CONTRACT THEORY IN THE SPOTLIGHT: OLIVER HART AND BENGT HOLMSTRÖM, 2016 NOBEL PRIZE WINNERS

Pierre Fleckinger, David Martimort

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Oliver Hart and Bengt Holmström were awarded the 2016 Swedish National Bank's Prize in Economic Sciences in Memory of Alfred Nobel for their contributions to the Theory of Contracts. Their works build a theory of firms and organizations that is based on two pillars: (1) Parties exert efforts or incur investments that increase the value of their relationships, but these actions are sometimes hidden, not directly observed, and thus cannot be contractually enforced by courts, and (2) contracts and ownership structures are (imperfect) responses to such informational frictions. Together, the contributions of these authors have paved the way for a complete renewal of the Theory of the Firm and Organizations Theory.

contract theory – incentives – moral hazard – incomplete contracts

Un coup de projecteur sur la Théorie des Contrats :
Oliver Hart et Bengt Holmström, Prix Nobel d’Économie 2016

Oliver Hart et Bengt Holmström ont reçu le Prix de la Banque de Suède en sciences économiques en mémoire d’Alfred Nobel pour leurs contributions à la Théorie des Contrats. Leurs travaux établissent une Théorie de la Firme et des organisations fondée sur deux piliers. (1) Les parties contractantes exercent des efforts ou accomplissent des investissements qui accroissent la valeur de leur relation, mais ces actions sont parfois cachées, ne peuvent être directement observées, et ne peuvent donc pas être spécifiées dans des contrats mise en œuvre par des cours de justice. (2) Les contrats et les structures de propriétés sont des réponses (imparfaites) à ces frictions informationnelles. Les contributions de ces auteurs ont ainsi conjointement ouvert la voie à un renouvellement complet de la Théorie de la Firme et de la Théorie des Organisations.

théorie des contrats – incitations – aléa moral – contrats incomplets

Classification JEL : D81, D86, L14

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1. Introduction

A classic joke among economists has it that Economics is the only field where a Nobel Prize can be awarded jointly to two scholars who hold exactly opposite views. Examples abound. Behavior on financial markets may be irrational or efficient, yet the study of such competing assumptions nevertheless deserves a joint Nobel Prize. Governance problems can be solved by trust and norms in some places, and by fiat authority and strict boundaries applied to firms elsewhere, and still, the two solutions call for a joint Nobel Prize. At first sight, Oliver Hart and Bengt Holmström could very well provide a new data point supporting this claim: The former is chiefly known for the so-called incomplete contracts approach, while the latter’s best-known contribution asserts that contracts should rely on as much information as possible.

Ostensibly, there seems to be a contradiction between these two views of contracts and organizations, although a closer look at the intellectual paths of these two giants in the field of modern microeconomic theory unveils more shared views than one might imagine. Differences in opinions, if any, often stem from different backgrounds. This is not only true in real life, the principle prevails in science as well. Maybe future economics historians will trace back the apparent differences of conception in the works of Hart and Holmström to differences in their primary core interests. To this end, and without falling into imperfect biographical anecdotes or Persuaders!-style analogies (after all Oliver Hart and Bengt Holmström only vaguely look like Tony Curtis and Roger Moore), it is worth pointing out a few facts on these authors’ backgrounds. Hart started his scientific career working in the field of general equilibrium and more specifically incomplete markets with a particular focus on the efficiency of stock markets, especially in his early works with Sanford Grossman. These articles were an immediate success in top journals like Journal of Economic Theory and Econometrica. One of the most prominent examples is without doubt Hart’s proof of the inefficiency of equilibria in incomplete markets by means of some famous counterexamples (Hart [1975]). As to Holmström, dating from as early as his Stanford PhD dissertation (Holmström [1977]), written under the supervision of Robert Wilson, he provided several fundamental contributions to the economics of organizations. While the first author dealt with the grand perspective of general equilibrium, the second started with the more modest but just as important concern of identifying the best micro-management inside organizations. In a seminal paper, Modigliani and Miller [1958] established that, with complete markets, a firm could finance any investment, indifferently through debt or equity, and that the respective shares of investment covered by such claims had no impact on that firm’s value. This finding is of course at odds with common observation, in that it leaves little scope for understanding the separation between ownership and control, and the multiplicity of financial claims and their consequences on a firm’s value, a theme which goes back to Adam Smith and, more recently, Berle and Means [1932]. In the seventies, general equilibrium theorists believed that a better understanding

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of markets’ incompleteness offered a way out of this problem. Unfortunately, their endeavor repeatedly came up against the difficulty of finding a unanimous objective function for the firm or, if such a function could be established, a unanimous way of maximizing it when a firm’s ownership is split between heterogeneous shareholders and markets are incomplete. Hart [1979] and Grossman and Hart [1979]s contributions belong to this line of research and although the latter paper can be viewed as offering a partial solution to the puzzle, it is fair to say that the general equilibrium approach has at best delineated the conditions under which a fundamental conflict of interests would remain between stakeholders of the firm. This approach did not make significant progress towards understanding the consequences of such conflicts on the distribution of profits and the size of investments. Indeed, it was not until Jensen and Meckling [1976] that the corporate finance literature picked up its modern momentum, putting agency problems and ownership issues at the very heart of analysis. The key problem is not that firms evolve in an environment plagued with incomplete markets thus leaving heterogeneous agents with only limited opportunities for insurance and wealth redistribution across states of nature and over time. This approach would unfortunately just take the sources of incompleteness as given. Instead, the key issue is that the very incompleteness of markets comes from asymmetric information somewhere in the economy; a point forcefully made by Spence and Zeckhauser [1971]. Not all activities can be priced – the missing markets aspect – and rewards for unpriced activities can only be indirect. Indeed, members of an organization exert efforts and make investments that increase the value of this organization; however, their actions are sometimes hidden, not directly observed, and thus cannot be contractually enforced by the courts. As a result, prices are inadequate tools to allocate resources in the economy. They must be superseded by contracts and ownership structures. Contracts and ownership structures are (imperfect) responses to underlying informational frictions. Agency problems should thus be viewed as the fundamental source of market incompleteness, thereby limiting trading opportunities. They should not be viewed as their possible consequences.

This concern for agency problems, especially when applied to the theory of the firm, undoubtedly found its origin in the work of Barnard [1938] who, very early on, emphasized the need to induce appropriate efforts from the members of an organization in a context where tasks have to be delegated in response to existing comparative advantages or informational asymmetries. A few decades later, Arrow [1963] introduced the idea of moral hazard. In a well-known paper on syndicates, Wilson [1968] studied the design of the optimal sharing rule among agents with different risk tolerances. Wilson also questioned under what conditions groups facing uncertainty behave as a single individual and thus agree on which actions they should be taking. Agreement on probability is found to be a key ingredient in achieving unanimity. Such agreements are of course unlikely when uncertainty is endogenous, when it depends on the action taken by a party (say, the agent), and when the action cannot be observed by the other party (the principal, who is a residual claimant for the organization’s proceeds) and a court of law. Following up on this, Ross [1973] wrote an important piece that laid out the modern technical presentation of the moral hazard problem as a variational
problem: The principal chooses a fee schedule contingent on any verifiable information with the objective of inducing the most preferred action from the principal’s viewpoint and ensuring the agent’s participation. It was soon recognized by Mirrlees [1999] (first version 1976) that, from a mathematical point of view, this problem might not be as well-behaved as one could hope. To illustrate, under some circumstances, discontinuous sharing rules could even result in reaching the first-best, so that moral hazard would not even be an issue; an unpalatable result. It is quite natural to speculate, and we will do so here, that Hart was very much concerned by these earlier developments and was particularly enthusiastic about the new perspective of endogenizing market incompleteness offered by the then-burgeoning field of agency theory. But it was probably also in Wilson [1968, 1969] and the framework proposed by Ross [1973] that Holmström found the key inspiration for his own research, be it on the design of sharing rules under moral hazard in principal-agent structures or in a team context. As an indirect heir of Bar-nard, Holmström went on to make the micromanagement of the delegation problem the cornerstone of his research in the field.

Before making a deeper analysis and description of Hart and Holmström’s key contributions, stressing their common concerns and where their approaches differ, we should warn readers that the models presented below come with as few equations as possible, and no proofs. We also stress that this review, faithful to the laureates’ contributions, focuses on theoretical insights.1 Rather than aiming at exhaustivity, our goal is to provide key intuitions, emphasize methodological contributions, and point out a few directions where the paradigms that these authors developed have turned out to be useful. More technical aspects can be found elsewhere (see for instance Laffont and Martimort [2002]).

The rest of the paper is organized as follows. Section 2 presents the fundamental problem of moral hazard in great detail. Sections 3 and 4 then present important direct extensions and applications of the paradigm, gathering topics such as multi-agent models, multitasking and market discipline. They center chiefly around Bengt Holmström’s contributions. Section 5 considers incomplete contracts and revolves around Oliver Hart’s contributions, spanning the property rights approach to the firm and foundational aspects. Finally, section 6 concludes this overview.

2. The Moral Hazard Paradigm

The starting point of agency theory, namely task delegation, is a fundamental feature of organizations. When, in carrying out a given task, an agent has a comparative advantage or informational advantage (a seemingly slightly different view of what is generally understood as a comparative advantage), the problem is to design a compensation scheme that ensures the agent will act in the principal’s best interest. This involves designing a contract that aligns the agent’s incentives with the principal’s objectives. The moral hazard problem arises when the agent can take actions that are not observable by the principal, leading to a conflict of interest.

1. The reader is here referred to the Nobel committee scientific background document that provides some relevant empirical references.

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advantage), he may be charged with doing a task on behalf of another party, the principal. Examples abound and include relationships between managers and shareholders, contractors and public authorities, peasants and landlords, insures and insurers. These relationships are managed by a sharing rule. For instance, the firm’s profit reflects both its manager’s effort and various exogenous shocks beyond the manager’s control. Were it possible to observe the agent’s effort, a simple forcing contract could be written to dictate the manager’s effort in a way that was optimal from the firm’s viewpoint. Absent direct monitoring of the manager’s effort, disentangling effort, and shocks in the manager’s performance is unfortunately no longer possible. The wage schedule, contingent only on the agent’s performance, must thus strike a correct balance between sharing risks between managers and shareholders according to their risk tolerance and inducing effort provision from the manager.

Holmström’s most prominent contribution to the basic theory of moral hazard precisely analyzes such a design, (Holmström [1979b]). Remarkably, it was published only one year after he completed his PhD dissertation. The paper set a new standard for the way economists look at the problem, following the seminal contributions of Ross [1973] and Mirrlees [1976]. Independently, Shavell [1979] obtained very similar results.

2.1. A Bare-bone Model

In a classic principal-agent problem of moral hazard, the agent provides an effort \( a \in A \subseteq \mathbb{R} \), where \( A \) is a set of feasible actions, which generates a (monetary) outcome \( x \) for the principal (\( X \) denotes the set of possible outcomes). The principal pays the agent an amount \( w \), and keeps the residual \( x - w \). The agent receives \( w \) but incurs a disutility cost \( c(a) \) where \( c \) is increasing and convex in effort. Leaving aside the technicalities related to the restriction to bounded sharing rules, Holmström [1979b] proposed to look at a slightly less general formulation of the moral hazard problem than the original Mirrlees model (Mirrlees [1999]).\(^2\) This new formulation entails a separability of the agent’s utility function between the disutility of effort and income. The problem is that the monetary outcome \( x \) is stochastic, because of underlying uncertainty about the state of the world, and that effort is not directly observable. Holmström’s analysis adopts the so called Mirrlees’ formulation,\(^3\) in which the density of the outcomes depends on effort, \( f(x, a) \), so that the underlying uncertainty is directly subsumed in the parametrized distribution. Since \( a \) is not directly observable, rather than simply pay the agent a fixed wage to compensate him for the cost, the principal must

\(^2\) In a competing paper, Shavell [1979] proposed a similar description of the moral hazard problem but was less explicit in characterizing the second-best solutions by means of modified Borch rules. Moreover, Holmström’s main focus was to rationalize the use of deductibles in insurance, while Shavell was concerned with the design of liability rules for stochastic environmental externalities.

\(^3\) Rather than the state-space approach, as in Ross [1973] for instance, where the production function depends explicitly on some exogenous and unobserved random variable.
introduce a variable payment \( w(x) \) so that the agent's stake in the result provides him with incentives to supply effort. Incentives come at a cost. When the agent is risk-averse, making the pay risky entails paying a risk premium so that the agent will agree to participate in the resulting lottery. Hence a trade-off arises between providing incentives and making the agent bear some risk.

Let \( u \) and \( v \) respectively denote the agent's and principal's Bernoulli utility functions for money. For the contract to be acceptable, the agent must be better off when contracting with the principal than with his best alternative, which gives him a payoff denoted by \( \bar{u} \). This is expressed in the agent's participation constraint:

\[
\int_{x} u(w(x)f(x,a)dx - c(a) \geq \bar{u}. \tag{1}
\]

Absent incentive compatibility constraint, the principal can recommend the efficient effort level \( a^b \) by means of a forcing contract, paying the agent only if he actually performs that effort. Given this effort level, the optimal sharing rule \( w(a) \) follows the familiar Borch's rule as in Wilson [1968]:

\[
\frac{v'(x - w^{b}(x))}{u'(w^{b}(x))} = \lambda^{fb} \tag{2}
\]

where \( \lambda^{fb} \) is the Lagrange multiplier of the agent's participation constraint.

When the agent's action is not directly contractible, the agent's effort cannot be directly commanded and can only be induced by the sharing rule \( w(a) \). This leads us to write the familiar incentive constraint:

\[
a \in \arg\max_{a \in \mathbb{R}} \int_{x} u(w(x)f(x,a)dx - c(a). \tag{3}
\]

This constraint simply expresses that the agent maximizes his payoff given the contract he has accepted. Admittedly, this expression of incentive compatibility is quite complex since it \emph{a priori} involves an infinite number of constraints when \( A \) is an interval. To start with, we are not even sure that a solution to the maximization problem exists for any sharing rule. An important step towards a simpler characterization is nevertheless obtained by replacing this incentive constraint with the following first-order condition:

\[
\int_{x} u(w(x)f_{x}(x,a)dx - c'(a) = 0. \tag{4}
\]

Optimizing the principal's expected revenue over the set of incentive-feasible contracts satisfying (1) and (4) yields a characterization of the opti-
mal incentive contract \( w(\cdot) \). This contract indeed satisfies the following modified Borch’s rule:\(^4\)

\[
\frac{v'(x - w^{sb}(x))}{u'(w^{sb}(x))} = \lambda + \mu \frac{f_a(x, a)}{f(x, a)}
\]

The fundamental equation (5) links the shape of the compensation schedule with the agent’s effort. In this equation, \( \lambda \) is still the multiplier of the agent’s participation constraint (1), while \( \mu \) is now the Lagrange multiplier of his (“local”) incentive constraint (4). Both are shown to be positive at the optimal contract. These “modified-Borch conditions” show that the equality between the standard marginal rate of substitutions across two different states no longer holds but must be modified to take into account how informative the realization of the agent’s performance is on his effort. Holmström thereby obtains an appealing description of the “second-best” sharing rule that incorporates this likelihood ratio.

At this point, we might highlight two important findings.

First, incentives are costly and the contract no longer efficiently shares risk between parties. As an illustration, if the principal is risk-neutral, he should bear all the risk and offer a flat contract. However, that cannot be the case when incentives are involved since the agent would have no incentive to exert an effort when operating for a flat wage. This is expressed directly in the equation by letting \( v' = 1 \) and \( \mu \neq 0 \).

Second, while equation (5) implies the optimality of variable pay, perhaps surprisingly, this does not necessarily mean that the agent’s wage will increase with performance. In order for this admittedly intuitive result to hold, we need to impose that the likelihood ratio \( \frac{f_a(x, a)}{f(x, a)} \) increases in \( x \); a point already made by Mirrlees [1976].\(^5\) When this condition is applied, better performances translate better news on the agent’s effort and the principal increases the agent’s reward for such effort-informative events.\(^6\) Interestingly, the monotonicity of the likelihood ratio also implies the intuitive feature that, with an optimal contract, the principal would want the agent to work harder.

FURTHER WORKS. It is here worth mentioning two important points that have been tackled by subsequent works on the moral hazard paradigm. First, reducing (3) to the first-order condition (4) certainly requires some assumptions. Following Mirrlees and correcting a flaw in his own analysis, Rogerson [1985a] shows that the first-order approach is valid when the monotone likelihood-ratio condition and the convexity of distribution function condition \( F(x, a) \) both hold. Jewitt [1988] notices that the convexity of

\(^4\) These aspects were discussed early on by Wilson [1968], and the next equation appeared in Mirrlees [1976], and in a slightly less general case in Ross [1973].

\(^5\) Milgrom [1981] provided some foundations for this additional assumption.

\(^6\) Clearly, there are other obvious reasons for not paying a wage that can decrease with output: the agent would then be tempted, to hide, secretly sell, or even destroy some output at the point of (locally) decreasing wages.

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the cumulative distribution function is not satisfied by standard distributions. He thus replaces that condition with less stringent assumptions which are now imposed jointly on the agent’s utility functions and distributions. This line of research is still quite active (Conlon [2009]; Kadan and Swinkels [2013]; Kirkegaard [2017]).

2.2. The Informativeness Principle

Holmström [1979b] indeed shows an “Informativeness Principle”, arguing that it is valuable to incorporate other signals of the agent’s performance if they are informative on his effort in the sense of changing the likelihood ratio and thus “refining” the modified Borch rule.

One of the most important lessons offered by Holmström [1979b] is to delineate exactly which extra signals should be included in the contract and which, if any, should be left aside. Which aspects of the agent’s performance should be featured by the contract? What are the possible benchmarks against which to compare this performance? Holmström’s analysis unveils the role played by informational systems in incentive design. It can be used to investigate the value of collecting more information on the agent’s effort than what is already available through looking at his own performance. Such additional information may be obtained by means of monitoring, or by means of comparisons between various agents’ performances (typically, benchmarking and yardstick competition).

Concretely, consider the case of the CEO of a firm that consumes great amounts of energy. A number of contractable indicators are available (such as profit, market value, turnover, operating costs, etc.) pertaining directly to the firm. There are also a virtually unlimited number of outside indicators against which to benchmark the performance of this CEO. Should external indicators such as the price of energy also be used in the incentive contract? Optimal (ex post) risk sharing suggests that oil price should be filtered out from the incentive formula. Moreover, the CEO has no impact on the global price of energy, which implies that in isolation this signal does not contain any intrinsic information on what he is actually doing. Formally, the likelihood ratio of this exogenous variable is always zero. But, if the cost of input increases, the firm’s profit decreases without the CEO being responsible. Hence, optimal risk sharing suggests that the energy price should be filtered out from the incentive formula. The contract could insure the CEO against this exogenous noise. However what if the CEO can also influence how dependent the firm is on energy? Then the price of energy is also relevant for incentives, but for a somewhat different reason now: the shareholders want the CEO to take it into account rather than be insulated from its variations. In such a case, neutralizing the price of energy in the incentive formula does not encourage the CEO to pursue a strategy that adapts to external circumstances. As this example illustrates, the question of which indicators to include in an incentive contract is far from trivial.

The analysis in Holmström [1979b] can be readily extended to a case where the principal (and a court of law) can also rely on multiple signals on
top of the performance $x$ to improve contract design. Indeed, Equation (5) can be generalized to the case where an additional signal $y$ is available. With a slight abuse of notation, we now obtain:

$$\frac{v' (x - w^{ab} (x, y))}{u' (w^{ab} (x, y))} = \lambda + \mu \frac{f_a (x, y, a)}{f (x, y, a)}.$$  

[6]

Henceforth, the agent’s wage should not depend on the extra signal $y$ if and only if the right-hand side does not depend on $y$. This is the case when the density function admits the following factorization:

$$f (x, y, a) = g (x, y) h (x, a).$$  

[7]

Reciprocally, any signal that is informative on $a$ should be included in the agent’s compensation scheme. This Informativeness Principle is a cornerstone of incentive theory and its ramifications have influenced management and accounting practices. This important result has indeed inspired a whole branch of the literature on managerial economics and accounting.7

When (7) holds, $x$ is actually a sufficient static for $(x, y)$ in trying to infer $a$. This result somewhat bridges the gap between the forces that lead to the optimal design of the compensation scheme from an ex ante viewpoint and a simple intuitive reasoning on what happens ex post. Although the principal in fact perfectly infers which effort is taken in equilibrium, everything occurs as if he were trying to verify ex post how likely it is that the agent has indeed performed the conjectured effort. To do so, the principal increases the agent’s pay if he is convinced that the correct effort was made. Naturally, in this inference problem, only variables that contain information on $a$ are useful. Finally, the exact characterization through equation (7) is remarkable since it is both a mathematical equivalence and an economically interpretable formulation.8

FURTHER WORKS. A by-product of the Informativeness Principle is that, in multi-agent organizations, common shocks that affect the performance of different agents should be filtered out; a result that echoes the earlier literature on tournaments (Lazear and Rosen [1981]; Nalebuff and Stiglitz [1983]). Looking for optimal contracts in such multi-agent environments also provided a better way to understand and clarify the role of competition between agents that had been highlighted by the literature on tournaments. The applied aspects are studied in section 3.2. This sizeable literature on tournaments, although it did not refer explicitly to the Informativeness Principle, relied on it heavily de facto but in instances where, because of the exogenous restrictions made on the available mechanisms, its effects were not immediately seen. In addition, the Informativeness Principle was probably also a key ingredient in understanding the role of supervision in hierarchies.


8. Related results are found in Harris and Raviv [1979] and Shavell [1979].
2.3. Tractable Models

While the classic moral hazard model used so far is elegant and possesses interesting features, it has one important drawback, i.e. it does not lend itself easily to applications, and characterization remains relatively abstract. In their more general form outlined in Section 2.1, moral hazard models suffer from a significant lack of tractability. In addition, comparative static exercises with respect to the distribution of shocks are at best fragile.

To overcome this tractability issue, three crucial advances have been put forward in the literature, two of them by Holmström and Hart. Grossman and Hart [1983a] proposed a two-stage approach to the problem that involves decomposing the principal’s problem by first determining the best way of implementing a given effort, then identifying an optimal effort, taking into account the implementation costs. This approach has proved fruitful in many instances because it allows for instance a more detailed analysis of information structures than the sufficient statistics results. Holmström and Milgrom [1987] took a quite different route in micro-founding a now very popular model that enables simple close-form solutions. Finally, a substantial part of the literature, especially motivated by corporate finance applications, employs a model with a risk-neutral agent subject to limited liability as studied by Innes [1990]. In this context, the trade-off no longer features insurance versus incentives, but rather efficiency versus rents. Holmström also contributed on this front in his work on market liquidity and corporate finance jointly produced with Tirole (Holmström and Tirole [1993]).

2.3.1. The Two-stage Approach

To avoid the issue of the existence of an optimal contract without making further a priori assumptions on the class of wage schedules under scrutiny, Grossman and Hart [1983a] recast the moral hazard problem in the case where the outcome space is finite. In the classic model, the set of feasible outcomes writes as $\chi = \{x_i | i = 1, ..., n\}$, and the agent’s effort affects the probability $\pi_i(a)$ of each outcome $x_i$. Here, for any given $a$ to be implemented, a risk-neutral principal simply seeks to minimize the wage bill under the incentive and participation constraints (namely (8) and (9) respectively) over all possible compensation schedules $(w(x_1), ..., w(x_n))$. Formally, the cost of implementing a given level of effort $a$ can thus be written as:

\[ C(a) = \min \sum_{i=1}^{n} w(x_i) \pi_i(a) \]

9. In particular Tirole [1986a] and Faure-Grimaud et al. [2003], among many others.
10. To be sure, they also assume that the agent’s utility is sufficiently separable in money and effort to proceed with the two-stage approach. The finite outcome assumption goes a long way in terms of tractability, for instance in the insurance literature.
\[ C^p(a) = \min_{(w(x_1), \ldots, w(x_n))} \sum_{i=1}^{n} \pi_i(a) w(x_i) \text{ subject to} \]
\[ \sum_{i=1}^{n} \pi_i(a) u(w(x_i)) - c(a) \geq \sum_{i=1}^{n} \pi_i(\hat{a}) u(w(x_i)) - c(\hat{a}), \forall \hat{a} \in A, \quad [8] \]
\[ \sum_{i=1}^{n} \pi_i(a) u(w(x_i)) - c(a) \geq \overline{\pi}. \quad [9] \]

Given the separability assumption regarding the agent’s utility function in wages and effort, the program can be transformed into a convex objective under linear constraints simply by considering utility levels \( u(w(x_i)) = u_i \) as the optimization variables. The existence and characterization of a solution then follows under weak conditions.

Denoting by \( B(a) = \sum_{i=1}^{n} \pi_i(a) x_i \) the principal’s expected benefit of implementing an action \( a \), the second-best optimal effort \( a^{ab} \) solves:

\[ a^{ab} \in \arg \min_{a \in A} B(a) - C^p(a). \]

From there, Grossman and Hart [1983a] were able to characterize optimal incentive contracts in much more detail than in the general case, thus explicitly deriving some properties of the agency costs of moral hazard \( C^p(a) \) and making a deeper analysis of information structures. The main applied legacy of Grossman and Hart [1983a] is thus a tractable moral hazard model with finite outcomes. This approach allows us to derive properties of the optimal incentive scheme, including monotonicity. The full characterization of the two-outcome scenario (with greater effort increasing the probability of better performance) indeed confirms the intuitive properties that are expected from an incentive contract, and lends itself to easily interpretable solutions. High outcomes are rewarded while low outcomes are punished as a way to provide incentives. This approach also enables a discussion of how the information structure affects the cost of implementing a given action. In particular, one important result in Grossman and Hart [1983a] is that agency costs increase as the information structure becomes garbled in the sense of Blackwell. The applications in different fields are by now countless, from insurance to macroeconomics. It is simply impossible to give credit to all of the contributors who have chosen this simple paradigm for studying moral hazard. In a sense, this very specific heritage could also be viewed as strong limitation of the moral hazard paradigm in view of practical applications. A pessimistic scholar could argue: “All that work for so little”. Of course, making such a statement would be a big mistake; simplicity and its virtues only constitute a valid path because the more general approach has been explored and the limits of a two-outcome model fully understood.

FURTHER WORKS. Adopting the techniques developed in Grossman and Hart [1983a], Mookherjee [1984] derived the properties of an optimal compensation scheme with multiple agents. In particular, this author provided necessary and sufficient conditions for independent and relative compensation schemes to be optimal. Of course, the absence of any externality (pro-
ductive or informational) across the projects run by different agents is a sufficient condition for independent compensations. The advantage of Grossmann-Hart’s model of moral hazard is to allow researchers both tractable and interpretable analysis of multi-agent organizations. As already pointed out by Mookherjee [1984], one important issue in multi-agent organizations is to ensure that agents coordinate their efforts on the most preferred ones from the designer’s point of view. Indeed, agents may implicitly or explicitly collude on more attractive effort profiles; an issue studied by Ma [1988]. Grossman-Hart’s approach has also been found useful on the more technical side to study how contract design can be affected in more complex environments. For instance, some authors have studied how exogenous constraints on transfers (maximal rewards or maximal punishments) affect contract design (Jewitt et al. [2008]), how common agency representations distort incentives (Bernheim and Whinston [1986]), and how competition leads to significant market failures (Kahn and Mookherjee [1998]).

2.3.2. Optimal Linear Contracts

Holmström and Milgrom [1987] provide another highly tractable model of moral hazard. They model a dynamic principal-agent relationship in which the principal observes periodically noisy aggregates of the agent’s performances over the period. In the continuous-time version of the model, the agent controls the drift of a Brownian motion. Although based on a set of very specific assumptions that somewhat depart from the general analysis of Section 2.1, this model has become the workhorse of countless applications. The very appealing result of this model is this optimal contracts are affine functions of the aggregate performance measure, namely the end-of-period aggregate. This result allows modelers to reason as if the agent were controlling the mean of a performance and, at the same time, to restrict the analysis to linear contracts.11 This linearity allows a simple determination of the incentive power of the optimal contract and to link that incentive power to fundamental parameters like the agent’s degree of risk aversion or the amount of noise that blurs observable performance. Needless to say, given what we know from Section 2.1, this requires substantial assumptions.12 In particular, the agent’s preferences must exhibit constant absolute risk aversion. The beauty of the result is that it provides a foundation for using a reduced-form model with CARA preferences and exponential noise in which linear contracts are optimal. This reduced form is often referred to as the LEN model (standing for Linear-Exponential-Normal). The model is the apparatus for most of the applied literature in finance, accounting and managerial economics. It is also the inspiration for more recent literature based on the same fundamental idea, i.e. complex circumstances can actually lead to simple forms of optimal contracts.

11. Note that Mirrlees [1999] noticed that discontinuous contracts could approximate the first best precisely under such circumstances. It is hence important to stress that Holmström and Milgrom [1987] made it possible to carry on using a simple tractable class of contracts, but with a proper interpretation of the circumstances under which they are indeed optimal.
12. See in particular Hellwig and Schmidt [2002] for a discussion of how continuous and discrete-time models are related.

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The typical simple LEN model features one slight departure from the Holmström [1979b] setting, i.e. the effort cost is monetary, so that (ex-post) utility is \( u(w(x) - c(a)) \). Moreover, the additional specifications of (1) CARA utility \( u(y) = -e^{-\kappa y} \) for the agent and risk-neutrality for the principal, (2) additive normal noise \( e \sim N(0, \sigma^2) \), so that \( x = a + e \), and finally (3) linear contract \( w(x) = \alpha + \beta x \), simplify greatly the problem. It becomes possible to work directly with the certainty equivalent of the agent’s net payoff under variable pay:

\[
CE(a, \alpha, \beta) = \alpha + \beta a - c(a) - \frac{rB^2 \sigma^2}{2}.
\]

The incentive constraints can be immediately replaced by the corresponding first-order condition, namely:

\[
\beta = c'(a).
\]

Then the participation constraint \( CE(a, \alpha, \beta) \geq CE \), which is binding at the optimum, pins down the fixed part of the compensation schedule \( \alpha \). Inserting these two conditions into the principal’s objective and optimizing with respect to the piece rate parameter \( \beta \) makes it possible to conclude. At the optimal contract, the incentive power \( \beta^{sb} \) satisfies:

\[
\beta^{sb} = \frac{1}{1 + rc''(a^{sb})\sigma^2}.
\]

Hence the more risk-averse the agent is \( (r) \), the more convex the cost \( c'' \) and the more noisy the performance measure \( (\sigma^2) \), the lower the power of incentives. This relationship has been the subject of extensive empirical work attempting to identify in particular whether or not CEOs’ real-life incentive packages follow the optimal incentive logic. It is fair to say that this negative relationship between risk and incentives has received relatively mild support from an empirical viewpoint (Jensen and Murphy [1990]; Pendergast [1999, 2002]). However it remains a basic building block of any variation of the basic model that challenges this negative relationship between risk and incentives: A nice example is provided by Baker [1992]’s analysis of the use of imperfect performance measurements.\(^{13}\)

Although tractable, and an important basis for applied works, it could be argued that the LEN model fails on several grounds. First, the assumption that the agent controls the drift of a Brownian motion translates, in the static reduced-form version of the model, into the assumption that the agent controls the mean of the performance. In other words, this model cannot account for the many settings where the agent’s task is indeed to manage risks on behalf of the principal (so as, for instance, to reduce the variance of

\[\ldots\]

\(^{13}\) Note that Holmström and Milgrom [1987] were not the only ones to identify the linearity of contracts, but menus of linear contracts are also useful as a way of implementing optimal mechanisms as pointed out by Laffont and Tirole [1986] in an adverse selection model dealing with the regulation of natural monopoly.
the principal's return); a setting that is particularly important for delegated portfolio management. Second, many incentive schemes used in practice, except perhaps sales commissions and piece-rates, are not linear. To illustrate this point, it is often the case that part of a CEO's compensation takes the form of privileged options to buy shares, and such instruments are clearly non-linear.

2.3.3. Limited Liability: Another Trade-off Between Rent Extraction and Efficiency

While not a contribution of Oliver Hart or Bengt Holmström, it is fair to mention here that another modeling of the moral hazard problem has been extensively used following Innes [1990]. The main departure from previous theories is that the agent (as well as the principal) is now risk-neutral. Then, following the original version, it is enough to transfer all the risk to the agent by making him a full residual claimant of the outcome \( x \): if the principal can sell the firm to the agent at its first-best value, all incentive concerns will disappear. However, this is not feasible when the agent is financially constrained compared to the size of the firm, or if law prevents making over-low or negative transfers to the agent, as is the case in virtually all employment relationships. Because sticks can no longer be used to provide incentives, only carrots can be used, and inducing a given level of effort from the agent requires leaving him with some rent. In this context, rent extraction rather than risk sharing becomes the central concern, and in general, it is not possible to attain the first-best level of effort if liability constraints are stringent enough. The very same aspect is the root of inefficiencies in other situations, such as moral hazard in teams (Section 3.1) and incentives provided through the allocation of property rights (Section 5).

3. Direct Extensions of the Paradigm

3.1. Moral Hazard in Teams

Alchian and Demsetz [1972] were the first to address the possible free-rider problem caused by team production. Free riding occurs within the firm's boundaries, even when technologies are common knowledge, provided that the agents' inputs into the production process are difficult to assess. Alchian and Demsetz [1972] emphasized the need for metering inputs to avoid shirking within a team, but also the fact that metering is costly. Their view provided a justification for two important organizational forms as optimal responses to this monitoring problem. The first one is exemplified by the hierarchical firm with managers playing the monitoring role. The second one is obtained with team production where monitoring is
performed by peers because it might be relatively easier in some specific contexts.

In a seminal paper, Holmström [1982a] challenged this view. The starting assumption is that the problem within team production comes from the non-verifiability of individual efforts; only team production can be used to provide incentives, and the only contracts feasible within the firm stipulate that teammates share the proceeds of production. This is a classic moral hazard ingredient and the familiar insight applies. To internalize the impact of their own production efforts, individual risk-neutral agents should actually be made residual claimants of the whole production proceeds. Clearly, such a mechanism violates budget balance: all agents cannot be simultaneously made residual claimants. Indeed, Holmström [1982a] demonstrated that any differentiable sharing rules would induce suboptimal effort choices. Instead, discontinuous rules that commit agents to destroy surplus if performance is not sufficient can restore first-best incentives even when efforts are non-verifiable. Of course, these rules can be quite difficult to enforce. Holmström [1982a] concluded that the main role of the principal was actually to become a budget-breaker absorbing any extra surplus needed.

The bulk of Holmström [1982a]’s argument can be readily presented in a simple two-player extension of the LEN model. Consider a firm made up of two teammates and suppose that the team’s output can be expressed as:

\[ x = a_1 + a_2 + \varepsilon \]

where \( \varepsilon \) is again normally distributed \( \varepsilon \sim N(0, \sigma^2) \) and where \( a_i \) is teammate \( i \)’s contribution to the firm’s output. The firm’s returns must be shared between the workers and, let us write teammate 1’s compensation as \( \beta x \); while teammate 2 gets the residual \( (1 - \beta) x \), since agents must share the overall proceeds under budget balance.\(^{14}\) Suppose that both teammates are risk-neutral, \( r = 0 \), and have the same disutility of effort \( c(\cdot) \). The certainty equivalents of their respective payoffs can be written as:

\[ CE_1(a_1, a_2, \beta) = \beta(a_1 + a_2) - c(a_1), \]

and

\[ CE_2(a_1, a_2, \beta) = (1 - \beta)(a_1 + a_2) - c(a_2). \]

The first-order conditions for the agents’ problems are immediately obtained as:

\[ \beta = c'(a_1) \text{ and } 1 - \beta = c'(a_2) \Rightarrow 1 = c'(a_1) + c'(a_2). \]

\[^{14}\text{The argument below is actually more general since it holds with any ex-post sharing of the proceed } (\beta(x), x - \beta(x)) \text{ where } \beta \text{ is a differentiable function.}\]
Instead, efficiency would call for choosing effort levels such that

\[ 1 = c' \left( d^b_1 \right) = c' \left( d^b_2 \right). \]  

The comparison of (11) and (12) makes it clear that increasing effort by one worker stifles incentives from the other in a second-best environment. Workers free ride on their effort provision in a team context. Importantly, this free riding has nothing to do with the possible externalities that would arise in the production function. Indeed, free-riding arises here in a context with an additive production function. The key reason for this problem is the inability to infer individual contributions in the total firm’s output.

**FURTHER WORKS.** Although settings differ, the trade-off between individual incentives in a team and budget balance that was highlighted above is reminiscent of the trade-off between dominant strategy incentive compatibility and budget balance that was highlighted in a context of asymmetric information by the mechanism design literature (see Green and Laffont [1977, 1979] among others). It is worth mentioning at this stage that Holmström [1979a] also touched upon this literature. He analyzed dominant strategy mechanisms for domains of preferences that are not connected, and showed that the class of Groves mechanisms does not exhaust all possibilities for designing such dominant strategy mechanisms. This certainly reveals how much Holmström was aware of these two different sides and of informational scenarios that might favor the incentive problem in teams.

Legros and Matthews [1993] offered a more positive perspective on the performance levels that can be achieved while satisfying budget balance. They provided a necessary and sufficient condition for efficient effort provision. They argued that this condition is satisfied in many interesting environments, although these environments fail to be “smooth” in a sense that they stipulated. They also suggested that mixed-strategy equilibria can be constructed to approximate arbitrarily close efficiency; a property sometimes referred to as virtual implementation. Rasmusen [1987] demonstrated that risk aversion and uncertainty on outcomes could help to implement a budget balance sharing rule that would severely punish all agents but one in case of bad performance. Finally, Rahman [2012] pursued this line of research and characterized contracts, based on mediated communication, that virtually implement efficiency even when a monitor obtains private and costly access to agents’ performances and may manipulate this subjective assessment.

### 3.2. Multiple Agents and Relative Performance Evaluation

The logic of incentive provision when individual contributions are not observable emphasizes the role of a principal as a budget-breaker. In more general contexts, this principal, perhaps representing the owners of the firm, may have a more active role in designing compensation for firm members.

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For instance, when agents manage distinct profit centers, their compensations may be based on their relative performances. Instead, they may be rewarded in terms of a joint performance, such as sales or profit. Pursuing and enriching early works on tournaments (Lazear and Rosen [1981]; Nalebuff and Stiglitz [1983]), the contribution of Holmström and Milgrom [1990] relies once again on the LEN model to delineate the circumstances under which competitive or joint incentives are optimal.

Consider a duplication of the single agent scenario, but with two agents, \( i = 1, 2 \), producing independently, according to the same production as before:

\[
x_i = a_i + e_i \quad (\text{for } i = 1, 2).
\]

The key parameter is the correlation \( \rho \) between the noise terms:

\[
\rho = \text{Corr}(e_1, e_2).
\]

Generalizing the linear contract model and assuming symmetry for simplicity, \(^{15}\) agent \( i \) is rewarded according to:

\[
w_i(x_i, x_{-i}) = \alpha + \beta x_i + \gamma x_{-i}.
\]

Following the now familiar logic for solving the model, we obtain for the optimal contract:

\[
\beta^{sb} = \frac{1}{1 + \rho \sigma^2 \left( a_{sb}^2 \sigma^2 (1 - \rho^2) \right)} \quad \text{and} \quad \gamma^{sb} = -\rho \beta^{sb}.
\]

Therefore, the principal uses relative performance evaluation as soon as the correlation is positive. The conventional interpretation is that the principal is able to better infer the associated noise \( x_i \) by observing both performances. This has two consequences. First, the incentives provided may be stronger, \( i.e. \beta^{sb} \) can be increased compared to the single agent case (as seen in the term \( 1 - \rho^2 \)). Second, the optimal (linear) scheme filters out some noise through \( \gamma \); if the other agent’s performance is high, it indicates that the noise terms were favorable, and the wage is corrected to reduce the luck component of the pay.\(^{16}\) While Lazear and Rosen [1981] and Nalebuff and Stiglitz [1983] showed that tournaments – an extreme form of Relative Performance Evaluation – may be preferable to piece-rate, Holmström and Milgrom [1990] show that a scheme in which \( \gamma \neq 0 \), \( i.e. \) richer than a simple individual piece-rate, is preferable as soon as \( \rho \neq 0 \).

This setting also enables a substantial discussion of work organization in terms of delegation and cooperation of the agents. Indeed, Holmström and Milgrom [1990] analyze various arrangements, in which the agents can side-

\(^{15}\) That is, identical noise variances and cost functions as well as symmetric contracts, hence identical efforts \( a_i^{sb} = a_{-i}^{sb} = a^{sb} \).

\(^{16}\) As stressed in Fleckinger [2012], one should be careful with this reasoning, which is quite dependent on the additive noise formulation.
contract among themselves, assuming that they can contract on effort. Such an arrangement allows them to better coordinate their efforts, and, more importantly, agents then act as a single agent with a reduced risk-aversion.\textsuperscript{17} However, allowing side-contracting precludes relative incentives. Since the value of relative performance evaluation increases with correlation, a correlation threshold exists below which allowing side-contracting and facing a more risk-tolerant coalition of agents dominates a competitive organization without side-contracting. This contribution, along with Varian [1990] for group-lending and Itoh [1991] as well as Ramakrishnan and Thakor [1991], initiated considerable applied literature on multiple agent organizations subject to moral hazard. The dynamics of such relationships have been studied in more recent contributions (Meyer and Vickers [1997]; Che and Yoo [2001]). An important takeaway from this literature is that competition is probably not as useful to alleviate moral hazard in organizations as was first suggested by the tournament literature and a basic application of the sufficient statistics results. The next paragraph goes deeper into important aspects of organizational design and moral hazard.

3.3. Multi-task Agency Problems

Equipped with the tractable model of linear contracts reviewed in Section 2.3.2, Holmström and Milgrom [1991, 1994] proposed a theory of the organization of tasks and jobs within a firm. The starting point is to generalize the standard moral hazard model in an environment where the agent has to perform several tasks that may either be complements or substitutes and which may be observed with different degrees of precision.\textsuperscript{18} The key insight is that an agent will make more effort on dimensions of his activity that are more easily observable and underperform on less easily measurable aspects.

Again, the LEN model is a formidable vehicle to provide the main intuition behind the multi-task fallacy. Suppose now that the agent, who is still risk-averse, undertakes two tasks on the principal’s behalf. Task $i$ generates an output

$$x_i = a_i + \epsilon_i \quad (\text{for } i = 1, 2)$$

where $\epsilon_i$ is again normally distributed ($\epsilon_i \sim \mathcal{N}(0, \sigma_i^2)$). The key assumption that we will be making is that efforts are perfect substitutes, so that the overall disutility writes as $c(a_1 + a_2)$ and task 1 is subject to less noise, i.e., $\sigma_1 < \sigma_2$.

In this multitask environment, we might still write the agent’s compensation as an affine function of its performances as $\alpha + \beta_1 x_1 + \beta_2 x_2$. From there, we may derive the expression of the agent’s certainty equivalent as:

\textsuperscript{17} This follows from Wilson [1968], and is pursued further in Itoh [1993].

\textsuperscript{18} On this issue, see also Laffont and Tirole [1991] for a model in an adverse selection setting.
The optimality condition for the agent’s behavior requires that he put all of his efforts into the most rewarding task:

\[
C(E(a_1, a_2, \alpha, \beta_1, \beta_2)) = \alpha + \beta_1 a_1 + \beta_2 a_2 - c(a_1 + a_2) - \frac{r}{2} (\beta_1^2 a_1^2 + \beta_2^2 a_2^2).
\]

Clearly, the principal finds it optimal to focus all incentive power onto the least noisy task and thus:

\[
c'(a_1) = \begin{cases} 
\beta_1 & \text{if } \beta_1 > \beta_2, \\
[0, \beta_1] & \text{if } \beta_1 = \beta_2, \\
0 & \text{otherwise}.
\end{cases}
\]

This result is an important factor to understand optimal clusters of tasks on the job (with a principle of unity of responsibility, an agent being given only one task), and to provide a simple theory of ownership (with the value of an asset being improved when the agent not only works with the asset but owns it). From this point, Holmström and Milgrom [1994] developed a theory showing how asset ownership, incentives and other job attributes should go hand in hand.

FURTHER WORKS. Many authors have embarked in the theory of multitasking and studied its consequences for organizational design. To quote a few, Itoh [1991] studied the value of mutual help on the shop, Dixit [1996] studied the low-powered incentive problems that arise in bureaucracies, and Martimort and Pouyet [2008] provided a theory of public-private partnerships based on the complementarity between investments and maintenance. Of particular importance is the contribution by Holmström and Milgrom [1990] who, again making use of the tractability of the linear contracts model, studied how a principal may want to design internal incentives within the firm, either to promote cooperation or deter collusion among the agents.

4. Further Extensions of the Paradigm

Agency theory often takes the bilateral relationship between a single principal and a single agent as the fundamental brick of analysis. The model of Section 2.1 is illuminative in this respect. In particular, the opportunities that the agent might get outside the relationship, the nature of informative signals that can be used to improve benchmarking, and the opportunity cost of investing in this particular relationship are all exogenously given.

In a market context, these variables should no longer be taken as fixed but instead depend on the market environment. The level of compensation...
needed to attract an agent, the benchmark stock performances of competing firms, and possible restrictions on outside activities, all depend on the institutional setting under consideration. Against this background, a principal cannot control all of the aspects that matter from the agent’s perspective, such as future employment opportunities or other benefits associated with individual reputation, and thus in this sense contracts are almost necessarily incomplete. In this section, we follow Holmström and Tirole [1989] in discussing the disciplinary role of labor, the product, and the financial market in improving managerial incentives.

4.1. Moral Hazard and the Labor Market

Early on, Fama [1980] argued that moral hazard issues within a firm would be alleviated by the disciplining force that internal and external labor markets exert on the firm’s managers. The intuition is that a manager paid according to the expected value of his productivity conditioned on past performances would exert his first-best effort. Holmström [1999b] (first version 1982) pointed out that this reasoning is incorrect if the shocks that impact the agent’s talent in each period are only serially correlated. In such contexts, at any single period, the past history of an agent’s performance is not enough to fully reveal his ability. Some scope for fooling the market always remains, and this makes it possible for the agent to shirk effort.

The dynamic reasoning can be essentially cast in a variation on the LEN setting, by having a third term capturing a fixed managerial talent, \( \theta \), and a two-period production process such that the output in each period is:

\[
x_t = \theta + a_t + \varepsilon_t, \quad \text{for } t = 1, 2
\]

where \( \varepsilon_t \) is a random shock with normal distribution and zero mean. Neither the manager nor the current and future employers know \( \theta \), but the successive realizations of performance reveal (at least partially) this parameter over time. A typical useful simplifying assumption is that in the second period, the manager obtains a fixed wage that depends on the market’s evaluation of his talent. That is, employers competitively bid for the agent by offering flat wages. This aims at minimally capturing the fact that the manager’s career prospects at date \( t = 1 \) influence incentives in the first period while in the second period, the manager has no incentive to exert effort. If \( \delta \) denotes the discount factor, the manager hence maximizes at \( t = 1 \):

\[
\alpha + \beta x_1 - c(a_1) + [\theta | x_1].
\]

Indeed, in the second period, the flat wage implies \( a_2 = 0 \), and hence the marginal productivity of the manager is only his expected talent. In this context, the first-period incentives have no reason to be aligned with the first-best. In particular, a classic profile of effort would put high effort first, so that the market increases its expectation of \( \theta \) (since the last reputational term increases with \( a_1 \)), followed by under-provision of effort and reputation “milking” by the agent.
This so-called “career concerns” model constructed by Holmström now constitutes an important building block for anyone interested in implicit incentives within an organization. Harris and Holmström [1982] have used this type of model to explain empirical regularities in labor contracts, such as wage rigidity over a career, and the positive correlation between earnings and experience, even controlling for productivity (see also Baker et al. [1994], for a later discussion on empirical evidence). In another related contribution, Holmström and Costa [1986] analyzed optimal contracts when a manager’s ability is revealed by his past investment decisions, and showed how well-designed internal capital budgeting can incorporate these concerns better than the market. Finally, Dewatripont et al. [1999] have successfully put forward this model to build a theory of missions and accountability in contexts where agents (bureaucrats) have multiple tasks to undertake. Broadly speaking, all reputation models of employment and career cycles are inspired by this pioneering modeling.

FURTHER WORKS. Still on the dynamics side, but focusing instead on complete contracting where an agent’s performance can be contracted in each period, Rogerson [1985b] extended the basic result of Section 2.1 to a multiperiod setting. He showed that contracts exhibit memory. A good outcome today is rewarded not only today but also by higher payments in the future. Intuitively, smoothing rewards over time is a way to gradually spread incentives and limit the risk borne by the agent in any given period. The literature on dynamic principal-agent modeling under moral hazard is now huge and applies to many fields, like dynamic public finance, macroeconomics, and corporate finance. On this active front, it is also worth mentioning the contribution by Fudenberg et al. [1990]. Put simply, these authors show that, once the principal and his agent have equal access to the financial market and reconstructing takes place in common knowledge of technology, it costs nothing to replace a long-term contract by a sequence of short-term ones. As pointed out by Arve and Martimort [2016] in related works, we can view the contribution of Fudenberg et al. [1990] as providing conditions under which not being able to write a long-term contract is not really an impediment to contracting. Transaction costs have no impact here.

Another line of research on the dynamics of contracts, to which Hart contributed extensively, considers the dynamics of employment when the firm has private information on market conditions, and must be incentivized not to cut wages by claiming that times are bad (Grossman and Hart [1983b]; Grossman et al. [1983]). Whether they use a general or partial equilibrium approach, these papers reach the conclusion that incentive constraints justify reductions in employment (a now well-known consequence of adverse selection, see Hart [1983b]).

4.2. Moral Hazard and the Product Market

An important question that naturally surfaced early on is the extent to which the product market disciplines the moral hazard of managers. It is tempting to believe that the pressure of competitors would erode the...
X-inefficiency associated with market power, echoing the long-standing saying by John Hicks that “the best of all monopoly profits is a quiet life”. Hart [1983a] made an early attempt to formalize the idea that competition indeed reduces managers’ slack in terms of delegation. In a rather specific model of moral hazard, he shows that competition does reduce X-inefficiency compared to monopoly when firms are subject to common shocks.

This line of research has led to numerous subsequent contributions, partially amending these results (Scharfstein [1988]; Martin [1993]). With his limited liability model of moral hazard, for instance, Schmidt [1997] provides contrasted results, showing in particular that more competition might actually reduce managerial incentives in an optimal contract, since paying the rent necessary for motivating managers becomes less valuable when profits are slashed by competition. As demonstrated further in Raith [2003], the case for competitive pressure as a source of managerial motivation is in principle ambiguous for several reasons, and hence sensitive to modeling assumptions. Whether or not firms consider markets with free-entry and the nature of competition, and whether or not bankruptcy is a risk (Schmidt [1997]) will have different implications for the kind of incentives that they set out to design. Beyond the nature of the competition, the role of managers has several dimensions that will impact the design, including whether their role is to reduce fixed or marginal costs. Perhaps more fundamentally, as pointed out in section 2.1, the link between risk and incentives is empirically not established, in the sense that the LEN model presented above, for instance, has little empirical support. As a result, whether competition reduces managerial slack jointly depends on how competition and risk are related, and whether the delegation model adequately reflects the internal functioning of the firm. This is somewhat unfortunate given the importance of the question for long-term growth (Aghion et al. [1999]). Finally, adopting a broader viewpoint whereby the organizational form is also a strategic decision made by the core of the firm, it becomes apparent that opposing the discipline provided by the product market and the internal incentive instruments of the firm is somewhat artificial, and that a joint analysis is preferable (Holmström and Tirole [1991]).

4.3. Moral Hazard and the Financial Market

Financial markets may also exert a fairly effective role in motivating managers. Holmström and Tirole [1993] argued that stock prices encapsulate information that may be valuable to improve managerial incentive schemes. In more liquid markets, more shares are traded, and more information is available from investors who have picked up signals on managers’ efforts.

19. The optimal contract, given the assumptions made, is simply to meet a profit target. The “slack” hence comes from the fact that input prices vary, and low input prices provide managers with a rent.

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This paper opened the doors to an important debate in the corporate finance literature on the trade-off between liquidity and control.\textsuperscript{20}

Holmström and Tirole [1997] provided a very simple model to analyze credit rationing due to moral hazard in the spirit of earlier work by Stiglitz and Weiss [1981]. An entrepreneur who has limited liability needs outside financing to undertake a project. Investors have a limited supply of funds and are competitive, making zero profit on any loan they make. The entrepreneur may exert effort and increase the probability of generating high profit, or divert resources towards private benefits. This very simple model generates an agency cost that prevents less wealthy firms from accessing the capital market. This provides a channel by which the credit crunch may hit less wealthy entrepreneurs more fiercely.

The relevance of this model to understand the recent financial crisis and its tractability make it extremely attractive to understand the supply of liquidity in the economy and, more broadly, corporate finance issues. We refer to the treatise by Tirole [2006] for a complete overview of these issues and a broader analysis of the very active field of corporate governance and control, which builds on early views regarding the separation of ownership and control discussed above.

5. Incomplete Contracts

The fundamental issue already raised by Coase [1937] is to determine whether it is preferable to realize a given transaction within a firm or through the market. The theory of complete contracts sketched out in Section 2.1 views organizations and firms as sub-economies that rule all activities of the contracting parties involved, even if they do so under the observability and verifiability constraints imposed by moral hazard (and/or hidden information, in a more general perspective). For instance, as noted above, Alchian and Demsetz [1972] argue that a hierarchy emerges because it improves monitoring and, at least partially, solves free-riding problems in teams. Yet, even this argument fails to recognize why monitoring is easier within a firm than through market relationships. If complete contracts were feasible, we would not be able to distinguish \textit{a priori} the relationship between an employee and an outside unit working at arm’s length for the firm. Both contractors would receive the same compensation schedule that would stipulate what should be done under every possible contingency and how proceeds should be shared. The agents would thus adopt the same behavior, again subject to the incentive constraints induced by verifiability, and profit would remain identical across both governance modes.

The theory of complete contracts thus has a hard time explaining a firm’s boundaries, unless it cuts the Gordian knot somewhere, assuming that firms have a comparative advantage in monitoring some activities. Williamson

\textsuperscript{20} See Burkart \textit{et al.} [1997] for instance.
[1975, 1985] repeatedly made this point in his own research and concluded that the challenge of any meaningful Theory of the Firm is to explain why vertical integration could be more costly than keeping units apart. Williamson refers to the concept of *selective intervention* to explain these integration costs. Put simply, the idea here is that when activities are integrated into a large firm rather than kept apart in separate units unavoidable changes occur in terms of incentive intensity (incentives are weaker in the integrated firm) and administrative controls (controls are more extensive). The argument is compelling but lacks sound foundations. What are these costs of selective intervention? And does it not once again involve putting an arbitrary comparative advantage for one governance mode over the other?

5.1. Hold-up and Property Rights

A key starting point to answer these questions, and the cornerstone of Oliver Hart’s seminal contribution to the Theory of the Firm, is to recognize that complete contracts cannot always be written. Incompleteness in contractual relationships is pervasive. Such incompleteness might come from a lack of comprehensiveness; not all future contingencies can always be described or even thought of at the time of writing an agreement. In a world of incomplete contracts, parties have to fill in the details of their relationships at later stages. In particular, the owner of an asset can choose its best use in case the contract breaks down with unforeseen contingencies. This party has all *residual rights of control* of this asset.

Indeed, a second key element to consider is that parties indeed make specific investments in non-human assets in a relationship so as to improve the value of their transactions. While many trading partners may be around *ex ante*, once sunk, these investments transform the trading relationship into an *ex post* bilateral monopoly (Klein *et al.* [1978]). This *fundamental transformation*, as coined by Williamson [1985], puts specific investments at the risk of *hold-up*. Williamson [1985] argues that integration solves this problem, although this view has often been criticized for having implicitly assumed that transactions within firms are no longer subject to the same hazards as those on the market (Whinston [2003]).

Grossman and Hart [1986], and later Hart and Moore [1990] in more complex environments, laid out a theory of vertical and horizontal integration that relies on these two elements and avoids the latter criticisms. The bulk of their argument is as follows. Parties may haggle *ex post* on how to share the surplus of their transaction. However, the gains from trade that they respectively obtain depend on what they can do if this bargaining breaks down (*it never does at equilibrium if ex post bargaining takes place under complete information*; this simplifying assumption made by Hart led him to dismiss the possible role of asymmetric information and thus monitoring to explain a firm’s limits). The key observation made by Grossman-Hart-Moore is that ownership affects the status quo payoff that an owner can obtain when using his asset outside the relationship. In turn, ownership thus has an impact on incentives to invest in the relationship in the first place. Since an
owner only gets a fraction of the overall surplus ex post, the owner’s marginal incentives to invest depend on the relative marginal impact of such an investment inside and outside the relationship. The hold-up problem is exacerbated when the owner cannot find an alternative use for a highly specific asset. The best governance mode, from an ex ante viewpoint, should thus minimize these distortions.

Formally, consider the buyer and seller of a widget. This widget is produced from two assets \( S \) and \( B \). The buyer and seller invest and, following Hart [1995], we will assume that these investments have no cross effects; the buyer’s investment only affects his valuation, both inside and outside the relationship. Similarly, the seller’s investment only affects his cost, again both inside and outside the relationship. By investing \( a_1 \), the seller reduces the cost \( c(a_1) \) of producing the good. By investing \( a_2 \), the buyer obtains a greater valuation \( v(a_2) \) for the good. Outside the relationship, trade takes place on a competitive market at an exogenous price \( \bar{p} \). On the market, the investments have lower values, namely \( \bar{v}(a_1, \Omega) \), and \( \bar{v}(a_2, \Omega) \). These values actually depend on the underlying ownership structure which is denoted by \( \Omega \). Formally, under buyer integration \( \Omega = \{B, S\} \) while under seller integration \( \Omega = \emptyset \). Under separation, \( \Omega = \{B\} \). To model the specificity of assets and the gains from striking a bilateral relationship, it is assumed that investments have a higher value inside the relationship, namely:

\[
v(a_2) - c(a_1) > \bar{v}(a_2, \Omega) - \bar{v}(a_1, \Omega) \quad \forall (a_1, a_2) \text{ and } \forall \Omega.
\]

Efficiency calls for maximizing the overall surplus inside the relationship, namely \( (d^b_1, d^b_2) = \arg\max_{(a_1, a_2)} v(a_2) - c(a_1) - a_1 - a_2 \) and thus (assuming strict concavity of the relevant functions):

\[-c'(d^b_1) = v'(d^b_2) = 1.
\]

Under an incomplete contract scenario, parties bargain ex post over the value of the surplus. Assuming that parties share the net surplus of the relationship equally, the price \( p \) that results from Nash bargaining solves:

\[
p = \arg\max_p (v(a_2) - \bar{p} - (\bar{v}(a_2, \Omega) - \bar{p})) (\bar{p} - c(a_1) - (\bar{p} - \bar{v}(a_1, \Omega)))
\]

and thus

\[
p = \bar{p} + \frac{1}{2} (v(a_2) - \bar{v}(a_2, \Omega)) - \frac{1}{2} (c(a_1) - \bar{v}(a_1, \Omega)).
\]

The buyer’s and seller’s ex ante payoffs thus write respectively as:

\[
V_B(a_1, a_2) = \frac{1}{2} (v(a_2) + \bar{v}(a_2, \Omega)) - \frac{1}{2} (c(a_1) - \bar{v}(a_1, \Omega)) - \bar{p} - a_2
\]

and

\[
V_S(a_1, a_2) = \bar{p} - \frac{1}{2} (c(a_1) + \bar{v}(a_1, \Omega)) + \frac{1}{2} (v(a_2) - \bar{v}(a_2, \Omega)) - a_1.
\]

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At a Nash equilibrium \((a_1(\Omega), a_2(\Omega))\), contingent on the ownership structure, we obtain:

\[-\frac{1}{2} (c'(a_1(\Omega)) + c'(a_1(\Omega), \Omega)) = \frac{1}{2} (v'(a_2(\Omega)) + v'(a_2(\Omega), \Omega)) = 1.\]

When investments have less marginal impact outside the relationship, we immediately obtain that investments are inefficiently low, capturing thereby the important logic behind the hold-up problem. Observe nevertheless that investments would be efficient if there was no specificity involved, and returns on investments in and out of the relationship would be the same.

Grossman and Hart [1986] and Hart and Moore [1990] have defined the best governance mode as that which best mitigates this hold-up problem. In a sense, the analysis is roughly similar to that relating to complete contracts, especially with the model of moral hazard in teams. Again, the optimal incentive structure maximizes welfare subject to verifiability constraints but now the problem is further constrained by the addition of incompleteness constraints. The novelty comes from the description of these incompleteness constraints, which make it impossible to write \textit{ex ante} contracts so as to share the surplus and force sharing rules to be replaced by bargaining protocols that feature parties' outside options determined by the ownership structure.

The theory involves a number of significant implications. For instance, it predicts that the party that benefits the most from owning the asset should indeed own it. By the same token, and maybe more interestingly, it also shows that complementary assets (in a sense defined by Hart and Moore [1990]) should be owned together, while independent assets should be owned separately.

This model is thus able to explain a number of important facts about the real world. A first direct consequence of such findings is that under increasing returns a large firm (comprising two assets) may be preferable to separate firms (comprising one asset each) because merging ownership has a positive impact on incentives to invest in these assets. Second, employees involved in routine tasks have very little incentive to improve such tasks and should not be allocated ownership of the relevant assets. Finally, firms may remain smaller in sectors (like IT) where assets are more flexible and synergies may be less significant.

FURTHER WORKS. Investments might not always be fully observable and, in the absence of any contract, parties may bargain \textit{ex post} under asymmetric information on the costs and benefits of the relationship. This is the case in many public and private procurement contexts. Tirole [1986b] showed that most bargaining structures may induce underinvestment, thereby supporting Williamson [1985]'s suggestion that opportunism leads to hold-up problems. Assuming instead complete information \textit{ex post}, Edlin and Reichelstein [1996] and Aghion \textit{et al.} [1994] showed that even simple non-contingent contracts (for instance breach remedy, or specific performance) can be used to restore the parties’ incentives to invest. Taken together, these papers show that there is no definitive view on whether or not hold-up problems can be easily solved in an incomplete contracting setting.

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5.2. Delegation and Authority

The view of the firm proposed by Hart, i.e., a collection of non-human assets, could be considered by some observers as somewhat problematic. At the end of the day, a firm is still somewhat reduced to a black box. As pointed out by Holmström [1999a] in a criticism of the Grossman-Hart-Moore approach, a firm is not only a collection of assets but also a set of communication channels among its members and a set of constraints on the behavior of those members; a contrasting view that echoes the more traditional Agency Theory. The question remains to determine how control rights are allocated in a context where, for instance, physical assets are of little relevance and other considerations shape organizational design. To illustrate this point, in the Grossman-Hart-Moore paradigm, the delegation of control between shareholders and managers, and the sub-delegation of control to lower tiers within the firm's hierarchy, are not the purpose of the analysis although such delegation is pervasive in practice.

This delegation problem between a principal and an agent was first studied by Holmström [1982b]. In a nutshell, the model goes as follows. Suppose that there is a set of possible actions $A$ available to the agent. Actions are a priors observable. The agent may have an informational advantage over the principal and thereby know about a state of nature $\theta$ that belongs to some set $\Theta$ and that is relevant for decision-making. The preferences of the principal and agent are defined over actions and states of nature, respectively as $U^p(a,\theta)$ and $U^a(a,\theta)$. Of course, the methodology of mechanism design could be used to determine an optimal mechanism, i.e., a mapping that would specify for each possible state of nature $\theta \in \Theta$ the agent's action $a(\theta)$ that would maximize the principal's expected payoff (assuming the latter keeps all bargaining power) $\int U^p(a(\theta),\theta)dF(\theta)$ where $F$ is now the c.d.f for $\theta$. The key assumption made here is that monetary incentives cannot be used to align the objectives of both the principal and the agent. The only remaining tool to constrain the agent's behavior is the amount of discretion left to the agent, in other words, the range of the delegation mechanism $A'=\{a(\theta)|\theta \in \Theta\}$. Holmström [1982b] then defines the value of delegation and discusses when it is valuable. Of course, the principal could always force its most preferred action from an ex ante viewpoint, i.e., $d^p \in \arg \max_{a \in A} \int_{\Theta} U^p(a,\theta)dF(\theta)$. This corresponds to a rigid mechanism that leaves no discretion. Instead, the principal could leave more discretion to the agent. The benefit is that we now have a state-dependent action (at least over some range), but the cost is that the action chosen by the agent in such a discretionary regime may conflict with the principal's choice. There is a trade-off between adopting rules and maintaining discretion.

What is interesting is that this model provides some foundations for the notion of authority and state-contingent delegation. The agent can be free from making his most preferred choice because of an informational advantage. The agent maintains genuine authority in some circumstances,
although the principal may restrict the agent’s action and retain formal authority, a distinction that goes back to Simon [1951].

FURTHER WORKS. The exercise of the right of control over an asset is certainly related to the degree of authority that the owner enjoys. Aghion and Tirole [1997] argued that whether a party that has formal authority also enjoys real authority depends on the structure of information, and in particular on whether the party who recommends a project knows if this project is relevant. Yet, this information structure is itself inherited from the distribution of formal authority. Delegating control to the agent boosts his incentive to gather information that is relevant for decision-making. There is now a trade-off between maintaining initiative and increasing monitoring.

Following Holmström [1982b], the mechanism design literature has received much attention in recent years with a particular focus on the condition under which interval delegation (the case where $A'$ is an interval) is optimal. On this front, we may refer to Melumad and Shibano [1991], Martimort and Semenov [2006] and Alonso and Matouschek [2008]. On the more applied ground, a sizable literature in political science has analyzed the conditions under which bureaucratic delegation by political principals may be beneficial (Epstein and O’Halloran [1994]; Hiriart and Martimort [2012]).

5.3. Foundations of Incomplete Contracts

In comparison with the adverse selection and moral hazard paradigms, the incomplete contracts literature has repeatedly been attacked for a possible lack of foundations. One key issue is that the hold-up problem analyzed in Section 5.1 relies on the absence of any long-term contracts between parties. All terms of the transactions are resolved ex post through bargaining. This stands in contrast with the role played by long-term contracts to secure long-term investments; a point made by the empirical literature on vertical integration (Monteverde and Teece [1982]; Joskow [1987]).

Hart and Moore [1988] introduced the possibility of writing long-term contracts as a way to possibly avoid the hold-up problem. Although their model has no consideration for property rights per se, their goal is to show that such long-term contracts might not prevent the hold-up problem; which in turn provides some rationale for the allocation of property rights stressed by Grossman-Hart-Moore. To this end, they consider a model that is very close to that described in Section 5.1. Suppose that a single unit has to be traded, with the distributions of costs and valuations being affected by specific investments made by each party (in a context where there is no externality and one party’s investment affects only its contributions to trade). A long-term contract should entail a price if trade occurs and a price if trade fails. In turn, following the mechanism design literature, these prices could be made contingent on messages that parties may send each other once their valuations and costs become common knowledge. Yet, parties always have the option not to send a message and to trade (or not) at certain given prices that serve as outside options for any renegotiation game that could take
place *ex post*. Hart and Moore [1988] showed that this possibility of renegotiation makes it impossible to achieve efficient trade and *ex ante* investments remain second best.

FURTHER WORKS. The most severe blow against the Grossman-Hart-Moore framework undoubtedly came from Maskin and Tirole [1999]. These authors pointed out that the methodology used by this literature suffers from a tension between two of its basic assumptions. The first one is that parties are sufficiently rational to perform dynamic programming and compute equilibrium payoffs, a necessary condition to justify underinvestment under the threat of hold-up for instance. The second one is the existence of transaction costs that preclude any sort of *ex ante* contracting. Maskin and Tirole [1999]'s rather negative conclusion is that transaction costs should be irrelevant. The construction of this argument is elegant but somewhat involved. It is based on the idea that parties could *ex ante* contract on payoff contingencies since they can at least evaluate the payoff consequences of their actions. Later on, parties may simply fill in the details of their arrangement once the state of the world is established and common knowledge. Under mild assumptions, the techniques of the subgame-perfect implementation literature can then be used to ensure that truth telling is equilibrium behavior at the various stages of the mechanism.

A more optimistic view of the relevance of the incomplete contracts paradigm was nevertheless offered by Segal [1999] and Hart and Moore [1999]. These authors showed that, in complex environments (where complexity is characterized by the number of irrelevant trading opportunities that may arise *ex post*), there is almost no value in signing a contract that will be renegotiated *ex post*. In other words, not signing an *ex ante* contract and (re)negotiating to an efficient outcome *ex post* when the state of nature becomes verifiable is almost optimal.

5.4. Applications

The incomplete contract paradigm is useful to delineate boundaries for firms and organizations. It is inherently a theory of how control is allocated and, as such, its implications go far beyond the sole Theory of the Firm. In this section, we discuss what the incomplete contracts paradigm has brought to our understanding of two such applications. The first one discusses the optimal capital structure of a firm trying to move away from Modigliani and Miller [1958]'s Irrelevance Theorem, which states that a firm's value is independent from how claims are distributed. The second application addresses where to optimally draw the boundaries between the public and private sectors; *i.e.*, it provides a theory of privatization that also goes beyond another Irrelevance Theorem (Sappington and Stiglitz [1987]), which also states that the cost of public services is independent from whether they are publicly or privately provided.

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5.4.1. Capital Structure of the Firm

We might think that the Grossman-Hart-Moore framework a priori suffers from several weaknesses. First, the allocation of control rights is chosen ex ante and cannot be made contingent on any signal that could be relevant to evaluate the benefits of different actions that cannot be specified in a contract. Second, incentives for investments cannot be adjusted by sharing return streams. Third, whichever party is supposed to buy an asset faces no wealth constraint. Instead, it is often the case that an agent may rely on outside financiers to buy assets and integrate them vertically or horizontally as predicted by Grossman and Hart [1986]. Applying the incomplete contracts paradigm to an analysis of the firm’s financial structure requires extending the framework along these lines. This important task was accomplished in a sequence of papers by Hart produced with various coauthors and close collaborators.

On this front, Aghion and Bolton [1992] were the first to establish that the optimal contingent allocation of control rights can sometimes be induced by standard debt contracts. Yet, as noticed by Hart [1995] himself, there are instances where this allocation does not reflect the practices of a debt contract, and control may not be allocated to the creditor when the debtor has failed to pay. Moreover, the non-verifiable action on which parties may exert control in Aghion and Bolton [1992] is somewhat abstract. Hart and Moore [1994] offer ways out of these problems with a model of cash diversion where either the debtor or his creditor may exert control on the decision whether or not to liquidate an asset. The idea is to show that, in times of bankruptcy, control rights should be allocated to the creditor.21

To illustrate these findings, consider the following bare-bone model inspired by (but admittedly different from) Hart and Moore [1994]. A cashless manager wants to undertake a project that requires an initial investment $I$. A creditor provides the requested funds. The project generates a non-verifiable profit $\pi$ which is drawn on the positive real line according to a cumulative distribution $F(\cdot)$ (with positive and atomless density $f(\cdot)$). A share $k\pi$ of this profit can be diverted by the manager and transformed into non-monetary private benefits. The remaining part $(1 - k(1 + \mu))\pi$ of profits may be seized by the creditor in a case where the manager does not pay back his debt (a fixed repayment $D$) and the firm runs into bankruptcy. Diversion has a cost $\lambda(1 + \mu)\pi$ borne by the creditor. In case of bankruptcy, the continuation of the project yields a private return $\lambda b \pi$ to the manager. Liquidation of the existing assets is worth $L$ to the creditor.

If the manager were to repay his debt, he would get a payoff $\pi - D$. His payoff in case he does not repay and the firm goes bankrupt depends on whoever gets control on continuation. Observe simply that the most efficient decision is to continue whenever $\lambda b \pi \geq L$ and to stop otherwise.

Manager control. When the manager keeps control, he can appropriate the whole surplus of a renegotiation towards this efficient decision even if he

has no cash to start with. While he would always prefer to continue, he can be made to change his mind if he receives the liquidation proceeds \( L \) from the creditor in case \( \lambda b < L \) and liquidation is efficient (we assume that the manager has all bargaining power at the renegotiation stage). In this scenario, not repaying the loan \( D \) yields a payoff to the manager worth \( \lambda \pi + \max \{ \lambda b \pi , L \} \) while the creditor only pockets the available profits \( (1 - \lambda (1 + \mu)) \pi \) since he gets zero whether continuation or liquidation is chosen because he has been forced to give up the liquidation value to the manager under the threat of inefficient continuation. From this, it follows that bankruptcy arises when

\[
\pi - D \leq \lambda \pi + \max \{ \lambda b \pi , L \} \iff \pi \leq \hat{\pi} = \begin{cases} \frac{D}{1 - \lambda (1 + b)} & \text{if } \frac{D}{1 - \lambda (1 + b)} \geq \frac{L}{\lambda b} \\ \frac{D + L}{1 - \lambda} & \text{otherwise}. \end{cases}
\]

The manager’s and creditor’s expected payoffs and the firm’s expected value are respectively given by

\[
U_M = \int_{\hat{\pi}}^{+\infty} (\pi - D) dF(\pi) + \int_{0}^{\hat{\pi}} (\lambda \pi + \max \{ \lambda b \pi , L \}) dF(\pi),
\]

\[
V_M = D (1 - F(\hat{\pi})) + \int_{0}^{\hat{\pi}} (1 - \lambda (1 + \mu)) \pi dF(\pi) - I,
\]

and

\[
U_M + V_M = \int_{0}^{\infty} \pi dF(\pi) - I - \left\{ \int_{0}^{\hat{\pi}} (\lambda b \pi - \max \{ \lambda b \pi , L \}) dF(\pi) \right\}.
\]

The last bracketed term can be interpreted as the agency cost of outside financing with manager control. Provided that \( \hat{\pi} \geq \frac{L}{\lambda b} \) (i.e., the face value of debt \( D \) is large enough compared to the liquidation value \( L \)), and \( \mu \geq b \) to capture the fact that transforming wealth into private benefits entails a dead-weight loss, this cost can be written as:

\[
AC_M = \int_{0}^{\hat{\pi}} \lambda (\mu - b) \pi dF(\pi) > 0.
\]

The agency cost of outside debt is the difference between the net cost of transforming wealth into private benefits over all states where bankruptcy arises.

**Creditor control.** The creditor is always willing to liquidate and, since the manager is cashless, he cannot be compensated to continue when it is efficient to do so. Not repaying the loan \( D \) yields zero to the manager while the creditor obtains \( L \). Now, bankruptcy arises when

\[
\pi - D \leq \lambda \pi \iff \pi \leq \hat{\pi} = \frac{D}{1 - \lambda}.
\]

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We can immediately check that \( \hat{p} > \tilde{p} \), i.e., bankruptcy arises more often when the manager keeps control and can enjoy the benefits of continuation; an intuitive result.

The manager’s and creditor’s expected payoffs and the firm’s expected value are now respectively given by

\[
U_C = \int_{\hat{p}}^{\infty} (\pi - D)dF(\pi) + \int_{0}^{\hat{p}} \lambda \pi dF(\pi),
\]

\[
V_C = D(1 - F(\tilde{p})) + \int_{0}^{\hat{p}} ((1 - \lambda(1 + \mu))\pi + L)dF(\pi) - I,
\]

and

\[
U_C + V_C = \int_{0}^{\infty} \pi dF(\pi) - I - \int_{0}^{\hat{p}} (\lambda \mu \pi - L)dF(\pi).
\]

The agency cost of outside financing with creditor control is now lower than with:

\[
AC_C = \int_{0}^{\hat{p}} (\lambda \mu \pi - L)dF(\pi) > 0.
\]

An interesting case arises when \( \hat{p} > \frac{L}{\lambda D} > \tilde{p} \). Then, the following chain of inequalities holds:

\[
AC_C < \int_{0}^{\hat{p}} \lambda (\mu - b)\pi dF(\pi) < AC_M.
\]

In other words, making control rights contingent on whether or not to continue to the creditors minimizes agency costs.

FURTHER WORKS. Public companies have a large number of shareholders and free riding may prevent them from exerting valuable control to curb the management’s incentives to enter into perquisite activities. Hart and Moore [1995] demonstrate that debt may play a role in forcing the management to do so; and actually may be a better tool than incentive schemes in contexts where the manager does not respond to monetary incentives. This is the first step towards a theory of capital structure where multiple claims can coexist. One issue here is thus to determine what formal bankruptcy procedure should be used to allocate priorities between various sorts of debt holder; an issue addressed in Aghion et al. [1994].

5.4.2. Privatization

It is often argued that private provision of services may cut down costs but also comes with less than optimal quality. Examples abound and include prisons, schools and health services. Although costs are easily observable...
and thus can be specified contractually for most services, quality is certainly a non-verifiable variable. The tension between providing incentives for each of these dimensions calls for a multi-tasking approach which bears some resemblance to the work of Holmström and Milgrom [1991] in a comprehensive contracting framework. On the other hand, the non-verifiability of quality calls for relying on the incomplete contracts paradigm to explain whether a given service should be publicly or privately provided. In this respect, Hart et al. [1997] present a model based on the idea that the fundamental difference between private and public ownership concerns the allocation of residual control rights in a multi-tasking environment.

A service provider, using an asset (for instance, a facility) can improve the quality of the service or reduce its cost. Cost reduction, however, has an adverse effect on quality. Formally, we shall assume that cost writes as:

\[ C = C_0 - e \]

where \( C_0 \) stands for the cost of a base version of the service and \( e \) is the service provider’s effort on cost reduction whose cost for the provider is \( e^2 / 2 \). On the other hand, quality of the service writes as

\[ B = B_0 - ke + i \]

where \( i \) now stands for the quality-improving investment whose cost for the provider is \( i^2 / 2 \) and \( 0 < k < 1 \) so that the perverse impact of cost-reduction on quality does not offset its benefits.

Efficiency would call for choosing a pair \( (e^*, i^*) \) that maximizes the net value of the service \( B - C - e^2 / 2 - i^2 / 2 \), namely:

\[ e^* = 1 - k \text{ and } i^* = 1. \]

When cost-reducing effort and investment, costs and quality are all non-verifiable, these targets cannot be specified in a contract. The allocation of residual rights determines reservation payoffs in the bargaining that takes place \textit{ex post} to share the gains from such innovations and, as a result, also provides \textit{ex ante} incentives to undertake the innovations. To see how this works, consider the following scenarios.

**Private provision.** The service provider owns the asset and is paid a fixed price \( P \) for his services. Absent renegotiation, the payoffs to this agent and the government are respectively:

\[ U = P - C_0 + e - e^2 / 2 - i^2 / 2 \text{ and } V = B_0 - P - ke + i. \]

Clearly, the service provider has no incentive to invest in quality, and the status quo outcome, in the absence of renegotiation, has \( (i^*_P = 0, e^*_P = 1), \text{ i.e., no quality improvement and excessive cost reduction. Suppose that the} \]

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parties share the incremental surplus $i$ from innovation according to the 50-50 Nash bargaining solution. Then, the players’ post-bargaining payoffs are respectively

$$U = P - C_0 + e + \frac{i}{2} - \frac{e^2}{2} - \frac{i^2}{2} \quad \text{and} \quad V = B_0 - P - ke + \frac{i}{2}.$$ 

Under private ownership, the equilibrium efforts are thus:

$$e_{pr} = 1 \quad \text{and} \quad i_{pr} = \frac{1}{2}.$$ 

Although incentives to cut on costs are excessive, incentives to provide quality are too low.

**Public provision.** The service provider is now an employee of the government who is paid with a fixed wage $P$ for his services. The value of the innovations is appropriated by the government, which is the owner. As a result, the service provider has no incentive to invest either in quality or in cutting costs, and the status quo outcome, in the absence of renegotiation, gives $(i_{pu} = 0, e_{pu} = 0)$. The incremental surplus of both innovations is thus worth $e (1 - k) + i$. The players’ post bargaining payoffs are thus respectively

$$U = P - C_0 + e + \frac{1}{2} (e (1 - k) + i) - \frac{e^2}{2} - \frac{k^2}{2} \quad \text{and} \quad V = B_0 - P - ke + \frac{1}{2} (e (1 - k) + i).$$ 

Under public ownership, the equilibrium efforts are thus:

$$e_{pu} = \frac{1 - k}{2} \quad \text{and} \quad i_{pu} = \frac{1}{2}.$$ 

Now, the incentives to innovate on both activities are too low.

The trade-off between privatization and public provision thus becomes to determine whether or not, conditional on an effort to improve quality that remains inefficiently low, it is preferable to foster incentives to cut costs on privatization. Yet, when quality becomes more important from a social welfare viewpoint, it may be preferable to keep government control.

Interestingly, this model can, modulo a slight modification presented in Hart [2003], be used to discuss the relevance of public-private partnerships. So-called “PPPs” are characterized by the fact that infrastructure building and its management (or maintenance) are bundled and allocated to the private sector, often for a very long period of time. In contrast, under the traditional procurement system, the government remains the owner of the infrastructure, approaches a builder to propose a design, and then allocates (through tender) its management to other firms in the private sector. A builder may undertake potential innovations, just as in the above model. Some of these investments can both increase the quality of the service and reduce costs (productive investment), while others can bring down the quality of the service and at the same time also reduce costs (unproductive investment). The theoretical question is whether the two tasks should be bundled or not. Under traditional procurement, the builder cannot internal-
ize the impact of his effort on either benefits or costs. He implements too little of the productive investment, but the right amount of the unproductive one. Under PPP, the builder somewhat internalizes the impact of his productive investment, whereas he also exerts too much unproductive effort. Again, when infrastructure quality is key, it may be optimal to bundle the tasks and rely on PPPs to provide the service.

6. Concluding Remarks

We would like to conclude this piece with a brief note on the directions of contemporary research that the two giants honored in 2016 paved the way for. We started with the question of how complete contracts are and/or should be, and it seems that today’s research does still revolve around this issue. Let us illustrate it with two points. First, the very popular notion of relational contracts that has taken the front stage in recent years is nothing but the natural evolution of the theory of implicit contracts, in contexts where long-term commitment is limited and all possible future contingencies are de facto not explicitly incorporated into contract provisions. Relational contracts can then substitute incomplete contracts in contexts where actions, although observable and thus used in implicit agreements, cannot be explicitly contracted. Second, early concerns on realism and tractability of optimal contracts are more than ever at the core of current research on simple and robust contracting.

Interestingly, as of today, the question of how markets shape contracts within firms and their financial structure still remains elusive, and a general equilibrium approach to the moral hazard and property rights paradigms is yet to be developed. Both Hart and Holmström are still active researchers on this front, the former having started a new line of research into understanding contracts that rely on new behavioral ingredients (e.g. Hart and Moore [2008]; Fehr et al. [2011]), and the latter proposing an original informational approach to corporate finance (e.g. Dang et al. [2017]).

References

AGHION P., DEWATRIPONT M., and REY P. [1994], Renegotiation design with unverifiable information. Econometrica 62(2), 257-282. 34

22. Subjective evaluation (see in particular MacLeod [2003]) as a source of simple and incomplete contracts, and relational contracts (see in particular Levin [2003]) as a substitute for complete contracts, are seminal contributions representative of new evolutions in contract theory owing to ideas pioneered by Hart and Holmström.
ARVE M. and MARTIMORT D. [2016], Dynamic procurement under uncertainty: Optimal design and implications for incomplete contracts. American Economic Review 106(11), 3238-3274. 27
BARNARD C. [1938], The Functions of the Executive. A Harvard paperback. Harvard University Press. 6
BERLE A. and MEANS G. [1932], The Modern Corporation and Private Property. Transaction Publishers. 5
BURKART M., GROMB D., and PANUNZI F. [1997], Large shareholders, monitoring, and the value of the firm. The Quarterly Journal of Economics 112(3), 693-728. 29
COASE R. H. [1937], The nature of the firm. Economica 4(16), 386-405. 30
CONNOL J. R. [2009], Two new conditions supporting the first-order approach to multisignal principal-agent problems. Econometrca 77(1), 249-278. 11
DANG T. V., GORTON G., HOLMSTRÖM B., and ORDOÑEZ G. [2017], April, Banks as secret keepers. American Economic Review 107(4), 1005-1029. 45

REP 128 (4) juillet-août 2018


FLECKINGER P. [2012], Correlation and relative performance evaluation. Journal of Economic Theory 147(1), 93-117. 23

FUDEMBERG D., HOLMSTRÖM B., and MILGROM P. [1990], Short-term contracts and long-term agency relationships. Journal of Economic Theory 51(1), 1-31. 27

GREEN J. and LAFFONT J.-J. [1977], Characterization of satisfactory mechanisms for the revelation of preferences for public goods. Econometrica 45(2), 427-438. 21


GROSSMAN S. J. and HART O. D. [1983b], Implicit contracts under asymmetric information. The Quarterly Journal of Economics 98, 123-156. 27


GROSSMAN S. J., HART O. D., and MASKIN E. S. [1983], Unemployment with observable aggregate shocks. Journal of Political Economy 91(6), 907-928. 27


HART O. [2003], Incomplete contracts and public ownership: Remarks, and an application to public-private partnerships. The Economic Journal 113(486), C69-C76. 43

HART O. and MOORE J. [1988], Incomplete contracts and renegotiation. Econometrica 56(4), 755-785. 36

HART O. and MOORE J. [1990], Property rights and the nature of the firm. Journal of Political Economy 98(6), 1119-1158. 31, 33


REP 128 (4) juillet-août 2018
HART O. and MOORE J. [2008], Contracts as reference points. 123, 1-48. 44
HART O. D. [1975], On the optimality of equilibrium when the market structure is incomplete. Journal of Economic Theory 11(3), 418-443. 4
HART O. D. [1979], On shareholder unanimity in large stock market economies. Econometrica 47(5), 1057-1083. 5
HART O. D. [1983a], The market mechanism as an incentive scheme. The Bell Journal of Economics 14(2), 366-382. 28
HELLWIG M. F. and SCHMIDT K. M. [2002], Discrete-time approximations of the holmström-milgrom brownian-motion model of intertemporal incentive provision. Econometrica 70(6), 2225-2264. 17
HOLMSTRÖM B. [1977], On Incentives and Control in Organizations. Ph. D. thesis, Stanford Graduate School of Business. 4
HOLMSTRÖM B. [1979a], Groves’ scheme on restricted domains. Econometrica 47(5), 1137-1144. 21
HOLMSTRÖM B. [1979b], Moral hazard and observability. The Bell Journal of Economics 10(1), 74-91. 8, 11, 12, 17
HOLMSTRÖM B. [1982b], On the theory of delegation. working paper Northwestern University. 34, 35, 36
HOLMSTRÖM B. [1999a], The firm as a subeconomy. The Journal of Law, Economics, and Organization 15(1), 74-102. 34
HOLMSTRÖM B. and MILGROM P. [1987], Aggregation and linearity in the provision of intertemporal incentives. Econometrica 55(2), 303-328. 14, 16, 18
HOLMSTRÖM B. and MILGROM P. [1991], Multitask principal-agent analyses: Incentive contracts, asset ownership, and job design. Journal of Law, Economics and Organization 7(0), 24-52. 23, 41
HOLMSTRÖM B. and MILGROM P. [1994], The firm as an incentive system. American Economic Review 84(4), 972-91. 23, 24
HOLMSTRÖM B. and TIROLE J. [1991], Transfer pricing and organizational form. The Journal of Law, Economics, and Organization 7(2), 201-228. 29
ITOH H. [1993], Coalitions, incentives, and risk sharing. *Journal of Economic Theory* 60(2), 410-427. 23
JEWITT I., KADAN O., and SWINKELS J. M. [2008], Moral hazard with bounded payments. *Journal of Economic Theory* 143(1), 59-82. 16
JOSKOW P. [1987], 02, Contract duration and relationship-specific investments: Empirical evidence from coal markets. 77, 168-185. 36
KADAN O. and SWINKELS J. M. [2013], On the moral hazard problem without the first-order approach. *Journal of Economic Theory* 148(6), 2313-2343. 11
LAMBERT R. [2001], 12, Contracting theory in accounting. 32, 3-87. 12
LAZEAR E. P. and ROSEN S. [1981], Rank-order tournaments as optimum labor contracts. *Journal of Political Economy* 89(5), 841-864. 13, 22, 23
LEGROS P. and MATTHEWS S. A. [1993], Efficient and nearly-efficient partnerships. *The Review of Economic Studies* 60(3), 599-611. 21

*REP* 128 (4) juillet-août 2018
MACLEOD W. B. [2003], Optimal contracting with subjective evaluation. The American Economic Review 93(1), 216-240. 44

MARTIMORT D. and POUYET J. [2008], To build or not to build: Normative and positive theories of public-private partnerships. International Journal of Industrial Organization 26(2), 393-411. 25

MARTIMORT D. and SEMENOV A. [2006], Continuity in mechanism design without transfers. Economics Letters 93(2), 182-189. 36


MASKIN E. and TIROLE J. [1999], Unforeseen contingencies and incomplete contracts. The Review of Economic Studies 66(1), 83-114. 37


MILGROM P. R. [1981], Good news and bad news: Representation theorems and applications. The Bell Journal of Economics 12(2), 380-391. 10

MIRRLEES J. A. [1976], The optimal structure of incentives and authority within an organization. The Bell Journal of Economics 7(1), 105-131. 8, 10

MIRRLEES J. A. [1999], The theory of moral hazard and unobservable behaviour: Part i. The Review of Economic Studies 66(1), 3-21. 6, 8, 16


MONTEVERDE K. and TEECE D. J. [1982], Supplier switching costs and vertical integration in the automobile industry. The Bell Journal of Economics 13(1), 206-213. 36

MOOKHERJEE D. [1984], Optimal incentive schemes with many agents. The Review of Economic Studies 51(3), 433-446. 16


PRENDERGAST C. [1999], March, The provision of incentives in firms. Journal of Economic Literature 37(1), 7-63. 18

PRENDERGAST C. [2002], The tenuous trade-off between risk and incentives. Journal of Political Economy 110(5), 1071-1102. 18

RAHMAN D. [2012], May, But who will monitor the monitor? American Economic Review 102(6), 2767-2797. 21

RAITH M. [2003], September, Competition, risk, and managerial incentives. American Economic Review 93(4), 1425-1436. 28


ROGERSON W. P. [1985a], The first-order approach to principal-agent problems. Econometrica 53(6), 1357-1367. 11

ROGERSON W. P. [1985b], Repeated moral hazard. Econometrica 53(1), 69-76. 27

REP 128 (4) juillet-août 2018


VARIAN H. [1990], Monitoring agents with other agents.


WILLIAMSON O. [1975], Markets and hierarchies, analysis and antitrust implications: a study in the economics of internal organization. A study in the economics of internal organization. Free Press.

