, 0])\frac{2}{\rho}\frac{X_E^2}{K_E^2}. \tag{26}$$

Note that $\hat{\sigma}^2$ depends positively on the productivity X_E and negatively on the cost K_E of high effort. In Figure 2, $\hat{\sigma}^2$ represents the borderline between region $\mathcal{I} + \mathcal{II}$ and region $\mathcal{III}$.

We first consider the case $S_0 > S_R$. In this case, implementing project d_R is optimal only if at the same time the agent is induced to invest high effort. This, however, creates a distortion in the allocation of risk so that project d_0 becomes more attractive for high values of σ^2.

Proposition 3 *Let $S_0 > S_R$. If $\sigma^2 < \hat{\sigma}^2$, then under the optimal contract the principal has the decision right and project d_R together with effort e_H is implemented. If $\sigma^2 > \hat{\sigma}^2$, the agent has the decision right and selects project d_0 in combination with effort e_L.*

Proof: It follows by Lemma 1 that the choice of project d_R can be implemented if and only if $h = P$. By setting $\beta = K_E/X_E$ and α so that the agent's individual rationality constraint is fulfilled, the principal gets the payoff

$$S_R + X_E - K_E - \sigma^2\,\frac{\rho}{2}\,\frac{K_E^2}{X_E^2}. \tag{27}$$

Alternatively, he can implement project d_0 by setting $h = A$, $\alpha = C_0$ and $\beta = 0$ to extract the first–best surplus S_0. If $\sigma^2 < \hat{\sigma}^2$ the first option yields a higher payoff; if $\sigma^2 > \hat{\sigma}^2$ the second option yields a higher payoff. Q.E.D.

We now turn to the case $S_0 < S_R$, in which project d_R always generates a higher surplus, independently of the agent's effort choice. The optimal contract provides an incentive for high effort as long as the project risk is not too high.

Proposition 4 *Let $S_R > S_0$. Then it is always optimal that the principal has the decision right; if $\sigma^2 < \hat{\sigma}^2$ and $S_R - S_0 \geq \bar{S}$, it is also optimal that the agent has the decision right. Project d_R is implemented together with effort e_H or e_L depending on whether $\sigma^2 < \hat{\sigma}^2$ or $\sigma^2 > \hat{\sigma}^2$.*

Proof: Under a contract with $h = P, \alpha = C_R$ and $\beta = 0$ the agent chooses effort e_L and so the principal gets the payoff S_R. Therefore, implementing project d_0 is never optimal. Alternatively, as we have shown in the proof of Proposition 3, the principal can induce the effort e_H and realise the payoff in (27). This payoff is higher (lower) than S_R if $\sigma^2 < \hat{\sigma}^2$ ($\sigma^2 > \hat{\sigma}^2$). If $\sigma^2 < \hat{\sigma}^2$ and $S_R - S_0 \geq \bar{S}$, by Lemma 1 also the agent prefers project d_R because the optimal contract satisfies $\beta = K_E/X_E$. Q.E.D.

Figure 2 summarizes our results: The provision of effort incentives is too costly in regions $\mathcal{I}$ and $\mathcal{II}$. In these regions the allocation of authority depends on which project yields a higher surplus with low effort: Since $S_0 > S_R$ in region $\mathcal{I}$, the principal delegates the decision right to the agent who selects project d_0. In contrast, in region $\mathcal{II}$, where $S_R > S_0$, project d_R is chosen under the principal's authority. Only in region $\mathcal{III}$ the agent exerts high effort on project d_R. In part (a) of this region the principal maintains the decision right; in part (b) the optimal allocation of decision rights is indeterminate because also the agent prefers project d_R over d_0.

We conclude from our analysis that the agent's private choice of effort expands the range of parameter constellations under which he receives the authority over project decisions. This observation is similar to Aghion and Tirole (1997) who show that delegation improves the agent's incentives for information gathering *before* a project is selected. In our model, however, the agent selects his effort *ex post* and his choice is determined by the compensation scheme rather than the allocation of authority. The driving force behind our results are complementarities between effort and project decisions. Indeed, there are two different effects: First, the trade–off between incentives and risk makes projects that require more effort less attractive to

implement. In our setting, where the effectiveness of effort increases with project size, this favors the delegation of authority because the agent is more inclined than the principal to select low cost projects. This effect occurs in region $\mathcal{I}$ of Figure 2. The second effect is that under a compensation scheme which induces high effort, the agent also partially internalizes the impact of his decision on the principal's output. As in region $\mathcal{III}(b)$ of Figure 2, this diminution of the externality problem enhances the agent's qualification for authority.

4 Asymmetric Information

Information, which is important for the efficiency of choice, is often localized and dispersed throughout an organization. Typically, different members have access to different information. Their willingness to communicate their private information may be stimulated by monetary incentives. But at least equally important is the allocation of control rights. This is so because the subordinates take into account how the decision maker reacts to the revelation of information. Their incentives to report truthfully depend on whether this has positive or negative consequences for their own benefits. Therefore, communication incentives and the allocation of authority interact with each other.

Actually, the optimal design of an organization may require the allocation of authority itself to be contingent on revealed information. In this section we show that such a transfer of control rights may facilitate the exchange of information.[8] We assume that the agent is privately informed about some 'state of the world' θ; he is willing to share his information with the principal if the latter contractually commits himself to delegate the decision right in certain states.[9]

We assume that the principal's verifiable gross benefit from project $d_i \in D$,

$$\theta\, X_i + \varepsilon, \tag{28}$$

depends not only on the measurement error ε but also on the state of the world, represented by the random variable $\theta \geq 0$. The agent is privately

[8] In an incomplete information framework, Aghion, Dewatripont and Rey (2001) show that the transfer of control rights can be used to allow the other party to establish a reputation for future cooperation.

[9] See also Aghion and Bolton (1992) who demonstrate in a model of debt financing that it may be optimal to transfer control in certain publicly observable states of the world.

informed about the true value of the parameter θ; the principal, however, only knows the distribution function $F(\theta)$ at the contracting stage.

If project $d_i \in D$ is undertaken, the agent incurs the non–verifiable cost C_i. Therefore, under a linear compensation scheme (α, β), the payoffs of the principal and the agent in state θ are given by

$$\begin{aligned} V(d_i, \alpha, \beta|\theta) &\equiv (1-\beta)\theta\, X_i - \alpha, \\ U(d_i, \alpha, \beta|\theta) &\equiv \beta\,\theta\, X_i - \frac{\rho}{2}\,\beta^2\sigma^2 + \alpha - C_i. \end{aligned} \tag{29}$$

The principal's expected payoff at the contracting stage is

$$\int_\theta V(d_i, \alpha, \beta|\theta)\,\mathrm{d}F(\theta). \tag{30}$$

Since the efficiency of project selection depends on the state θ, the principal will optimally ask the agent to reveal his information. Indeed, by the Revelation Principle, there is no loss of generality in assuming that the optimal contract induces the agent to report θ truthfully.[10] Contingent on the agent's report θ, the contract specifies a decision $d_i(\theta)$, a compensation scheme $(\alpha(\theta), \beta(\theta))$ and the allocation of the decision right $h(\theta)$. We denote by

$$H_P \equiv \{\theta|h(\theta) = P\}, \quad H_A \equiv \{\theta|h(\theta) = A\}, \tag{31}$$

the set of states in which the principal and the agent, respectively, become endowed with the decision right.

Since decisions are non–contractible, a contract has to satisfy the usual incentive restrictions:

$$\begin{aligned} d_i(\theta) &\in \mathrm{argmax}_d\, V(d, \alpha(\theta), \beta(\theta)|\theta) \qquad \text{if} \qquad h(\theta) = P, \\ d_i(\theta) &\in \mathrm{argmax}_d\, U(d, \alpha(\theta), \beta(\theta)|\theta) \qquad \text{if} \qquad h(\theta) = A. \end{aligned} \tag{32}$$

Further, the agent should not be able to gain by misrepresenting the true state. This is ensured by the 'truthtelling–constraints':

$$\begin{aligned} U(d_i(\theta), \alpha(\theta), \beta(\theta)|\theta) &\geq U(d_i(\theta'), \alpha(\theta'), \beta(\theta')|\theta) \text{ for all } \theta' \in H_P, \\ U(d_i(\theta), \alpha(\theta), \beta(\theta)|\theta) &\geq \max_d U(d, \alpha(\theta'), \beta(\theta')|\theta) \text{ for all } \theta' \in H_A. \end{aligned} \tag{33}$$

[10] The Revelation Principle is applicable here, even though the principal cannot contractually commit to a decision. This is so because his choice does not depend on the value of θ that the agent reports. If this were not the case, the modified Revelation Principle of Bester and Strausz (2001) could be used to derive the optimal contract.

The first of these constraint guarantees that the agent has no incentive to misreport some state $\theta' \in H_P$ when the true state is θ. Similarly, by the second constraint the agent cannot gain by misreporting some state $\theta' \in H_A$. The optimal contract for the principal maximizes his expected payoff in (30) subject to the agent's individual rationality constraint and the restrictions in (32) and (33).

Under perfect information the optimal contract would not have to satisfy the truthtelling–constraints in (33). But, there are situations where also under asymmetric information they are not binding. As we have seen in Section 2, if D contains only two projects, then under perfect information the principal always obtains the first–best surplus from the project implemented in state θ. Similarly, if the project risk σ^2 is too high, the agent will optimally bear no risk and so the principal gets the entire project surplus. Whenever this is the case, there is no conflict between the allocation of decision rights and communication incentives.[11]

Proposition 5 *If the optimal contract under perfect information satisfies $\beta = 0$ in each state θ, then the corresponding allocation of decision rights is optimal also under asymmetric information.*

Proof: Let $X(d_i) \equiv X_i$ and $C(d_i) \equiv C_i$. Note that under perfect information the agent's individual rationality constraint is always binding so that $U(d_i(\theta), \alpha(\theta), \beta(\theta)|\theta) = 0$ for all θ. Suppose that the first condition in (33) is not satisfied for some $\theta' \in H_P$. Then

$$\begin{aligned} U(d_i(\theta'), \alpha(\theta'), \beta(\theta')|\theta) &= \beta(\theta')\,\theta\,X(d_i(\theta')) - \\ \frac{\rho}{2}\,\beta(\theta')^2\sigma^2 &+ \alpha(\theta') - C(d_i(\theta')) > 0. \end{aligned} \tag{34}$$

But, by individual rationality,

$$\begin{aligned} U(d_i(\theta'), \alpha(\theta'), \beta(\theta')|\theta') &= \beta(\theta')\,\theta'\,X(d_i(\theta')) - \\ \frac{\rho}{2}\,\beta(\theta')^2\sigma^2 &+ \alpha(\theta') - C(d_i(\theta')) = 0. \end{aligned} \tag{35}$$

In combination with (34) this implies $\beta(\theta')[\theta - \theta']\,X(d_i(\theta')) > 0$, a contradiction to $\beta(\theta') = 0$. Now suppose that the second condition in (33) is not satisfied for some $\theta' \in H_A$. Then there exists a $d \in D$ such that

$$\begin{aligned} U(d, \alpha(\theta'), \beta(\theta')|\theta) &= \beta(\theta')\,\theta\,X(d) - \\ \frac{\rho}{2}\,\beta(\theta')^2\sigma^2 &+ \alpha(\theta') - C(d) > 0. \end{aligned} \tag{36}$$

[11] Notice that the following result also holds generally if the project output is non–verifiable, because then one must have $\beta = 0$.

Since $\theta' \in H_A$, we have

$$U(d_i(\theta'), \alpha(\theta'), \beta(\theta')|\theta') = 0 \geq U(d, \alpha(\theta'), \beta(\theta')|\theta') = \beta(\theta')\,\theta'\,X(d) - \frac{\rho}{2}\,\beta(\theta')^2\sigma^2 + \alpha(\theta') - C(d). \tag{37}$$

By (36) and (37) we have $\beta(\theta')[\theta - \theta']\,X(d) > 0$, again a contradiction to $\beta(\theta') = 0$. Q.E.D.

Proposition 5 indicates that asymmetric information generates additional distortions only when monetary incentives are used to influence the agent's decision behavior. To illustrate the result, let $D = \{d_0, d_R\}$ with

$$X_0 < X_R, \quad C_0 < C_R \tag{38}$$

and denote by

$$\theta^* \equiv \frac{C_R - C_0}{X_R - X_0} \tag{39}$$

the critical value of θ for which both projects generate the same surplus. Under perfect information, project d_R is optimal for all $\theta > \theta^*$. In these states, the principal thus retains the decision right and pays the agent $\alpha(\theta) = C_R$ for working on project d_R. In all other states, the agent gets the payment $\alpha(\theta) = C_0$ and has the right to select d_0. It is easy to see that the same arrangement is feasible also when only the agent knows the true value of θ: If $\theta < \theta^*$, the agent cannot gain by misreporting some $\theta' > \theta^*$ because he would then loose the right to select the low cost project d_0. Similarly, if $\theta > \theta^*$, the agent could get the decision right by reporting $\theta' < \theta^*$. Yet, this does not increase his payoff because he has to pay $C_R - C_0$ for the right. Effectively, trading authority supports truthful revelation of private information.

5 Multistage Decisions

In reality, most organizations face a steady flow of decision problems rather than a single problem. Also, typically it is not a single party that is in charge for all decisions. Instead decision rights are often decentralized and control rights in different areas are divided between different parties. As an example, a firm may first have to decide whether or not to develop a new product. When a new product has been made available, a marketing strategy has to be chosen. It is not necessary and may not be desirable that

the same party has authority over decisions in both the development and the marketing stage.

In this section we consider a two-stage decision problem. We show that, depending on complementarities between the sequence of decisions, the optimal governance structure may endow the principal with the control right at one stage and the agent at the other. This also indicates that it may be advantageous to split the overall decision process into several sub–decision stages. This allows the organization to fine–tune the allocation of decision rights and may enhance the efficiency of project selection.

In the first stage of the decision process, a decision $d_i \in D_1$ is selected. This decision may affect the set of decisions $D_2(d_i)$ that are feasible at stage 2. Depending on the decisions $d_i \in D_1$ and $d_j \in D_2(d_i)$, the principal receives the output $X_{ij} + \varepsilon$ and the agent's cost is C_{ij}. Therefore, under a payment scheme (α, β) the principal's and the agent's expected payoffs are

$$\begin{aligned} V(d_i, d_j, \alpha, \beta) &\equiv (1-\beta)X_{ij} - \alpha, \\ U(d_i, d_j, \alpha, \beta) &\equiv \beta\, X_{ij} - \frac{\rho}{2}\,\beta^2\sigma^2 + \alpha - C_{ij}. \end{aligned} \tag{40}$$

In addition to the payment scheme, a contract specifies the allocation of the decision right $h_1 \in \{P, A\}$ over D_1 in stage 1 and $h_2 \in \{P, A\}$ over D_2 in stage 2.[12]

Even though decisions are not verifiable to outsiders, we assume that the decision maker at stage 2 is informed about the first–stage decision. Accordingly, implementability requires that the second–stage decision $d_j \in D_2(d_i)$ satisfies

$$\begin{aligned} d_j(d_i) &\in \operatorname{argmax}_d V(d_i, d, \alpha, \beta) \qquad \text{if} \qquad h_2 = P, \\ d_j(d_i) &\in \operatorname{argmax}_d U(d_i, d, \alpha, \beta) \qquad \text{if} \qquad h_2 = A, \end{aligned} \tag{41}$$

for a given $d_i \in D_1$. The party who is in control over D_1 in stage 1 anticipates the second–stage decision described in (41). Thus $d_i \in D_1$ has to satisfy the incentive restriction

$$\begin{aligned} d_i &\in \operatorname{argmax}_d V(d, d_j(d), \alpha, \beta) \qquad \text{if} \qquad h_1 = P, \\ d_i &\in \operatorname{argmax}_d U(d, d_j(d), \alpha, \beta) \qquad \text{if} \qquad h_1 = A. \end{aligned} \tag{42}$$

The principal's objective is to design a governance structure (h_1, h_2) and monetary transfers (α, β) so that the implemented sequence of decisions (d_i, d_j) maximizes the joint surplus $V + U$.

[12]Note that h_2 cannot be made contingent on d_1 because d_1 is not contractible.

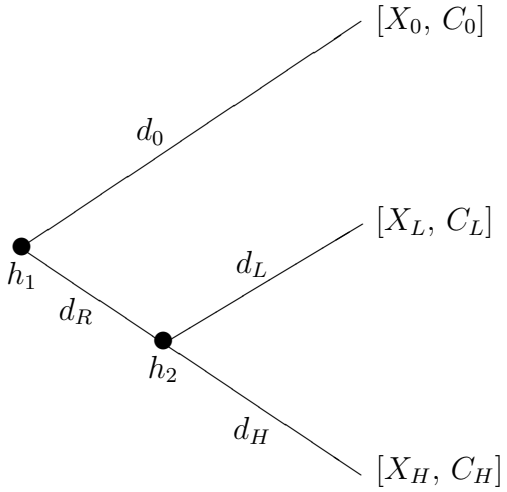

Figure 3: *Multistage Decisions*

To show that there may be gains from decentralizing authority, we consider a variation of the environment in Section 2: In stage 1 the feasible set $D_1 = \{d_0, d_R\}$ contains two possible decisions. If d_0 is selected, the decision process ends, i.e. $D_2(d_0) = \emptyset$, and project d_0 is implemented. If, however, d_R is chosen in stage 1, then in the second stage either project d_L or d_H can be selected, i.e. $D_2(d_R) = \{d_L, d_H\}$. For simplicity, denote $X_L \equiv X_{RL}, X_H \equiv X_{RH}, C_L \equiv C_{RL}$, and $C_H \equiv C_{RH}$. Figure 3 illustrates the sequence of decisions and the resulting expected outputs and costs of the three possible projects.

As in Section 2 we assume that

$$0 \leq X_0 < X_L < X_H, \quad 0 \leq C_0 < C_L < C_H. \tag{43}$$

The first–best surplus from project $d_k \in \{d_0, d_L, d_H\}$ is $S_k \equiv X_k - C_k$; project d_k is first–best efficient if $S_k \geq S_\ell$ for all d_ℓ. It follows from (43) that, after d_R has been selected, the agent will choose d_L if he has the decision right in the second stage, whereas the principal will choose d_H in this situation. Moreover, in the first stage the agent prefers d_0 while the principal prefers d_R. These considerations immediately lead to the following result:

Proposition 6 *The optimal contract specifies $h_1 = P$ and $h_2 = A$ if project d_L is first–best efficient. Otherwise, either $h_1 = h_2 = A$ or $h_1 = h_2 = P$ is optimal depending on whether $S_0 > S_H$ or $S_H > S_0$. The principal always receives the first–best surplus from the implemented project.*

Under the single–stage decision procedure in Section 2 the principal could not appropriate the first–best surplus from project d_L. Here this is possible by

dividing control rights between the principal and the agent in the first and the second stage of the decision process. This arrangement limits the excessive power of either party and facilitates the implementation of 'intermediate'–size projects.

Proposition 6 also indicates that decentralizing decision procedures by defining different areas of control may enhance the overall efficiency of the organization. Indeed, as we have seen in Section 2, in a single–stage decision problem the principal can always achieve the first–best when only two choices are available. By a simple backward induction argument this observation can be extended to multi–stage decision procedures: Whenever at each stage one out of two possible decisions has to be selected, then it is possible to allocate the decision rights at the various stages in such a way that the final outcome maximizes the joint surplus of the principal and the agent! Thus, especially in complex situations where the overall project selection involves a large number of different aspects, sequential decision procedures with a divided–control arrangement are likely to be optimal.

6 Conclusions

In this paper, we have developed a simple theory of the optimal assignment of decision rights in the theory of the firm. The basic idea is that in a world of incomplete contracts monetary incentives cannot fully reflect the impact of decisions on the benefits and costs of all members of the firm. Therefore, the party who has authority over decisions does not take these externalities into account and its objective is not identical to maximizing the firm's overall surplus. Also, because the members of the firm have conflicting interests, the surplus that can be realised depends on the identity of the decision maker. The optimal allocation of authority assigns the decision right to the party whose objective can be aligned most closely with maximizing the joint surplus. Even though incentive payments may be insufficient to implement the first–best decision, monetary transfers play an important role in our analysis. They allow distributing the realised surplus so that authority becomes tradeable between the members of the firm.

Our model can easily integrate other factors that may be important for the design of organizations. We have discussed the role of effort incentives, asymmetric information and multi–stage decision procedures. Our analysis has been confined to a two–person environment where a principal requires an agent to undertake a single project. One desirable extension is to consider a multi–person organization facing a number of decision problems. This

would allow studying more complex forms of authority relationships. Finally, our approach is applicable not only to the theory of the firm but also to other organizations. A potentially interesting application is, for example, the distribution of authority between different governmental institutions.

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