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Source: *Econometrica*, Vol. 67, No. 4 (Jul., 1999), pp. 741-781
Published by: The Econometric Society
Stable URL: http://www.jstor.org/stable/2999457
Accessed: 28/10/2013 01:47

Econometrica, Vol. 67, No. 4 (July, 1999), 741–781

INCOMPLETE CONTRACTS: WHERE DO WE STAND?[1]

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The paper takes stock of the advances and directions for research on the incomplete contracting front. It first illustrates some of the main ideas of the incomplete contract literature through an example. It then offers methodological insights on the standard approach to modeling incomplete contracts; in particular it discusses a tension between two assumptions made in the literature, namely rationality and the existence of transaction costs. Last, it argues that, contrary to what is commonly argued, the complete contract methodology need not be unable to account for standard institutions such as authority and ownership; and it concludes with a discussion of the research agenda.

KEYWORDS: Incomplete contracts, unforeseen contingencies, authority, transaction costs.

1. INTRODUCTION

THE PURPOSE OF THIS PAPER is to take stock of the advances and directions for research on the incomplete contracting front.[3] It emphasizes methodological issues over questions about the economic relevance of incomplete contract models. Incomplete contracting arguably underlies some of the most important questions in economics and some other social sciences, and unquestionably has been left largely unexplored and poorly understood. A methodological divide may have developed in our profession in recent years between those who advocate pragmatism and build simple models to capture aspects of reality, and others who wonder about the foundations and robustness of these models, and are concerned by the absence of a modeling consensus similar to the one that developed around the moral hazard and adverse selection paradigms in the 70's. (I personally have sympathy for both viewpoints.)

Almost every economist would agree that actual contracts are or appear quite incomplete. Many contracts are vague or silent on a number of key features. A

[1] Walras–Bowley lecture delivered at the 1994 North American Summer Meetings of the Econometric Society in Quebec City.

[2] This paper could not have been written without the intellectual stimulus of several researchers with whom I have been fortunate to collaborate. It builds on key insights due to Oliver Hart on incomplete contracts and to Eric Maskin on implementation. I have also benefited much from working on the topic of the lecture with Philippe Aghion, Mathias Dewatripont, Bengt Holmström, and Jean–Jacques Laffont.

I am very indebted to Jean–Jacques Laffont and Eric Maskin for their substantial input in the preparation of the paper. I am also grateful to Philippe Aghion, Bernard Caillaud, Oliver Hart, Martin Hellwig, Bruno Jullien, Bentley MacLeod, Eric Rasmussen, Patrick Rey, Steve Tadelis, a co-editor, and three referees for helpful comments.

[3] Ten years have elapsed since Oliver Hart's Fisher–Schultz lecture on the topic (see Hart (1989)), and twelve years since his and Bengt Holmström's (1987) World Congress survey of contract theory, which also touched on incomplete contracting. There has since been much activity in the area, including significant work by these two authors.

case in point is the organization of political life. In the executive, ministries and agencies are given loose objectives, such as "promoting the long-range security and well-being of the United States" (US Department of State), "fostering, promoting and developing the welfare of the wage earners of the United States" (US Department of Labor), or as "establishing 'just and reasonable rates' for electricity or telephone" (Public Utility Commission). No mention is made of the many contingencies that may determine the ministry's desirable choices and of how decisions are to react to these contingencies. Similarly, the legislative branch of the government is set up as a distribution of agenda setting powers, voting rights, and checks and balances between houses rather than as a contract specifying how public decisions follow from the elicitation of information about the economy and the society. Indeed, I would argue that the difficulties encountered in conceptualizing and modeling incomplete contracting partly explain why the normative agenda of the eighteenth century political scientists—namely addressing the question of how one should structure political institutions—has made little progress in the last two centuries.[4]

Incomplete contracting is argued to be the key to a good understanding of a number of economic issues as well. Consider the patent system. It has long been recognized that patents are an inefficient method for providing incentives for innovation since they confer monopoly power on their holders. Information being a public good, it would be ex post socially optimal to award a prize to the innovator and to disseminate the innovation at a low fee. Yet the patent system has proved to be an unexpectedly robust institution. That no one has come up with a superior alternative is presumably due to the fact that, first, it is difficult to describe in advance the parameters that determine the social value of an innovation and therefore the prize to be paid to the inventor, and, second, that we do not trust a system in which a judge or arbitrator would determine ex post the social value of the innovation (perhaps because we are worried that the judge might be incompetent or would have low incentives to become informed, or else would collude with the inventor to overstate the value of the innovation or with the government to understate it). A patent system has the definite advantage of not relying on such ex ante or ex post descriptions (although the definition of the breadth of a patent does).

The recent upsurge in incomplete contract modeling was primarily motivated by organizational issues: what determines the size of the firm, how authority is distributed within the firm, and how the corporate charter and the financial structure (voting rights,[5] powers of the board of directors, feasibility of takeovers, debt-equity structure[6]) organize the control of insiders by outsiders. As defined, e.g., by Simon (1951), a decision right or authority granted to a party is the right

[4]Substantial progress has been made in the last twenty years through the application of economic techniques to political science, but this progress has been largely confined to the positive side—namely explaining how actors behave under specific voting and agenda setting institutions.

[5]See Grossman–Hart (1988), Harris–Raviv (1988), and Gromb (1993).

[6]As in Aghion–Bolton (1992), Dewatripont–Tirole (1994), and Hart (1995).

for the party to pick a decision in an allowed set of decisions. A *property right* on an asset, i.e., its ownership, is a bundle of decision rights. Hart (1989, p.1765) argues that "ownership of an asset goes together with the possession of residual rights of control over the asset; the owner has the right to use the asset in any way not inconsistent with a prior contract, custom, or any law." Walras (1898; 1990, p. 177–178) saw ownership as a vector of rights including the rights to use the asset, to sell it, and to receive the proceeds. A substantial body of literature in organization theory and corporate finance has recently developed around these notions of authority and property rights. As a final motivation, incomplete contracting is also perceived to underly a number of legal issues such as the courts' enforcement of private contracts,[7] fiduciary duties,[8] and antitrust policy.

For all its importance, there is unfortunately no clear definition of "incomplete contracting" in the literature. While one recognizes one when one sees it, incomplete contracts are not members of a well-circumscribed family; at this stage an incomplete contract is rather defined as an ad hoc restriction on the set of feasible contracts in a given model. The concept of "ad hoc restriction" is of course subjective: to give it some content, we will in Section 3 take the standard approach to contract theory as the benchmark. The methodology developed in the last thirty years to treat moral hazard, adverse selection, and implementation problems provides a well-defined delineation of the set of feasible outcomes[9] by incentive constraints. Incomplete contracting then relates to a focus on a subset of feasible outcomes through the imposition of restrictions on the set of allowable contracts. Note that by looking at outcomes we do not necessarily associate the use of a "simple contract" with the incomplete contracting approach: Indeed, if this simple contract turns out to deliver the feasible outcome that the parties desire, there is no sense in which the contract is incomplete, although it is then "apparently incomplete."

In the literature, incomplete contract models are usually preceded by an invocation of *transaction costs*, namely one or several of the following three ingredients:

Unforeseen contingencies: "Parties cannot define ex ante the contingencies that may occur (or actions that may be feasible) later on. So, they must content themselves with signing a contract such as an authority or ownership relationship that does not explicitly mention those contingencies, or with signing no contract at all."

Cost of writing contracts: "Even if one could foresee all contingencies, they might be so numerous that it would be too costly to describe them in a contract."

[7]On this, see, e.g., Schwartz (1992) and the discussions by Hart (1990) and Tirole (1992).

[8]See, e.g., Barca–Felli (1992) and Hart (1993).

[9]As emphasized in Hellwig (1996) it does not circumscribe the set of feasible contracts. Indeed, there are always an infinity of contracts giving rise to the same feasible outcome. On the other hand, economic agents care only about outcomes and not about contracts per se.

Cost of enforcing contracts: "Courts must understand the terms of the contract and verify the contracted upon contingencies and actions in order to enforce the contract."

Although most agree that there is something to this "hand-waving," few feel comfortable with it. This paper will, using Maskin–Tirole (1999a), analyze the most-commonly invoked motivation for incomplete contracts, namely unforeseen contingencies. The other two motivations will be discussed in the conclusion.

Regarding unforeseen contingencies, there is no arguing that we do not go through the whole "tree of knowledge" before writing a contract. I certainly did not think through what this lecture would be like before agreeing to give it. Not only was there uncertainty about whether I could clarify my thoughts in certain areas (unfortunately there still is), perhaps more importantly for our purpose there was no precise measure or definition of what a proper Walras–Bowley lecture on the topic would constitute, except for the vague and rather unenforceable intent of writing a paper suitable for a general audience and offering insights for future research.

Unforeseen contingencies however are not a good motivation of models of incomplete contracting *as they currently stand*. The reason is simple: In the incomplete contracting literature, parties to a contract are assumed to behave rationally (as stressed by Hart (1990)). They choose the contract, e.g. the allocation of a property right, and subsequent variables, e.g. investments, so as to maximize their expected utility. At the very least they know how payoffs relate to the initial contract and investments. In other words, dynamic programming implies a minimum amount of foreseeability, namely that of payoffs, even if we make the assumption that parties do not know how and under what circumstances these payoffs will be achieved. This observation puts a lower bound on what they know ex ante and therefore on what they can achieve through a contract. We provide sufficient conditions under which the indescribability of contingencies does not restrict the set of payoff outcomes that can be achieved through contracting between parties. (This set can be a first- or second-best set depending on the nature of the incentive constraints.)

The paper is organized as follows. Section 2 illustrates the main themes of the incomplete contacting literature through a simple R&D example. The section first describes the optimal complete contract approach with describable and indescribable contingencies, with and without the possibility of ex post contract renegotiation. It then offers an alternative approach to contracting based on the allocation of a property right (in the instance, patent ownership), and obtains some economic implications of the property right approach. It finally uses this R&D example to introduce some elements of the more general debate about the use of incomplete contract modeling. Section 3 summarizes the critique of incomplete contract modeling developed in Maskin–Tirole (1999a). Last, Section 4 discusses the research agenda in two steps. It first argues that standard complete contracting tools may have been too hastily dismissed as unable to explain the phenomena that motivate incomplete contracting modeling. In my view, complete contracts can shed substantial light on why and when simple institutions fare relatively well and are prominent. The case for not dismissing the standard approach too quickly however should not stifle the conceptual innovation in alternative paradigms, as I discuss at the end of Section 4.

2. AN ILLUSTRATION OF THE GROSSMAN–HART APPROACH: THE R&D GAME

To illustrate the assumptions and some themes of the incomplete contracting literature, let us consider a bare-bones (and economically trivial) version of the management of innovation model in Aghion–Tirole (1994). This model is a variant of the Grossman–Hart (1986) model, in which cash constraints and shares of a verifiable profit are introduced. While these models involve double-sided moral hazard, we will focus on one-sided moral hazard in order to simplify the exposition and to facilitate the comparison with the standard, complete contract principal-agent model (we could have alternatively chosen to exposit the double-moral-hazard framework).

2.1 *The Model and Its Complete Contracting Solution*

The agent (A), a research unit, attempts to produce an innovation of deterministic value $V > 0$ to a user, the principal (P). At stage 1, the agent incurs unobserved disutility of effort $g_A(e)$, where $g'_A > 0, g''_A > 0$, $g'_A(0) = 0, g'_A(1) = \infty$. Effort e is normalized to be the probability of making a (useful) innovation. The first-best effort level satisfies $g'_A(e) = V$. Let $e_0 \geq 0$ denote the minimum level of effort the agent can get away with without being detected.[10] At stage 2 (ex post), both parties observe whether a (useful) innovation took place. We assume for the moment that the fact that the agent produces an innovation that has value V (or characteristics creating value V) for the principal is verifiable by a court. The agent has no resources and is protected by limited liability; he is risk neutral above this income.[11] The principal is risk neutral; she picks the agent and chooses an incentive scheme.

The complete contract treatment of this model is that of the "efficiency wage" literature. The contract describes the innovation and stipulates that the agent will receive some reward y if he brings about the specified innovation, and (optimally) 0 if he fails. The reward y can take any nonnegative value and fully determines the agent's incentives. Assuming no discounting and an interior solution ($e^* > e_0$), the optimal complete contract, namely the optimal reward y^*, is given by

$$\max_{\{e,y\}} \{e[V-y]\} \quad \text{subject to} \quad g'_A(e) = y.$$

[10]Alternatively, e_0 could represent the effort that is made when the agent is given no monetary incentives and therefore is driven by intellectual curiosity, ego, or career concerns.

[11]So, the agent has utility from income y: $u_A(y) = -\infty$ for $y < 0, u_A(y) = y$ for $y \geq 0$.

An optimal second-best solution satisfies $0 < y^* < V$. The principal trades off a high probability of discovery (high reward) and a low rent for the agent (low reward).

In practice, the parties are unlikely to be able to describe precisely the specifics of an innovation in an ex ante contract, given that the research process is precisely concerned with finding out these specifics, although they are able to describe it ex post. The absence of a precise description raises the concern that the agent might deliver an innovation of no value to the principal and some mechanism must be designed that elicits the value of the innovation to the principal while not describing it ex ante.

This situation is then one with *indescribable contingencies*. A key point, though, is that with rational actors the contingencies are not unforeseen even though they cannot be described ex ante. One way of thinking about the problem is that the parties envision the existence of $n \geq 1$ possible techniques available at date 2, which, for want of a better description, they ex ante label 1 through n. The parties know that in case of "innovation" one of the techniques will have value V for the principal and the other techniques no value, say. In the absence of innovation, none of the available techniques has any value to the principal.

Despite the indescribability of contingencies, the principal is able to obtain the same payoff outcome as when the innovation is ex ante describable. Consider the following public contract for the R&D game ("public" means that the contract is lodged in court or with an arbitrator):

"(1) The agent ex post describes a technique to be transferred to the principal. (2) The principal accepts the transfer of technology specified by the agent, in which case she pays $y = \lambda V, 0 \leq \lambda \leq 1$, to the agent, or turns it down, in which case she pays nothing. (3) No renegotiation of the contract or any other trade between the two parties is allowed."

If credible, this contract allows the parties to implement any reward they wish even if the innovation cannot be described ex ante.

2.2. *Complete Contracts and Renegotiation*

In the R&D game, the ex ante indescribability of the innovation has no impact on payoffs provided the initial contract is meant to be final and nonrenegotiated. This is no longer so if the parties can renegotiate ex post. Let us assume that after the mechanism designed by the initial contract is played, the two parties can renegotiate to their mutual advantage if the prescribed outcome is inefficient. We assume that bargaining yields Nash outcomes, namely equal sharing of gains from renegotiation.

When the agent's performance is describable ex ante and verifiable ex post (the first situation), the possibility of renegotiating the contract is irrelevant since the contract yields an ex post efficient allocation by specifying that the innovation, if any, is transferred to the principal.

With ex ante indescribable techniques, the public contract stated above is not immune to renegotiation if it specifies a transfer price $y > V/2$. Suppose that the agent innovates but the principal refuses to purchase the innovation described by the agent, implicitly pretending that the agent has not invented anything useful. Gains from trade are then not exhausted and the two parties have an incentive to write a second contract. Under the Nash bargaining solution, the principal then pays only $V/2$. Conversely, when $y < V/2$, the agent can force renegotiation by offering a useless innovation to the principal, who must then reject the agent's proposal. So, for this contract, the only implementable sharing rule under renegotiation is $\lambda = 1/2$, as opposed to all $\lambda \epsilon [0,1]$ in the absence of renegotiation.

On the other hand, there might exist contracts that are consistent with indescribability and yet do better under the possibility of renegotiation than the public contract defined above. Appendix 1 shows that, under limited liability for both parties, it is indeed possible to implement other sharing rules, but renegotiation still has a cost: *The implementable sharing rules under indescribable contingencies and renegotiation are exactly those* λ*s in* $[0, 1/2]$;[12] and so those in $(1/2, 1]$ are eliminated by the possibility that parties have to write a new contract (the result is also shown to generalize to the possibility of introducing third parties into the contract). The intuition for this result is that in the presence of an innovation the principal can always behave ex post as if no innovation had occurred. The indescribability of contingencies makes it impossible for the contract to detect such a strategic behavior by the principal, and guarantees that the principal gets the same pre-renegotiation payoff as when no innovation occurs. So, the possibility of renegotiation guarantees the principal at least half of the surplus of innovation. In a sense, the proof reflects the philosophy of the assumption in Hart–Moore (1988) that in the absence of trade, courts cannot find out whose fault it is.

An implication of this result is that if the optimal complete contract in the absence of renegotiation allocates most of the surplus to the agent ($\lambda^* > 1/2$), then in the presence of renegotiation, *the parties cannot gain from a contractual relationship*; that is the absence of the contract yields the feasible sharing rule ($\lambda = 1/2$) that is closest to the optimal sharing rule in the absence of renegotiation.

REMARK: The R&D game is one particular example of a "game with cooperative investments." Roughly speaking, an investment is cooperative if it affects the trading partner's surplus more than the investing party's surplus. Here, the agent's investment impacts the principal's surplus, but not the agent's ex post production cost, which is equal to zero. Che and Hausch (1998) show more generally that cooperative investments are difficult to protect even through

[12] If the agent can "hide" a useful innovation at the implementation stage and then disclose it to the principal at the renegotiation stage, then sharing rules $\lambda < 1/2$ are infeasible as well; and the parties can only implement the sharing rule, $\lambda = 1/2$, that corresponds to the absence of contract.

optimal contracts in the presence of renegotiation. Indeed, they provide conditions under which optimal contracts cannot do better than a complete absence of contracts. The Che–Hausch result and the one presented here, do not rely on the number of goods being large, in contrast with a similar result obtained by Segal (1999) and Hart–Moore (1999) for "selfish investments," namely investments that mainly affect the investing party's surplus. See Segal–Whinston (1998) for an excellent synthesis of the various results.

2.3. *Incomplete Contracting*

Incomplete contracting approaches make assumptions on the class of feasible mechanisms. In our context, it is assumed that:

• One can assign to one of the two parties a general property right or patent on *any* innovation. That is, we envision that the agent produces blueprints that then fall into his hands or the principal's hands, with the explicit right to use or sell them. The principal freely uses the innovation if she owns it (the agent is then a research employee), but must purchase it from the agent if the agent owns it (the agent is then an independent researcher.) In the latter case, the license fee y is determined according to some sequential bargaining process. Let us follow the literature by assuming that the outcome of bargaining is the Nash bargaining solution ($y = V/2$).

• The realized value (0 or V) for the principal of any innovation transferred to her is observable by both parties at stage 2, but cannot be verified by a court.[13] In contrast, the license fee, which is equal to the research unit's profit, is verifiable, and the principal as well as third parties can ex ante be given shares in A's income.

To sum up, an incomplete contract is here defined as an allocation of a property right on the innovation together with a rule for sharing A's license fee. It is clear that, *with only two parties* and ownership contracts, the sharing rule is ineffective (as was anticipated by Hart–Moore (1990, fn. 7)). Either the principal owns the innovation, and there is no license fee to be shared, or the agent owns the innovation, and (in any sequential bargaining process) the parties bargain over the *real* license fee, namely the nominal license fee minus the share given back to the principal.[14]

So, we are left with just property rights. A-ownership yields $y = V/2$ and P-ownership $y = 0$. More generally, a properly chosen date-2 random allocation of the property right yields any (expected) $y \in [0, V/2]$. Property rights contracts

[13] It can be either a private benefit for the principal as it allows her to economize on her effort; or else it cannot be recovered from the principal's many activities. Property rights tend to be irrelevant if the impact of invention on user profit is measurable (see Anton–Yao (1994, p. 202)).

[14] See Aghion–Tirole (1994) for more details.

thus create a welfare loss for the principal if the solution y^* to the complete contracting program satisfies $y^* > V/2$. Note, though, that the set of feasible sharing rules is the same as under complete contracting and renegotiation.

REMARK: Random allocations of the property right can be replaced by a deterministic property right given to the agent together with a third party holding share $(1 - 2y/V)$ of the agent's profit. This third party can be interpreted as a financier (bank, venture capitalist, ...) who makes no use of the innovation but cofinances the project and receives part of the license fee.[15] This alternative is superior to a random allocation of the property right when the agent is also indispensable, in that there are no blueprints the principal can seize and the principal must bargain with the agent for the completion of an innovation even if the principal owns the innovation (as in Hart–Moore (1994)). Then the only possible sharing rule in the absence of cofinancing is $y = V/2$, while cofinancing allows any sharing rule $y \in [0, V/2]$.

2.4. *Some Themes of the Incomplete Contracting Literature*

We can use the R&D game and straightforward extensions to illustrate some of the main ideas of the incomplete contracting literature.

The first theme, familiar from the work of Grossman–Hart (1986), Hart–Moore (1990), and Williamson (1985) among others, is that *the allocation of property rights determines the bargaining powers in the ex post determination of the terms of trade* and that the holders of property rights are somewhat protected against the expropriation of their specific investment. Property rights thereby boost the holders' incentives to invest. In the R&D game the allocation of ownership implicitly defines a rule for sharing the benefits of the innovation and affects the agent's date-1 behavior. He has no incentive to exert effort beyond e_0 as an employee and exerts effort e given by $g_A{}'(e) = V/2$ (assuming $g_A{}'(e_0) < V/2$) as an independent researcher. Ownership thus raises the agent's incentive to innovate.

A second common theme is that the *exercise of property rights is limited by the indispensability of the other party in the ex post production process* (Hart–Moore (1994)). In the R&D game, the buyer's indispensability limits the agent's share to 50% (or more generally to the share that results from bargaining between the

[15] It is here assumed that the third party—who has congruent interests with the agent in the bargaining with the principal—does not participate in the bargaining process. On the other hand, it is clear that the idea that third-party shareholding helps capture some of an independent agent's rent extends to situations in which the third party is brought into the bargaining process, except in the extreme case in which the agent can credibly commit not to bargain with the principal unless the third party gives him his shares without compensation.

two parties) even if the agent owns the innovation. Suppose in contrast that there are other potential users of the innovation, who are willing to pay $V' \leq V$ for an exclusive license (no potential user has any value for a nonexclusive one, say). An auction among the potential users yields V' in case of innovation. The proceeds V' can be shared in any arbitrary way between the agent and the principal. And, when $V' = V$, any sharing rule can be implemented through the combination of an auction and shareholdings.

The existence of ex post competition provides the agent with a protection against the principal's opportunism in a situation of incomplete contracting. Ex post competition however may be costly if the agent makes a technological choice concerning the specialization to the principal's needs (the following is adapted from Holmström–Tirole (1991); see also Segal–Whinston (1997)). Suppose that during the R&D process the agent picks not only the probability of discovery, but also one of two research technologies with identical probabilities of success for a given effort. The specialized one, if successful, yields utility V to the principal and 0 to any other potential user. The general or flexible one, if successful, yields utility $v \in ((V/2), V)$ to any alternative user, and $\tilde{v} \in (v, V)$ to the principal. Suppose the agent has the property right on the future innovation. The agent optimally picks the flexible technology. Assuming that the bargaining with the "outside option" proceeds as in Binmore et al. (1986), the agent receives $v > V/2$ in case of success while the principal receives $\tilde{v} - v$. In that sense a market (defined as the existence of ex post competition for the innovation) is more informative about the agent's performance than an exclusive relationship. Competition raises the agent's stake from $V/2$ to v but is bought at social cost $V - \tilde{v}$. Clearly if v and $\tilde{v}$ are close to $V/2$, competition does not improve incentives much and is purely wasteful. In contrast, competition is desirable if $\tilde{v}$ is close to V and high powered incentives for the agent are crucial.[16] Thus, if P and A are two divisions of the same firm, the firm's headquarters would like to allow A to trade outside the firm in the latter case, but not in the former.[17]

A third theme of the literature is that *the allocation of decision rights may affect the efficiency of ex post trade*. It is well known that bargaining under asymmetric information[18] leads to inefficient haggling or suboptimal trade. Conferring authority on one of the parties or on a third party (arbitrator,

[16] The reasoning here assumes that the principal holds no share in the agent's profit. When the principal holds share λ, the agent's payoff in case of innovation is still $V/2$ for the specialized technology, and becomes min $(\tilde{v}/2, (1-\lambda)v)$ for the flexible one. The results are robust to the introduction of principal's shares as long as high powered incentives are required.

[17] As Williamson (1975) and the business management literature on the M form and transfer pricing have emphasized, the main issue is then whether the headquarters can build a reputation for exercising this right only when competition is wasteful and for abstaining from using the right when the lack of specialization is not very costly and competition is desirable from an incentive viewpoint.

[18] The allocation of decision rights also affects the decision when utility is nontransferable among the parties.

headquarters, ...) may eliminate this inefficiency. Coase (1937) and Williamson (1985) view the reduction of haggling as a major benefit of "integration."

In the symmetric information R&D game described above, the date-2 decision (the transfer of innovation) is efficient regardless of the ownership structure. This is generally no longer the case in the presence of asymmetric information. For example, suppose as before that with probability e there is a (positive value) innovation and with probability $1 - e$ there is no innovation. The value of the innovation is drawn from a continuous distribution on $(0, \infty)$ with mean V and is known only by the principal. Nothing changes under P-ownership. But general results on bargaining under asymmetric information[19] show that for most bargaining processes under A-ownership, bargaining may yield an inefficient trade (too little or delayed licensing here). So, the bargaining process that results from A-ownership is unlikely to be efficient, whereas no inefficiency occurs under P-ownership.

A fourth theme of the literature, which is related to the first, is that *clusters and splits of multiple decision rights are governed by incentive considerations*. For example, Hart–Moore (1990) and Hart (1995) argue that highly complementary assets should be owned in common. Because such rights are valueless in isolation, splitting complementary assets protects no one against the expropriation of specific investments in ex post bargaining. Concentrating the rights in a single hand reduces the number of hold ups.

In the R&D game, suppose that exploiting the innovation requires the use of two complementary physical assets, a and b. Splitting the two assets between the principal and the agent is equivalent to giving them both to the agent, since both arrangements before bargaining exhibit the same status quo, namely no exploitation of the innovation by the principal. So common ownership is (weakly) optimal. Next, could it be optimal to introduce a second principal (a financier, say) and to split ownership of a and b between the two principals? Consider the interesting case in which incentive considerations require the agent to own the innovation. If ownership of the two physical assets is split between two principals, the exploitation of an innovation requires the consent of three parties (the agent and the two principals) instead of two. The agent may then obtain, say, only $V/3$ in bargaining. In contrast, if the two physical assets are jointly owned by a single principal, then the agent is likely to obtain more, say $V/2$, in bargaining. Common ownership of the complementary assets reduces the extent of expropriation and thus raises the agent's stake in the innovation.[20]

Second, property rights may be split so as to properly distribute incentives. In the context of the R&D game, the split may be an allocation of property rights on different types of innovation between the agent and the principal. The split is

[19] Myerson–Satterthwaite (1983), Laffont–Maskin (1979).

[20] We are here assuming unconditional property rights, i.e., property rights allocated to one or the two parties at the initial date. More generally, property rights might be allocated ex post on the basis of the parties' announcements of willingnesses to pay for these rights (see, e.g., Hart (1995) and Maskin–Tirole (1999b)).

then governed by a straightforward criterion of "comparative advantage in creating value."[21]

2.5. *The Incomplete Contract Controversy in the Context of the R&D Game*

Concerns about the approach illustrated in Section 2.3 can be readily summarized: Might we be focusing on too small a class of contracts? Could the property right institution be an artifact of our modeling? Obviously, the fact that the property right institution is widely observed provides encouragement to search in this direction but is per se no justification for assuming it. Property rights should be derived from primitives. Let us imagine a dialogue between an "incomplete contract theorist" and a critic of the incomplete contract approach (whom we will call for convenience the "complete contract theorist"). I voluntarily polarize the positions to better highlight the arguments.

Complete contract theorist: "I agree that in a context like R&D the content of trade is hard to describe precisely ex ante. But incomplete contract theorists lack a coherent model that would unambiguously define the set of feasible contracts starting from first principles (the cost of writing contracts, etc...) and optimize over this set. I am for example worried about the "observable but nonverifiable" assumption, namely the postulate that the state of nature is ex post observed by several parties (here at least the principal and the agent) and yet the elicitation of this information takes only crude forms, namely uncontrolled bargaining in the case of A-ownership and no elicitation in the case of P-ownership.

In a different register, I wonder whether the indescribability assumption really restricts the set of feasible contracts relative to the complete contract paradigm. Indeed the public contract described in Section 2.1, in which the agent ex post describes a technique to be transferred, that the principal is then free to buy at a prespecified price, is a case in point. We saw there that the same outcome as under describable contingencies could be obtained. Property rights then give way to a standard sharing agreement."

Incomplete contract theorist: "The contract you propose seems unreasonable, for several reasons. First, I wonder about the robustness of this contract to uncertainty about the principal's valuation. Inefficiency will result if her realized

[21] To illustrate this, suppose there are n types of innovations and that property rights can be differentiated according to the type of innovation. The probability of making innovation k is $e + \theta_k$. Let V_k denote the value of innovation k and let $\alpha_k V_k \in \{0, V_k/2\}$ denote the agent's share in the value of innovation k. That is $\alpha_k = 0$ if the principal owns innovation k and $\alpha_k = \frac{1}{2}$ if the agent owns it. The optimal split of property rights maximizes, say, the principal's expected payoff $\Sigma_k(e+\theta_k)(1-\alpha_k)V_k$ subject to a given level of the agent's marginal incentive $\Sigma_k \alpha_k V_k$. At the optimum, the agent should own the low θ_k innovations and the principal the high θ_k ones.

Such straightforward reasonings can rationalize familiar business and legal institutions of ownership of innovation, such as shop rights (under which an employee owns the innovation but the employer enjoys a free, nonexclusive and nonassignable license), the trailer clause and the "hired for" doctrine (under which the split between the employer and the employee is determined by the date or the nature of the innovation). For more details, see Aghion–Tirole (1994).

willingness to pay for the innovation is lower than the reward y. Second, and more importantly, I believe that a court would not enforce this contract and would allow mutually advantageous renegotiation even if the parties have explicitly ruled it out. The reason why a court might allow further trading after the contract resulted in no trade is that such a trade, if voluntary, necessarily improves the welfare of all parties. So, even if the commitment not to allow future trades is ex ante socially optimal, it is no longer ex post socially optimal.

Let me provide further motivation for the courts' refusal to enforce the contract. There might be other, unforeseen desirable trades between the two parties that the court would have a hard time distinguishing from the trade that would result from the renegotiation of the contract. The court then would not prevent such trades. Moreover, the court may be unable to prevent further trades if these are disguised through complex transactions with third parties.

As we noted in Sections 2.2 and 2.3, renegotiation in the R&D game makes quite a difference as to what can be implemented. As a matter of fact, the parties in that instance incur no loss when focusing on ownership contracts."

Complete contract theorist: "I concede that contracts such as the one I proposed are somewhat unrealistic. On the issue of robustness to different payoff specifications, I would argue that the uncertainty about payoffs could and should be explicitly modeled. On renegotiation, let me point out that if courts can commit to enforce contracts (as is assumed in the incomplete contracting literature), they might also commit to preventing any renegotiation that is explicitly ruled out by a contract. The court's reputation might be the vehicle for commitment in both cases. The fact that renegotiation is mutually advantageous may not be a compelling reason for courts not to enforce the contract. After all courts send people to jail even though this is ex post socially inefficient.

Although I am sympathetic to the idea that in practice the parties are ex ante reluctant to prevent ex post mutually advantageous renegotiation (which, together with the benefits of business secrecy, may be why contracts are rarely made public, and therefore are easy to amend), I feel uneasy about the come back of incomplete contracting through those mysterious, unforeseen future trades that cannot be distinguished from the renegotiated trade. Once more I would feel more comfortable with a more precise modeling."

Incomplete contract theorist: "Even if we take for granted that courts enforce contracts that are registered with them, you are presuming a centralized court system or at least the possibility for the two parties to sign a contract saying that no other agreement (direct or indirect through third parties) registered with another court or arbitrator is enforceable. I find this quite unrealistic."

Let us here quit this dialogue to analyze the incomplete contracting methodology in more detail.

3. "UNFORESEEN" CONTINGENCIES AND INCOMPLETE CONTRACTS

3.1. *Complete Contracts*

By lack of a better definition, we will say that a contract is incomplete if it does not exhaust the contracting possibilities envisioned in the complete contracting literature. That is, our benchmark for incomplete contracting will be the complete contract paradigm, as defined in general environments by, say, Laffont–Maskin (1982) and Myerson (1982).[22] The important feature of complete contracting is that the only impediments to perfectly contingent contracting are that the agents may have private information at the date of contracting (adverse selection), receive future information that cannot be directly verified by contract enforcement authorities, that this information may be private information (hidden knowledge) and that agents may take actions that cannot be verified (moral hazard). There is no limitation on the parties' ability to foresee contingencies, to write contracts, and to enforce them.

Incomplete contract models usually assume that information is symmetric among the parties. We will therefore, focus on symmetric information environments, although we should point out that informational symmetry is not central to the debate between complete and incomplete contracting. The *symmetric information implementation literature* studies one prominent class of complete contracting models in which agents have no private information. Namely, there are a number of possible states of nature that can be described ex ante in a contract. Parties to a contract initially do not know which state of nature will prevail. Ex post they all observe the realization of the state of nature. This realization is not verifiable by a court and must be elicited from the agents. An optimal contingent contract would specify a state-contingent allocation. The challenge is therefore to elicit the state of nature from the agents in a manner that uniquely implements the state-contingent allocation.

A set of powerful results has been derived starting with the seminal 1977 contribution of Maskin (1999). This lecture is no place to present even a brief treatment of Nash implementation theory. See Moore's (1992) excellent survey for a pedagogic and yet relatively exhaustive survey, and Osborne–Rubinstein (1994, Ch. 10) for a more concise treatment. The exact results depend on the solution concept adopted—Maskin's initial conditions for Nash implementation have been relaxed through the use of refinements of Nash equilibria such as subgame perfection or trembling-hand perfection or by allowing approximate implementation—and on the number of agents—it is easier to find out that someone is a liar when there are more than two agents.

[22] Recall for instance Myerson's formulation. There are n agents, $i = 1, \dots, n$, and T periods, $t = 1, \dots, T$. The n agents initially sign a contract in which they empower a mediator (a center, or a machine) to receive messages, take decisions (which may include transfers to and from the agents) and make "recommendations" to the agents. More precisely, (i) at the beginning of each period, agents receive new information privately (this allows for hidden knowledge); (ii) agents then communicate their information to the mediator; (iii) on the basis of these informations, the mediator takes a decision and sends a private message to each. How the mediator's decision and messages relate to the messages he receives is determined by the contract; the messages can be interpreted as recommendations for what the agents ought to play in the next stage; (iv) on the basis of the private message he receives from the mediator, each agent privately chooses some action (this is the moral hazard part). As usual the revelation principle implies that one can restrict attention to mechanisms in which each agent truthfully reveals his information at each date; similarly, one may focus on mechanisms in which the mediator's recommendations are obediently followed.

The bottom line of this literature is that the nonverifiability of information by a court is in general no obstacle to the implementation of contracts contingent on this information as long as this information is commonly observed by several parties. The qualifier "in general" roughly reflects the fact that information that is no longer *payoff-relevant*—meaning that it does not alter the agents' von Neumann–Morgenstern (VNM) utility functions in the continuation game—cannot be elicited as a unique outcome. So, for example, unmeasurable past services rendered by an employee to a firm and having no impact on the employee's and the firm's continuation payoffs cannot be elicited in a unique way. By definition, the impact of payoff-irrelevant information on utilities is "sunk" and so the information cannot be truthfully elicited. This information therefore can be used in the contract only if it is verifiable by the enforcement authority.

This point sheds light on one of the main offerings of the complete contracting ritual: the notion that a variable is "observable but nonverifiable." This phrase is used by incomplete contract theorists to mean not only that the variable is observed by all contracting parties and not by a court (and therefore is not verifiable), but also that elicitation mechanisms that might make it *de facto* verified by a court are assumed away (so, under common usage, the phrase is understood to mean more than it formally implies). Complete contract theory actually offers a clue as to when this assumption admits foundations: A variable that is observable by the parties and not by the court cannot be elicited if it is payoff irrelevant when it is learned by the parties.

In contrast, information that affects preferences over decisions yet to be selected can typically be elicited; for example, one can assess an agent's willingness to pay for decision x over decision x' by having the agent pay a surcharge for decision x. In a situation of symmetric information among agents, furthermore, the level of this surcharge can be assessed by a second agent, who, by assumption, knows the first agent's willingness to pay for decision x over decision x'.

Simple "Maskinian" elicitation mechanisms used in practice include auctions, financial markets, and option contracts, since such mechanisms force agents to reveal their willingnesses to pay for goods and services, financial income streams, control rights, and so forth. While simple elicitation mechanisms may suffice in specific economic environments, the implementation literature in contrast has had to build complex mechanisms in order to demonstrate the generality of the underlying ideas. The object of this literature is therefore not to recommend for application in specific economic problems such (abstract and unrealistic) mechanisms that are designed for very general environments, but rather to show the robustness of the elicitation concept embodied in familiar institutions such as auctions and option contracts.

To fix ideas, we will in the rest of Section 3 consider the standard three-stage model (Figure 1): The parties ($i = 1, \dots, n$) contract at date 0. At date 1, each chooses an unverifiable effort or investment e_i; let $e = \{e_i\}_{i=1,\dots,n}$. At date 2, the state of nature ω is realized (according to a distribution that depends on e). A

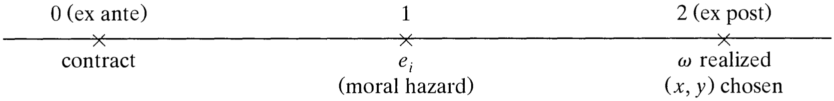

FIGURE 1

decision $a=(x, y)$ must then be taken, involving a physical action x (in the feasible set defined by ω) and monetary transfers $y=\{y_i\}_{i=1,\ldots,n}$ (such that $\Sigma_i y_i=0$). The parties have state-contingent preferences over x and y. The VNM utilities are then $u_i^{\omega}(x, y_i)$ (the impact of efforts can be subsumed in ω). The rest of the section gives an informal account of Maskin–Tirole (1999a).

3.2. *Indescribable Contingencies and the Irrelevance Theorem*

We will, like the incomplete contract literature, assume that the parties are rational, in that they are able to figure out the *payoff* consequences of their contract and investments even if they are unable to conceive the physical circumstances that will give rise to these payoffs. A simple but key observation is that *with rational agents contingencies are never unforeseen*; *they are "at worst" indescribable*. At the very least, the parties can always envision the existence of actions, which at the contracting date can be labelled by numbers for want of a better description, and a mapping from those actions into (dollar or util) payoffs. This defines "number-based payoff functions." The only difference with standard "action-based payoff functions" is that actions are identified with numbers rather than described by physical attributes.

That is, under describable contingencies, to each state of nature ω is associated a feasible physical action set X^{ω} and payoff functions $u_i^{\omega}(x, y_i)$. Under indescribable contingencies, the parties envision only the (possibly infinite) number $|X^{\omega}|$ of actions in X^{ω} (but not the actions themselves) and functions $v_i(k, y_i)$, where $k \epsilon \{1, \ldots, |X^{\omega}|\}$ are integers; the parties further have a probability distribution over such functions, which for each vector e of investments, is consistent with the distribution over the action-based payoff functions. The key to a good understanding of the economic implications of our analysis is to *view this ex ante indescribability of the contingencies as a garbling of the information structure*, *and the analysis as an investigation as to when this garbling of the information structure impacts the efficiency of contracts*.

Under the utilitarian approach adopted in economics, parties do not care per se about contingencies; they only care about the impact of contingencies on payoffs. Then, the indescribability of contingencies matters only to the extent that it restricts the set of payoffs that can be obtained through contracting. This suggests studying the following question: Start from a situation in which contingencies are ex ante describable, and look at the optimal contract that can be written by the parties under these circumstances. Then assume that the contingencies become ex ante indescribable, that is they are just numbers (although, like in the incomplete contract literature, they later become describable). Can the parties still secure the same expected payoffs through contracting as when the contingencies are ex ante describable?

The answer turns out to be remarkably simple. Intuitively, the indescribability of contingencies implies that the contract will not be able to discriminate (in terms of payoffs) between two states of nature that give rise to the same preferences. More precisely, consider two states of nature in which the number-based payoff functions are (up to a VNM affine transformation) the same. So, the actions may be different, but up to a relabelling of actions the preferences are identical. Because the parties cannot tell apart these two states of nature ex ante and because VNM equivalence further precludes any ex post distinction, the payoffs generated by the contract under indescribable contingencies must be the same (up to the VNM transformation).

In contrast, this contract can implement different payoffs in two states of nature that do not exhibit the same number-based payoff functions. This step requires extending the standard implementation result that payoff relevant information can be elicited, to the case in which contingencies are ex post but not ex ante describable. It turns out that ex ante indescribability does not make it more difficult to discriminate between the two states of nature; one can, as in the incomplete contracting literature, let the parties themselves suggest (describe) actions at stage 2 once they can conceive of them: see Appendix 2 for an illustration.

If one takes this technical step as given and so one knows that differences in payoffs across states of nature can be elicited from the parties, the central question of whether ex ante indescribability restricts the set of payoffs that can be obtained through contracting boils down to the question of whether an optimal contract under describable contingencies would ever prescribe different payoffs in two states of nature in which the parties have the same preferences. If the answer is negative, then indescribability is irrelevant.

The latter question is a standard one in incentive theory. Intuitively, one might want to discriminate between two payoff-equivalent states of nature ω and ω' if this either provides *insurance* to the agents at stage 2 or strengthens their *incentives* at stage 1. This however will not happen under the following two assumptions:

(a) *State independence of the ratios of marginal utilities of money*: The ratio of two agents' marginal utilities of money is the same in payoff-equivalent states of nature. A class of preferences satisfying this assumption is given by

$$u_i^{\omega}(x, y_i) = w_i^{\omega}(x) + \alpha^{\omega} z_i(y_i).$$

Risk neutral preferences, and a subset of risk averse preferences satisfy this assumption, which rules out any benefit from cross insurance across equivalent states: Since $\alpha^{\omega} = \alpha^{\omega'}$ for two-payoff equivalent states ω and ω', two parties do not gain by offering each other insurance across these two states, when the states are describable and verifiable by a court so that contracts can indeed be contingent on them. Indescribability then does not impair insurance opportunities.

(b) *Unidentifiability of effort*: For any two payoff-equivalent states ω and ω', the stage-2 probability of ω conditional on the event $\{\omega, \omega'\}$ is independent of investments e. In other words, no information can be inferred about investments from knowing exactly which of payoff-equivalent states ω and ω' occurred. This means that the initial contract under describable and verifiable contingencies cannot impact incentives for investments by discriminating between ω and ω'. And so the impossibility to distinguish between ω and ω' under indescribable contingencies does not affect the parties' ability to provide incentives.

It is therefore intuitive that, *under these two assumptions* (and some innocuous ones), *indescribability is irrelevant* (Maskin–Tirole 1999a). Payoffs that can be obtained under describable contingencies can also be implemented when contingencies are indescribable. The reader will also have noted that the two assumptions are stronger than needed for the irrelevance result. For, even if payoff-equivalent states ω and ω' are describable, they cannot be distinguished if they are not verifiable by a court;[23] and so even if the parties wanted to generate different payoffs in states ω and ω' to create insurance or to boost incentives, they would be unable to do so even under describable contingencies, as the next subsection will illustrate.

The literature on incomplete contracts focuses on preferences and technologies that satisfy the irrelevance theorem. The next section provides straightforward examples in which the assumptions are not satisfied and draws the implications of their violation.

3.3. *When does Indescribability Matter? Does it Engender a New Paradigm?*

We have seen that under some conditions indescribability is irrelevant. While these conditions are often satisfied by incomplete contract models, they are not innocuous. Let us give concrete examples in which they are violated and so indescribability matters.

As we observed in Section 3.2, indescribability may matter in the absence of renegotiation only if, when states are describable, (i) a court can distinguish between (verify) two payoff-equivalent states of nature ω and ω', and (ii) the optimal contract specifies different payoffs in these two states. The discrimination mentioned in (ii) may be motivated by the desire to either provide the parties with insurance at date 2 or to boost their date-1 incentives. We illustrate the two possibilities separately.

The *insurance motivation* can be illustrated by the following example, which violates assumption (a): Ignore the date-1 investments. Simply, one of the parties, party 1, has a random income at date 2. This party has exponential

[23] We are assuming that describable states of nature are not necessarily verifiable by a court, since the court may not observe their realization.

(*CARA*) utility, so that the realization of income has no impact on his VNM utility function (and therefore cannot be elicited). Income is not directly observable. Suppose that there are two states of nature ω_1 and ω_2. In states of nature ω_1 (ω_2), party 1's income is low (high). If states of nature are ex ante describable by the parties and verifiable by a court, party 1 can sign insurance contracts with other parties and will receive (give) income in state ω_1 (ω_2). In contrast, if states of nature are indescribable, no insurance can be provided and contracting has no value. Interestingly, note that indescribability is equivalent to a situation in which ω_1 and ω_2 are ex ante describable, but the mapping from the state of nature to party 1's income is unknown (that is, given the parties' ex ante knowledge the low income is equally likely in states ω_1 and ω_2). In this sense, indescribability can be viewed as a garbling of information.

The *incentive motivation* is illustrated by the standard principal-agent model (e.g., Mirrlees (1999), Holmström (1979), Shavell (1979)). In this model, the agent exerts an unobservable effort at date 1, resulting in some random benefit for the principal at date 2. There is no date-2 physical action. A contract specifies a transfer from the principal to the agent, contingent on the benefit. The model thus assumes that the benefit for the principal is describable and verifiable; it does not satisfy assumption (b) if the principal is risk neutral or has CARA utility: The benefit (that is, the date-2 state of nature) is then payoff-irrelevant, and yet it contains information about the agent's effort. Thus, unidentifiability of effort is violated.

Incentives cannot be provided to an agent whose performance is not ex ante describable, or equivalently when performance measures are describable but the link between effort and these performance measures is unknown. So, for example, moving from the classical situation in which the ex post benefit to the principal is describable and verifiable to one in which it is not entails a loss of welfare for the principal since the benefit cannot be elicited ex post.

These insurance and incentive examples show that the irrelevance of indescribability should not be taken for granted. They further indicate that the impact of indescribability is actually quite familiar. Garblings of information structures and their impact on the value of contracting have been central themes of the complete contract literature. The introduction of indescribability into our modeling therefore does not seem to require a new paradigm. But it suggests some limitations in the efficacy of contracting.

3.4. *Renegotiation*

Let us now allow for the possibility of contract renegotiation. After the contract by the parties is implemented, the parties can "at stage 3" write a new contract and thereby undo any inefficient outcome. The general analysis of "complete contracting under renegotiation" is due to Maskin–Moore (1999) and was refined by Green–Laffont (1992, 1994) and Segal–Whinston (1998). It is important to distinguish between the following two possible observations:

• "*Renegotiation may constrain what can be achieved in a given environment.*" For example, we saw that for the R&D game renegotiation is innocuous when the innovation is describable and verifiable (Section 2.1), but restricts the set of feasible rewards when it is not (Section 2.2). Indeed, we saw that, for those parameters for which renegotiation reduces the efficiency of the contract, the parties cannot gain from a contractual relationship, a conclusion derived more generally by Che–Hausch (1998) for the class of "cooperative investments." Another illustration of the idea that renegotiation can substantially limit the power of complete contracts is provided by Segal (1995, 1999). Segal considers a buyer-seller relationship in which there are n possible goods, only one of which is to be traded. The goods can be described ex ante but their payoffs are not known until date 2. Ex post, $(n-1)$ goods correspond to bad trades for one of the parties, some yielding no utility to the buyer and the others involving expensive goldplating. The two parties' investments affect only the payoffs attached to the "relevant good" and they are "selfish" in that a party's investment affects only her own surplus. The parties are risk neutral. Segal shows that, *for n large*, a complete contract can barely improve on the absence of a contract (that is, on ex post bargaining) when renegotiation is allowed, while it yields the first best in the absence of renegotiation. Similarly, Hart and Moore (1999) provide a simple example with the same conclusion (no value of contracting under renegotiation, first best in the absence of renegotiation) as in Segal. Last, Maskin–Tirole (1999b), building on Hart–Moore (1999), describes an environment in which the property right institution is optimal when the parties cannot commit not to renegotiate.

• "*Renegotiation may invalidate the irrelevance of indescribability.*" In contrast with the first observation, which compares payoff outcomes with and without renegotiation for a given environment, the second question takes renegotiation as given, varies the environment, and wonders whether the irrelevance result still holds.

Maskin–Tirole (1999a) obtains two results for the case of renegotiation. Their Theorem 4 speaks to the second point and derives conditions under which what can be implemented under describable states and renegotiation can also be implemented under indescribable states and renegotiation. For conciseness, we will focus on their Theorem 3, which speaks to both points. It makes stronger assumptions than those made in the absence of renegotiation. Parties are assumed to be strictly risk averse, with $u_i^{\omega}(x, y_i) = U_i(w_i^{\omega}(x) + y_i)$. Transfers y_i are unconstrained. It is assumed that the equilibrium monetary transfers between the parties resulting from the renegotiation from an inefficient allocation to an efficient one are the same whenever the states ω and ω' are payoff-equivalent. Under this assumption and strict risk aversion (together with innocuous assumptions), the possibility of renegotiation and the indescribability of contingencies (even combined together) do not restrict the payoffs that can be attained through contracting. Although this assumption is often satisfied in incomplete contract models, it is not innocuous and it is not guaranteed by assumptions (a) and (b): see Maskin–Tirole (1999a) for more detail. The stronger assumptions that are required for the result *suggest* that indescribability is more likely to matter when renegotiation is possible, presumably because the constraints imposed on contracting by renegotiation make it harder to make up for the informational garbling implied by the indescribability of contingencies.

4. EXPLAINING REAL WORLD CONTRACTS AND INSTITUTIONS

4.1. *Realism of Complete Contracts Models*

The recent upsurge of incomplete contract models has been partly motivated by a perception that the principal-agent model and its variants predict contracts that, on the one hand, are "too powerful" in that they underestimate the difficulties involved in real world contracting, and on the other hand, lack realism. Yet, we have seen that the common motivation for incomplete contracting, namely the indescribability of contingencies, does not per se invalidate the classical approach to contracting. A purist approach must therefore either discard the rationality postulate or ponder over why our models predict contracts that are too powerful and unrealistic. We pursue the latter route in this and the next subsection.

There are a number of reasons why in practice the efficacy of complete contracts may be limited. We here list a few of these reasons, and discuss some of them:

(a) *Indescribability of contingencies*, as viewed, as we discussed, as a limitation on the verifiability of contingencies by contract enforcement authorities.

(b) *Renegotiation* (although complete contract theorists are divided about the importance of the lack of foundations for why parties do not find ways to prevent ex post beneficial, but ex ante detrimental renegotiation).

(c) *Collusion*.[24] Complete contracts are particularly powerful when the parties have symmetric information. They can then use parties to check on each other's truthtelling, while asymmetric information requires more costly elicitation mechanisms. But, as Laffont and Martimort (1997) show, symmetric information also facilitates collusion among the members of an organization. So it is precisely when complete contracts (in the absence of collusion) are the most powerful that they are also most likely to be weakened by the possibility of collusion.

(d) *Wealth constraints*, which put limits on the use of money to elicit the parties' willingness to pay for specific services or decisions.

(e) *Enforcement by human beings*. Scant attention has been paid in the literature to the enforcement mechanism. In practice, contracts are enforced by human beings. Judges are subject to both moral hazard (they may not put

[24] See Laffont–Rochet (1997) and Tirole (1992) for surveys of the impact of collusion on organizational design.

enough effort into reading and understanding the details of the case) and adverse selection (they may not have the proper background to understand what the parties tell them; they may also have their own preferences, in the form of legal precedents and principles, which they may embody in their decisions, sometimes regardless of what the contract says or what the parties want). Judges and arbitrators may also collude with the parties. This implies that judges may not enforce the letter of the contract. And, when the contract is not very precisely specified, which is usually the case,[25] judges may not enforce its spirit.

One may argue, though, that standard complete contract theory sometimes presumes *too little* use of arbitrators. Let us return to the symmetric information, Nash implementation literature. As we discussed in Section 3.1, a state of nature commonly observed by the agents cannot be costlessly elicited when the state of nature no longer affects the agents' von Neumann–Morgenstern preferences when they learn it. We gave the example of an agent who contributed to an organization in the past in a way that no longer bears on future payoffs. Now headquarters and courts often award rewards or order transfers between parties on the basis of the value of payoff-irrelevant past actions. This is seemingly ruled out by implementation theory which requires equilibrium uniqueness in the announcement of such information, while the equilibrium set is necessarily independent of payoff-irrelevant information.

How should one account for this discrepancy? In practice, headquarters or courts endowed with the authority to award rewards or order transfers between parties may *strictly* prefer to choose these rewards or transfers "fairly" because they have at least some concern about their reputation for fairness, which may make them valuable in the future. "Hold on!", will rightly point out the complete contract theorist, "the appeal to reputation refers to unmodelled future interactions and therefore to a different game. If these future interactions were properly accounted for, the payoff irrelevant information would become payoff relevant—at least for the arbitrator—and complete contract theory would rationalize the existence of rewards seemingly based on pure fairness considerations." The problem with this is that the purist approach requires modeling and subjecting to the initial contract all future interactions of the parties, including the arbitrator, with other parties (that they may not even have met yet), the future interaction of these parties with other parties, and so forth. This is perhaps stretching complete contracts too much. The question is of course where to draw the line, namely where to invoke transaction costs to make complete contracts more tractable and more reasonable.

(f) *Ex ante asymmetric information.* In the last ten years researchers have tried to use adverse selection to provide foundations for the absence of covenants or

[25] Writing costs are of course related to *enforcement costs*, for a more precise description of contingencies simplifies enforcement. Courts are then less likely to ponder over the spirit of the agreement.

measurements and thereby show that apparently incomplete contracts can actually be optimal complete contracts.[26]

There are two notions of "endogenous incompleteness." The first is the *nonelicitation of private information.* This phenomenon is usually labelled "bunching", "pooling" or "nonresponsiveness" depending on the specific context. The second is the *lack of dependence of the contract on a verifiable variable.* For instance, in Aghion–Bolton (1987) and Hermalin (1988) the parties need not have the event of breach be verified by a court even if it is costless to do so. Screening or signaling considerations rule out the use of penalties for breach (or more precisely yield a "corner solution" at no penalty) and therefore make the measurement of breach superfluous.[27]

[26] In Aghion–Bolton (1987), a supplier signals that he is confident that competitors will not enter his product market by not specifying an otherwise efficient penalty for breach for his customers. By doing so he reduces the efficiency of the contract but obtains better terms of trade from the customers. In Hermalin (1988, Ch. 1), it would be efficient for workers and firms to sign long-term contracts (again specifying penalties for breach) in order to promote investments. They nevertheless end up signing short-term contracts because talented workers want to signal that they are not afraid of going back to the job market tomorrow and less talented ones are forced to follow that strategy in order not to reveal their type. A similar phenomenon can be found in Diamond's (1993) model of short-term vs. long-term debt in which good borrowers issue inefficiently short run debt in order to signal that they are not afraid of going back to the capital market. Aghion–Hermalin (1990) shows that legal restrictions on private contracts may prevent wasteful signaling (see also Hermalin–Katz (1993)). Spier (1992) considers an insurance market in which there is costly state verification. In equilibrium the insuree may forego insurance based on the realized state in order not to signal a high probability of accident. Similar ideas have been developed in the context of financial economics: See Allen–Gale (1994, p. 144–145).

[27] The following highly stylized example conveys the intuition for the more sophisticated and interesting complete contracting foundations for incomplete contracting in the literature. There are two cashless parties, 1 and 2, who must decide whether to engage in a relationship. A satisfactory relationship yields strictly positive private benefits S_1 and S_2 to the two parties. An unsatisfactory one yields strictly negative private benefits U_1 and U_2. Party 2 knows the probability $\theta \in [0, 1]$ of a satisfactory relationship. Party 1 has strictly positive prior density $f(\theta)$ on this probability.

Suppose now that a contract can make an unsatisfactory relationship less disastrous and yields new strictly negative private benefits $\tilde{U}_1 \geq U_1$ and $\tilde{U}_2 > U_2$, and that party 1 chooses whether to have a contract or no contract (or, possibly, a contract with probability x). Assume further that party 2 is more eager to enter the relationship in that $S_2/S_1 > \max(U_2/U_1, \tilde{U}_2/\tilde{U}_1)$. Then, one can show that if $\tilde{U}_2 - U_2$ is sufficiently large relative to $\tilde{U}_1 - U_1$, party 1 chooses not to write a contract even though a contract ex post raises the utility of both contracting parties: Suppose that party 1 offers to write a contract with probability x if party 2 decides to engage in the relationship. Let $\hat{\theta}(x)$ be the minimum probability of success so that given x, party 2 would want to enter the relationship. That is, $\hat{\theta}(x)$ is defined by

$$\hat{\theta}(x)S_2 + [1 - \hat{\theta}(x)][x\tilde{U}_2 + (1-x)U_2] = 0.$$

The maximization of

$$\int_{\hat{\theta}(x)}^{1} [\theta S_1 + (1-\theta)[x\tilde{U}_1 + (1-x)U_1]]f(\theta)d\theta$$

yields corner solution $x = 0$.

Of course asymmetric information need not always "simplify" contracts. For one thing, contracts may optimally include an announcement of one's type after contracting, which would not occur if this type were commonly known.[28] More interestingly, the desire to signal or screen may lead parties to contract on variables that would not be contracted upon under symmetric information. For example, the parties may proceed to a wasteful state verification if a state contingent contract improves screening possibilities. Or in a Spencian model in which training is chosen after a labor contract is signed, the wage will be picked contingent on the level of training while no training would even occur if it did not improve productivity and information were symmetric at the contracting stage.

Venturing into unknown territory, let me conclude this discussion of asymmetric information by arguing that there may be an interesting interaction between "unforeseen contingencies" and asymmetric information. There is a serious issue as to how parties form probability distributions over payoffs when they cannot even conceptualize the contingencies and actions that yield those payoffs, and as to how they end up having common beliefs ex ante. When we make decisions in a situation that we perceive as one of unforeseen contingencies, for example when we undertake a challenging research program, we probably proceed by analogies with better known, past situations and combine them with some specificities of the current situation to reach some assessment of the expected return and riskiness. If this turns out to be the way we form expectations about future payoffs when we do not foresee the contingencies, we should have some doubts about the validity of the common assumption that the parties to a contract have symmetric information when they sign the contract; for, they will in general have different points of comparison; and, for a given analogy, they might have different views on how far one can push this analogy and to transpose past experience. Asymmetric information should therefore be the rule in such circumstances, and would be unlikely to disappear through bargaining and communication (except perhaps in situations in which parties have congruent interests).

4.2. *From Agency Models to Decision Processes*

Classical contract theory has been widely criticized for its failure to account for the existence of decision rights. This section argues that there is in this respect more in classical contract theory than meets the eye.

4.2.1. *Classical contract theory and decision rights*

Classical contract theory has devoted much attention to discretionary behavior under the headings of "hidden knowledge" and "moral hazard."

[28] See Maskin–Tirole (1992) for more details.

Hidden knowledge refers to private information $\theta \in \Theta$ received by a contracting party after the contract has been signed. Optimal complete contracts account for hidden knowledge by allowing the party who receives private information to select a decision (e.g., an output and a transfer) in a prespecified menu X of such decisions. We are not far from Simon's definition of authority (see the introduction), although the motivation is certainly different. Here the power to decide is linked with informational superiority.

Moral hazard refers to actions that are chosen by one party and unobserved by the others.[29] As in the case of hidden knowledge, the informed party makes a decision within some set A. This set of hidden actions or efforts is usually exogenously given in moral hazard problems, while the set A in the hidden knowledge case, namely the set of functions from Θ into X, is part of the mechanism design through the choice of X.

Are the hidden knowledge and moral hazard paradigms part of a proper theory of authority? Yes and no. They do satisfy Simon's definition of authority. Yet, the two paradigms do not quite fit the spirit of Simon's or Coase's contributions. In particular, the notion of hierarchy is absent. They are "principal-agent" paradigms in which the agent has authority! Why does our common sense tell us to resist the logical implication of agency models, namely that agents are the decision makers and therefore can be viewed as "bosses"? Why should one say that the agent has "discretion" rather than "authority"?

This tension may be addressed in two ways. The first consists in realizing that there is not one concept of authority, but two: *formal and real authorities*. Formal authority refers to the authority relationship one would want to prevail. For example, in the hidden knowledge and moral hazard paradigms, it is in general optimal for the principal to reduce the agent's discretion as much as possible; that is, any possibility that the principal would have to shrink the agent's decision set A would be welcome. Real authority refers to who actually gets her way.

Agency models of hidden knowledge and moral hazard are models of real authority without any (interesting) allocation of formal authority. Conversely, control rights models are models of formal authority which do not address the real authority concerns of these two agency paradigms. The next section brings together the agency models and control right models à la Grossman–Hart–Moore.

An alternative approach to addressing this tension is to consider *double moral hazard* (or multiple moral hazard with more than two parties). Both the principal and the agent then have (hidden knowledge or moral hazard) discretion in their

[29] The importance of unobservability is stressed in Hermalin–Katz (1991). They show that in the standard moral hazard model the first best (verifiable effort) outcome can be obtained if the principal observes the agent's effort before output or profit is realized, a result well in line with the Nash implementation literature reviewed in Section 3.1. Edlin–Hermalin (1997) analyzes a buyer-seller situation with specific investment by the seller under the possibility of ex post contractual renegotiation. That paper provides conditions under which option contracts can achieve the first best.

own "sphere of competence" or "sphere of influence." Double moral hazard in general only partially solves the tension as it does not obviously define a hierarchy. But there are instances in which there may be a natural hierarchical interpretation. Take the model of debt and equity in Dewatripont–Tirole (1994).[30] This model was developed following Aghion and Bolton (1992)'s insight that a firm's financial structure design is about allocating (contingent) control rights to the firm's outsiders. The idea of the debt-equity paper is the following: (i) Proper incentives require that the firm's insiders face the prospect of tough action (intervention) by outsiders if performance is poor, and soft action (passivity) in case of good performance; (ii) if the soft/tough action cannot be contracted upon say because it is indescribable, a control right must be given to outsiders to implement the action. Outsiders must then be themselves given proper incentives in the form of return streams. Hence the "double moral hazard" terminology. Control rights are then correlated with return streams. Further, if "intervention" consists in reducing risk, debt, with its conservative bias, is given control in bad times, and equity, which is less obsessed with risk reduction, receives control in good times.

The "cannot be contracted upon" suggests an incomplete contract model. But it can be given an equally valid complete contract interpretation that does not imperil economic insights. The outsiders' decision might simply be subject to moral hazard or hidden knowledge. A mixed moral-hazard hidden-knowledge view is particularly apt in this context. Suppose that the set of possible tough actions X (divest a division, reduce labor costs, strengthen audits, ...) is known, but that the environment $\theta \in \Theta$ that conditions the optimal action by outsiders is not. Then one can empower an outsider with the right to pick an action in X, trusting that he will acquire information θ, at least if information acquisition is not too costly.

4.2.2. *Authority*

This section makes two points. First, incomplete contract modeling is not needed to approach standard concepts of authority, such as Max Weber's notions of rational and collegial authorities. Second, authority relationships are extreme cases of more general decision processes that may attempt to provide the appropriate checks and balances to a single-handed exercise of control rights.

To show this, let us use a variant[31] of the Aghion–Tirole (1997) model of formal vs. real authority (and emphasize quite different themes.) Consider an organization composed of a principal and an agent. The organization can

[30] Whether one wants to view this outsiders/insiders model as one of a hierarchy is perhaps semantic, and certainly depends on the exact meaning one wants to give to "hierarchy."

[31] There are some modeling differences with the (1997) paper: (1) I develop the complete contracting version while it is only mentioned in the paper, which is couched in terms of incomplete contracting. (2) I allow the status quo utilities to differ from 0. (3) Each party learns only his own payoffs, while he learns both parties' payoffs in the paper. This last change has no impact, but shortens the exposition.

implement a status quo project 0 that yields known profit $B_0 \geq 0$ together with a private benefit $b_0 \geq 0$ to the agent. This status quo may be interpreted either as "doing nothing" (the parties decide not to interact, in which case $B_0 = b_0 = 0$ is a natural assumption), or as "pursuing current policy" or "renewing last year's budget," that is, as the absence of policy innovation. The agent's private benefit can be thought of as a perk or as (minus) the disutility attached to implementing the project. The agent screens among n alternative projects $k = 1, \dots, n$. Project k yields verifiable profit B_k together with private benefit b_k to the agent. While these profits and private benefits differ among projects, alternative projects all look ex ante identical. The principal and the agent only know that there are two possibilities: With probability α, one of the projects yields profit $B > B_0$ and private benefit $b > b_0$ and the others yield large negative profit and private benefit (this is just to ensure that an alternative project will not be drawn at random). Preferences are then "congruent." With probability $1 - \alpha$, one project yields profit $B > B_0$ and private benefit 0, while a second project yields profit 0 and private benefit $b > b_0$, and all other alternative projects yield large negative profit and private benefit. Preferences are then dissonant.

For simplicity (this is not crucial), let us assume that the agent is very risk averse and therefore does not respond to monetary incentives. He then receives a constant wage, normalized at zero, and the principal receives the profit. The agent has reservation utility 0, say.

There is moral hazard on the agent's side. The agent incurs (unobserved) disutility of effort $g_A(e)$, discovers with probability e which project is best for him, and learns nothing with probability $1 - e$. The principal discovers her preferred project with exogenous probability E and learns nothing with probability $1 - E$.[32] (Alternatively, one could assume that the parties learn all payoffs: see our (1997) paper.) A complete contract must then consider four possibilities:

- Both parties are informed (probability eE): each recommends his preferred project. With probability α, these projects are the same and the project is implemented.[33] With probabilities $1 - \alpha$, preferences are dissonant. The principal's and the agent's preferred projects are implemented with probabilities x_P and x_A. The status quo is implemented with probability $x_0 = 1 - x_P - x_A$.
- Only the agent is informed (probability $e(1 - E)$): the agent's preferred project is implemented with probability y_A and the status quo prevails with probability $y_0 = 1 - y_A$.
- Only the principal is informed (probability $E(1 - e)$): the principal's preferred project is implemented with probability z_P and the status quo prevails with probability $z_0 = 1 - z_P$.

[32] Part of our (1997) paper as well as its application to corporate growth in Aghion–Tirole (1995) and the papers by Burkart–Gromb–Panunzi (1997) on corporate finance and monitoring and by de Bijl (1994a,b) on strategic delegation are preoccupied by the impact of various organizational factors on E. There is no point endogenizing E for the purpose of this section.

[33] We could allow implementation with some probability between 0 and 1, but it is obvious that it is optimal to implement it with probability 1 (as this improves both efficiency and the agent's incentive to collect information).

• No one is informed (probability $(1-e)(1-E)$): the status quo is implemented with probability 1.

A contract is thus defined by the vector $\{x_A, x_P, y_A, z_P\}$. In a first step, we proceed as if a court could verify which of these four information structures prevails. The discussion of the implementation of the corresponding optimum will make it clear that this verifiability assumption is not needed and therefore is a purely technical device. We will define an optimal contract as one that maximizes the principal's expected profit subject to the agent's incentive constraint (the agent's individual rationality constraint is automatically satisfied here). We can then wonder whether the optimal contract can be implemented through some simple decision process. A decision process specifies how to reach a decision and does not require an ex ante explicit description of the alternative projects or states of nature. Here are a few examples of decision processes:

• *P- or A-authority*: The contract $\{x_P = 1, y_A, z_P = 1\}$ can be implemented by giving authority to the principal if *either* $y_A = 1$ and $\alpha B > B_0$ or $y_A = 0$ and $\alpha B < B_0$. That is, in the case in which only the agent is informed, the agent can get his way only if the principal's expected payoff exceeds the status quo payoff. Similarly, the contract $\{x_A = 1, y_A = 1, z_P\}$ can be implemented by giving authority to the agent if either $z_P = 1$ and $\alpha b > b_0$ or $z_P = 0$ and $\alpha b < b_0$.

• *Collegial authority*: Collegial authority requires that both parties agree to depart from the status quo in order for an alternative project to be implemented. It thus imposes a strong status quo bias. Collegial authority implements the contract $\{x_0 = 1, y_A, z_P\}$ where either $y_A = 1$ if $\alpha B > B_0$ or $y_A = 0$ if $\alpha B < B_0$, and either $z_P = 1$ if $\alpha b > b_0$ or $z_P = 0$ if $\alpha b < b_0$. Note that when both are informed and there is noncongruence, any alternative project is vetoed by one party and therefore only contracts with $x_A = x_P = 0$ can be implemented by collegial authority.

A related institution is *veto collegiality*.[34] Under veto collegiality, one party has authority, except that the other party has the right to impose the status quo if he does not like the other party's choice. This institution is actually very common when $B_0 \geq b_0 = 0$: An employee in general has the right to quit if he does not like the employer's decisions. One can then talk about an *exit right* for the subordinate. In the environment considered here, veto collegiality and collegial authority coincide.[35]

[34] Max Weber (1968, p. 272) defines veto collegiality as follows: "Alongside the monocratic holders of governing powers, there are other monocratic authorities which, by tradition or legislation, are in a position to delay or to veto acts of the first authority." An example of veto collegiality is the closed rule institution in Congress, under which the floor chooses between the status quo and the committee's proposal.

[35] The two need not coincide in general. Suppose for instance that the agent is not infinitely risk averse and that the parties can transfer money; and that both parties are aware of the existence of two projects that they both prefer to the status quo but on which they have conflicting preferences. Collegial authority will in general give rise to some bargaining, in which one party pays some money to the other in order to obtain his preferred project. By contrast, if the principal has authority and the agent veto power, the principal has agenda setting power and can obtain her preferred project without compensating the agent.

• *Authority with gatekeeping counterpower* (or partial veto): In this institution, one of the parties (the gatekeeper) defines the agenda, that is preselects a set of projects X in which the other party (the decision maker) then chooses the final project. The gatekeeper must select a superset X of a predetermined set $\overline{X}(X \supseteq \overline{X})$. If $\overline{X}$ is the set of all projects, then the decision maker has full authority. Conversely, if $\overline{X}$ is the empty set, the gatekeeper has full authority. In our environment, a natural and more interesting minimum choice set is $\overline{X} = \{1, \ldots, n\}$. In this example, the gatekeeper's only prerogative is to force the decision maker to depart from the status quo, giving the organization an innovation bias. Authority with gatekeeping counterpower for example can implement contract $\{x_A = 1, y_A = 1, z_P = 1\}$ even when $\alpha b < b_0$.

The *optimal complete contract* maximizes the principal's expected profit subject to the agent's marginal incentive being equal to some level:

$$\max_{\{x_A, x_P, y_A, z_P\}} \{eE[\alpha B + (1-\alpha)[x_P B + (1 - x_P - x_A)B_0]]$$
$$+ e(1-E)[y_A \alpha B + (1-y_A)B_0]$$
$$+ E(1-e)[z_P B + (1-z_P)B_0] + (1-E)(1-e)B_0\}$$

subject to

$$E[\alpha b + (1-\alpha)[x_A b + (1 - x_P - x_A)b_0]]$$
$$+ (1-E)[y_A b + (1-y_A)b_0] - E[z_P \alpha b + (1-z_P)b_0]$$
$$- (1-E)b_0 \geq g_A'(e) \quad (\mu)$$

and

$$x_A + x_P \leq 1 \quad (\lambda).$$

Letting L denote the Lagrangian and μ and λ the (nonnegative) shadow prices of the constraints and $\lambda' \equiv \lambda / E(1-\alpha)$, the derivatives of the Lagrangian with respect to the control variables are ("$\propto$" denotes "proportional to"):

$$\frac{\partial L}{\partial x_A} \propto -eB_0 + \mu(b - b_0) - \lambda',$$

$$\frac{\partial L}{\partial x_P} \propto e(B - B_0) - \mu b_0 - \lambda',$$

$$\frac{\partial L}{\partial y_A} \propto e[\alpha B - B_0] + \mu(b - b_0),$$

$$\frac{\partial L}{\partial z_P} \propto (1-e)(B - B_0) - \mu(\alpha b - b_0).$$

Let us first rule out a trivial case. If $\alpha B \leq B_0$, an uninformed principal does not want to follow the agent's recommendation. Intuitively, either the principal is uninformed and she prefers (in expectation) the status quo anyway, or she is informed and then she does not need the agent. An inspection at the first-order conditions shows that P-authority is then optimal (with $\mu = 0$). So let us assume that $\alpha B > B_0$ from now on. Then $y_A = 1$: That the principal when uninformed is willing to go along with the agent's recommendation is not only ex post efficient for the principal but also encourages the agent to acquire information.

For conciseness, we focus on the leading case in which $z_P = 1$. This case always obtains if $\alpha b < b_0$. Intuitively, letting the principal get her way when only she is informed raises the principal's payoff and also, if $\alpha b < b_0$, encourages the agent to acquire information. When $\alpha b > b_0$, it *may* be optimal for incentive purposes to commit not to implement the principal's preferred project when only the principal is informed, even though both parties would ex post prefer to go along with the principal's recommendation. Let us rule out this possibility by conveniently invoking renegotiation proofness, that is the possibility for the parties to undo, by mutual consent, their commitment and to follow the principal's suggestion, which makes them better off in expected terms.[36] Hence $z_P = 1$.

Given $y_A = z_P = 1$ (the informed party gets his way), we are left with only three possibilities (or possibly with randomizations over these three possibilities):

- $x_P = 1$: The optimal complete contract can then be implemented through *P-authority*.
- $x_A = 1$: The optimum can then be implemented by the following procedure: The principal is the gatekeeper and decides whether to rule out the status quo; that is $\overline{X} = \{1, \ldots, n\}$. The agent then picks a project in $\overline{X}$ if the status quo was ruled out and in $\overline{X} \cup \{0\}$ if the status quo was allowed by the principal. Clearly, $x_A = y_A = 1$. When only the principal is informed, the principal rules out the status quo (which is important if $\alpha b < b_0$) and can on the side suggest her preferred project to the agent. The optimum can then be implemented through *A-authority with P-gatekeeping counterpower*.
- $x_0 = 1$: The status quo is then chosen if both are informed and disagree while the informed party gets his way if the other is uninformed. A necessary condition for $x_0 = 1$ to be optimal is that gains from moving from the status quo are not too large: $(B - B_0)(b - b_0) < B_0 b_0$.[37] In particular, $x_0 = 1$ cannot be optimal if the status quo consists in "doing nothing" ($B_0 = b_0 = 0$).

Suppose first that $\alpha b > b_0$. Then the optimum can be implemented by *collegial authority*. Second, assume that $\alpha b < b_0$. Roughly, the agent can impose the status quo when he knows for sure that a policy innovation is bad for him ($x_0 = 1$), but cannot otherwise ($z_P = 1$). The optimum does not seem to be implementable through a simple institution in our context although it would in variants of the model. For example, with transferable utility one could allow the

[36] Renegotiation proofness needs to be involved only in the case $\alpha b > b_0$. On the other hand, it does not impact the rest of the analysis because the optimum otherwise specifies Pareto-efficient decisions.

[37] $x_0 > 0$ implies $\lambda = 0$ and $\delta L / \delta x_A \leq 0$, $\delta L / \delta x_P \leq 0$.

agent to exit after posting a hostage, so that the agent would exit only when he is substantially hurt by the principal's decision.

To sum up, this complete contract model predicts either an authority relationship or a more balanced decision process. The choice among decision processes reflects in an intuitive way the congruence of preferences, and the determinants of incentives. To be certain, our framework is a simple one, and one might wonder whether its insights carry over to more complex situations, for instance to the case of monetary incentives. We would argue that its insights are robust. The agent's responsiveness to money would alter incentives,[38] but would not change the basic point. Organizations must take decisions about which their members are unlikely to systematically agree. Decision processes must therefore be designed that trade off the objectives of the organization and the incentives of its members. The need for such a design is conceptually distinct from the debate between incomplete and complete contracting.

4.3. *Alternative Approaches and Concluding Remarks*

This lecture had two purposes. First, it tried to provide a simple, nonexhaustive account of the state of the incomplete contract literature. Second, and its main object, it analyzed the incomplete contract methodology. It made two main observations:

(1) Incomplete contract models presume that parties to a contract use dynamic programming to analyze the consequences of contract forms and post-contractual decisions. Under this rationality postulate, the indescribability of contingencies does not affect the payoffs that can be obtained through contracting by the parties under the assumptions often made in the incomplete contracting literature. In contrast, the indescribability of contingencies is costly when these contingencies are ex post observable by the enforcement agencies, and the parties would like to specify different payoffs in a payoff-equivalent state of nature in order to provide insurance or boost incentives. The impact of indescribability is then akin to a garbling in the measurement information structure.

(2) Complete contract theory has long been criticized for its failure to account for standard institutions such as authority or property rights. I argued that incomplete contracting is not a compulsory ingredient of a theory of these institutions. In some contexts complete contracts can deliver in a natural way standard decision processes, including the allocation of control rights to one party and collegial decision processes, as well as reasonable comparative statics. Parties to a contract anticipate that they will hold different views on what course their relationship should follow; they therefore must define a decision process that determines whose viewpoint (or an alternative course of action) will prevail. This idea is conceptually distinct from that of incomplete contracting.

[38] See Aghion–Tirole (1997) for the introduction of monetary incentives in a different context.

A few comments on these observations are in order. Concerning the first, the irrelevance of describability of contingencies and actions may be more a challenge to modeling than a descriptive phenomenon. It may point more at a methodological difficulty in approaching incomplete contracts than at a belief that describability cannot improve matters even under the conditions of the irrelevance theorem.

Concerning the second observation, I do not regard existing complete contract theory as the panacea; my belief, though, is that it has been dismissed too quickly as being unable to account for some standard institutions, and that we should candidly compare its methodology and insights with those of alternative approaches. Simple decision processes such as authority relationships and collegial decision making were shown to implement optimal complete contracts only in highly stylized models. It is likely that the implementation of optimal contracts will become more complex as we consider less structured examples. But I do not find this worrisome.[39]

What's next? It would be presumptuous for me to try to delineate the research agenda. At most can I offer a few unstructured personal views on it:

(3) I am not opposed to a versatile approach. For all the questions raised by incomplete contract modeling, this modeling has been very useful in organizing thoughts about economic issues.[40]

(4) While existing complete contract theory can in some situations capture the heart of the matter, oftentimes it will not. It goes without saying that breakthroughs in the modeling of transaction costs and bounded rationality are eagerly awaited.[41]

For example, many have argued that contingencies are missing because of substantial costs of writing them. While there is no arguing that writing down detailed contracts is very costly, we have no good paradigm in which to apprehend such costs. Assumptions such as introducing a fixed cost per contin-

[39] Perhaps an analogy might be useful in explaining my point of view. A long-standing complaint about principal-agent models is that optimal incentive schemes derived from theory can be much more complex than those observed in reality. Simple contracts such as incentive schemes that are linear in performance are optimal only in extreme, nongeneric circumstances. Yet the fact that simple contracts are optimal in some circumstances suggests that actual contracts are not necessarily far off the mark; and importantly it provides handy environments in which the paradigm can be used to generate new insights. (While I am no good judge of the usefulness of optimal linear contracts in an adverse selection context (see Laffont–Tirole (1993)), I find Holmström and Milgrom (1987)'s model of optimal linear contracts under moral hazard a very useful tool for thinking about a range of agency issues (as evidenced by their subsequent works)).

[40] As a matter of fact, while my coauthors and I have sometimes obtained complete contract foundations (in Aghion–Tirole (1994, 1997), Dewatripont–Tirole (1994, 1999), and Laffont–Tirole (1993, Ch. 16)), the research and intuitions were developed in an incomplete contracting framework.

[41] Recent developments on the relaxation of the Savage axioms for an individual decision maker trying to capture "unforeseen contingencies" (e.g., Ghirardato (1994), Kreps (1992), Modica–Rustichini (1993), Pacheco–Pires (1994)) are clearly welcome. More work remains to be done to derive an operational model of bounded rationality that can be used to model the themes of this paper.

gency (Dye (1985)) are often criticized as ad hoc.[42] It is clear that case studies would be very useful both to build proper modeling tools and to assess the significance of writing costs.

Similarly, researchers (e.g. Moore (1992)) have worried about the complexity and robustness of optimal complete contracts. Complexity matters because contracts are played by real players, who must not be daunted by hard-to-grasp equilibrium strategies. Unfortunately, too little effort has been exerted by critics of complete contracts to prove that optimal contracts are complex—in some yet to be defined sense—[43] and by their proponents to demonstrate that optimal allocations can be implemented, at least approximately, by combinations of simple mechanisms such as auctions and authority relationships. Robustness to the players' mistakes or to misspecifications is very important, but again our understanding of how to model robustness is very limited.

In this regard, I would expect institutions such as authority, property rights, and patents to be popular not only for the incentive considerations developed in this and other papers, but also because they have good robustness and learning properties.[44] By robustness, I mean that these simple contracting forms are likely not to be very suboptimal when the parties make mistakes in their view of the world (this of course requires a theory of bounded rationality) or in the execution of the contract. By good learning properties, I have in mind that these institutions are *universal*, that is, are not context-dependent. This implies, first, that parties can learn how to behave under such institutions even if they have observed behavior only in different contexts; and, second, that their efficiency can be learned by transposition from one environment to another. I do hope that more fundamental research will be undertaken along these and other lines, that will put the insights derived in incomplete contracting approaches on firmer ground.

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Manuscript received Novermber, 1994; final revision received January, 1999.

APPENDIX 1: INDESCRIBABLE CONTINGENCIES AND RENEGOTIATION IN THE R&D GAME

Let us assume that the parties can sign a public contract (that is, file the contract with an arbitrator or a court, which obligates them to play the mechanism they construct), but cannot commit not to register another contract with another court. Let us obtain an upper bound on what contracts can achieve when renegotiation is feasible. To this purpose we stack the deck in favor of

[42] For example, a constant real wage clause would have an infinite cost under this assumption (Hart–Holmström (1987)).

[43] An exception to this neglect is the paper by Anderlini and Felli (1994), which puts a bound on the complexity of a (complete) contract by requiring that the mapping between states and outcome be computable through an algorithm using a finite number of steps. See also MacLeod (1994) for a discussion of complexity issues.

[44] I am grateful to Eric Maskin for discussions on this topic.

what contracts can achieve by looking at a hypothetical situation in which the potential innovations are describable:

Gedankenexperiment (*describable innovations and unknown payoffs framework*): "There are $n \geq 1$ possible date-2 techniques, all of which can be described ex ante. What is unknown is their payoff to the principal in the case of innovation: only one yields V and the others yield 0. So, which technique, if any, is useful is yet unknown. The techniques are ex ante indistinguishable and therefore have probability $1/n$ each of being the relevant one if a discovering is made. The two parties learn which technique is useful after discovery."

Clearly the unknown payoff framework presumes too much knowledge (the potential innovations can be described) in the R&D context. However, as we mentioned, it provides a useful benchmark because it yields an upper bound on what can be achieved under indescribable innovations. We make two further assumptions:

Renegotiation: The timing is as follows: (i) P and A write a contract specifying ex post message spaces M_A and M_P and the outcome (technique transferred, monetary transfer) as a function of the messages, (ii) A exerts some effort e, (iii) the state of nature (whether there is an innovation and its name) is realized, (iv) A and P send messages $m_A \in M_A$ and $m_P \in M_P$, (v) the contract is implemented, (vi) the two parties can further contract if they wish so (in which case the gains from this second contract are split).

Limited liability: To keep things tractable, let us assume that both parties are infinitely risk averse under 0 utils and risk neutral beyond 0 utils.[45] Let us call this assumption "limited liability."

Let (a_0, b_0) denote the agent's and the principal's expected utilities in the absence of innovation (state 0) and (a_1, b_1) their expected utilities in case of an innovation (state 1). Let (α_0, β_0) denote the agent's and the principal's equilibrium message strategies in the absence of innovation, and (α_1, β_1) denote these strategies in case of an innovation. Let us consider a symmetric mechanism, so that equilibrium outcomes are the same regardless of the nature of the innovation, and one can choose (α_1, β_1) to be the same, up to the relabelling of goods, for all innovations. (The reader will check that one actually cannot improve on a symmetric mechanism.)

Assume in a first step there is no third party. Let $y(\alpha, \beta)$ denote the expected transfer from the principal to the agent for message strategies (α, β). The key result is the following lemma.

LEMMA: $b_1 \geq b_0 + \dfrac{V}{2}$.

PROOF: Incentive compatibility for the principal in state 1 (innovation) requires that

$$b_1 \geq -y(\alpha_1, \beta_0) + \frac{V}{2}.$$

(When messages are (α_1, β_0), either the useful innovation is transferred and the principal receives gross surplus V, or it is not and the principal gets $V/2$ through renegotiation.)

Incentive compatibility for the agent in state 0 (no innovation) yields

$$y(\alpha_0, \beta_0) \geq y(\alpha_1, \beta_0).$$

Hence,

$$b_1 \geq -y(\alpha_0, \beta_0) + \frac{V}{2} = b_0 + \frac{V}{2}. \qquad Q.E.D.$$

[45] That is, $u_A = y_A$ if $y_A \geq 0$, $u_A = -\infty$ if $y_A < 0$, and $u_P = y_P + xV$ if $y_P + xV \geq 0$, $u_P = -\infty$ if $y_P + xV < 0$, where y_A and y_P are the two parties' incomes from their relationship, and $x = 1$ if P receives a useful innovation and $x = 0$ otherwise.

Last, because $a_0 \geq 0$ and $a_0 + b_0 = 0$, $a_0 = b_0 = 0$ and because $a_1 + b_1 \leq V$,

$$a_1 - a_0 \leq \frac{V}{2}.$$

One cannot give the agent a stake in discovery exceeding $V/2$.

With a third party who has no information other than the ex ante information and simply acts as a sink or source, let c_0 and c_1 denote the expected income of the third party in states 0 and 1. Because $a_0 \geq 0, b_0 \geq 0, c_0 = -a_0 - b_0 \leq 0$. The third party's ex ante participation constraint requires $c_1 \geq 0$. Because the lemma still holds, we have

$$a_1 - a_0 \leq \frac{V}{2} - c_1 \leq \frac{V}{2}.$$

REMARK: We assumed that blueprints that are useful and yet not transferred to the principal remain the property of the agent. The lemma would still hold if the blueprints were given to a third party, as long as the principal (who, recall, is indispensable) can purchase the blueprints from the third party at price $V/2$. As long as renegotiation is feasible, the only way to deprive the principal from the possibility of acquiring the innovation later on is to destroy the blueprints and make sure they will not be recreated, which in general is not a reasonable assumption.

APPENDIX 2: AN ILLUSTRATION OF THE IRRELEVANCE THEOREM

To illustrate the discussion in 3.1 and 3.2 as well as the irrelevance result, let us introduce a framework which, although quite special, encompasses many existing incomplete contract models. This framework has the two-party, three-stage structure of the R&D game.

At date 1, each party $i \in \{1,2\}$ sinks some unverifiable investment or effort e_i and incurs disutility of effort $g_i(e_i)$. At the beginning of date 2, the state of nature ω is realized, which together with the effort vector $e = (e_1, e_2)$ determines the date-2 von Neumann–Morgenstern preferences through the parties' "ex post types" $\theta = (\theta_1, \theta_2)$:[46]

$$\theta_i = \Phi_i(e, \omega).$$

Party i's *gross surplus* $S_i(\theta_i, x)$ depends on party i's type and on a date-2 action x (e.g., a vector of trade attributes) in a fixed set of physical actions X. Letting y_i denote party i's income, his net surplus is $y_i + S_i(\theta_i, x)$. Party i's preferences are thus given by

$$u_i(y_i, e, \omega, x) = y_i + S_i(\theta_i, x) - g_i(e_i).$$

This framework includes the R&D game, in which only party 1, the research unit, exerts effort ($e_2 = 0$) and only party 2, the user, enjoys a gross surplus ($S_1 = 0$). Note also that assumption (a) is trivially satisfied because of risk neutrality. In contrast, assumption (b) need not be satisfied, since for given θ that is for given date-2 VNM preferences, the knowledge of ω conveys information about e. On the other hand, only the payoff-relevant information, namely the types, can be elicited at date 2, and so date-2 payoffs can depend only on θ unless ω is describable and verifiable.

• *Describable contingencies*: The symmetric information implementation literature makes the following assumptions:

– *No transaction cost*: all variables (e, ω, θ, x) are conceptualized and describable ex ante at no cost in a contract.

– *Ex post symmetric information about VNM preferences*: θ is commonly observed by the two parties (but not by a court) at stage 2. (It does not matter whether ω and e are commonly observed.)

– *Verifiability*: The court (or arbitrator) observes/verifies the decision x, transfers between the parties, and, of course, any messages (m_1, m_2) sent by the two parties at date 2 concerning e, ω, θ or even "irrelevant" variables such as the weather, ...

[46] We here keep e and ω separate. As we noted, e could be included in ω.

– *Enforceability*: The court enforces contracts that are consistent with its information structure just described.

A contract thus defines message spaces M_1 and M_2 for the two parties. At date 2, the two parties observe both VNM preferences, and then send messages $m_i \in M_i$ to the court, which enforces a decision $x(m_1, m_2)$ and transfers $y_i(m_1, m_2)$.

In this framework, we can be more specific about the extent to which "observability but nonverifiability" may be an oxymoron to a complete contract theorist. As long as θ is indeed payoff-relevant, it can be elicited at no cost; *everything is as if the court observed* θ *and* x, *and not only* x. The intuition is that a contract can ask the parties to announce preferences[47] at date 2 and to give them incentives to challenge each other in case of misrepresentation. In contrast, the court cannot elicit at date 2 in a unique way additional and commonly held information about ω and e; for, these variables no longer affect date-2 VNM preferences (on transfers and decision) and therefore have no impact on the set of outcomes of any game.

To each θ is associated a set $F(\theta)$ of date-2 feasible gross surpluses (S_1, S_2):

$$F(\theta) \equiv \{(S_1, S_2) \mid \text{there exists } x \text{ in } X \text{ such that } S_i = S_i(\theta_i, x),\ i = 1, 2\}.$$

We assume that conversely each F corresponds to a single θ, that F is convex, and that for each F, there exists a unique efficient point (that is, maximizing $S_1 + S_2$ over F).

For simplicity, we assume that the optimal complete contract is ex post efficient. That is, it implements ex post efficient gross surpluses $S^*(F) = \{S_1^*(F), S_2^*(F)\}$ for each F on the equilibrium path. Let $y^*(F) = \{y_1^*(F), y_2^*(F)\}$ denote the transfers to be implemented.

- *Indescribable contingencies*: Suppose that at date 0, the state of nature ω, the action x, and the types θ, are not describable by the parties. On the other hand, the parties can contract on a "no trade" action $x = \phi$ that yields both parties gross surplus 0 in any state of nature. Here is what is commonly known at date 0 and therefore can be exploited in a contract:

– *Rationality*: For each party, to each vector of investments is associated a subjective probability distribution over the (bounded) sets F of date-2 feasible gross surpluses for both parties.

– *Ex ante symmetric information*: The two parties' subjective conditional probability distributions over the sets of date-2 feasible gross surpluses F coincide and are common knowledge.

– *Ex post symmetric information*: It is common knowledge at date 0 that at date 2, information about θ (that is, about VNM preferences) and about X (the set of feasible decisions) will be symmetric and that both parties will be able to contract at date 2 on any decision $x \in X$.

Let us show that the describable-contingencies $S^*(F)$ and $y^*(F)$, and therefore the associated payoffs can still be implemented when contingencies are indescribable. Consider the following mechanism, played at date 2, and inspired by the subgame-perfect implementation literature (see Moore–Repullo (1988), and Moore (1992) for an overview):

STAGE 1: Party 2 describes an action x and a feasible set $\hat{F}$ in the support of feasible sets. Let $\hat{S} = (\hat{S}_1, \hat{S}_2) = (S_1^*(\hat{F}), S_2^*(\hat{F}))$ denote the implied announcements of efficient gross surpluses. Transfers $y^*(\hat{S})$ are made (these are "base transfers" that are made no matter what happens in the rest of the game).

[47] In specific environments, symmetric information implementation does not require an explicit elicitation of the commonly observed state of nature. Aghion–Dewatripont–Rey (1994) considers a buyer-seller relationship in which the good to be traded can be contracted upon but the state of nature defining the ex post cost and benefit from trading is not. By specifying some noncontingent status quo level of trade and by allowing renegotiation and constraining the renegotiation through a judicious choice of penalties, they show that at least under risk neutrality, the first-best state-contingent outcome and investments can be implemented. (Chung (1991) obtains a similar result by assuming the distribution of the bargaining power in the renegotiation game. See also the further results contained in Edlin-Reichelstein (1996), Lülfesman (1995), MacLeod–Malcomson (1993), and Nöldeke–Schmidt (1995, 1996, 1997).)

STAGE 2: Party 1 either accepts x (the game is over) or challenges party 2 in one of three ways:

Challenge A_1: Party 1 chooses a $y_2^{\#} \neq \hat{S}_2$ and gives party 2 the choice between x and {$\varnothing$ (no trade), party 2 receives $y_2^{\#}$ in cash}.

Challenge B: Party 1 chooses $y_1^{\#} < \hat{S}_1$ and asks for {$\varnothing$ (no trade), party 1 receives $y_1^{\#}$ in cash}. Party 1's demand is satisfied and the game is over.

Challenge C: Party 1 makes a counteroffer, consisting of an action $\tilde{x}$, a transfer $\tilde{y}_{12} > 0$ from 1 to 2, and an announcement of some gross surpluses $(\tilde{S}_1, \tilde{S}_2) \notin \hat{F}$.

STAGE 3: In case of challenge A_1, party 2 can either choose to receive cash $y_2^{\#}$ and not trading (the challenge is then successful if and only if $y_2^{\#} < \hat{S}_2$) or to stick to x with no new transfer (the challenge is then successful if and only if $y_2^{\#} > \hat{S}_2$). In case of challenge C, party 2 chooses among: (i) accepting $\tilde{x}$ and transfer $\tilde{y}_{12}$; (ii) not trading and receiving in cash $\tilde{y}_2 < \tilde{S}_2 + \tilde{y}_{12}$ for some $\tilde{y}_2$ of his choice; and (iii) challenge party 1 with a challenge A_2, consisting in offering {$\varnothing$ (no trade), $\tilde{y}_1 < \tilde{S}_1$ in cash to party 1} for a $\tilde{y}_1$ of party 2's choice. Challenge C is unsuccessful if either (ii) or (iii) is picked.

STAGE 4: In case of challenge A_2, party 1 chooses between receiving cash $\tilde{y}_1$ and not trading (the challenge is successful) and sticking to $\tilde{x}$ with no new transfer (the challenge is unsuccessful).

A challenged party pays a large sum of money K no matter whether the challenge is successful or not. This fine is paid to a charity (third party), unless a challenge A_1 or A_2 is successful, in which case the fine goes to the other party. A challenging party who is unsuccessful also pays a large fine to the charity."

To sum up, the final transfers are $y^*(\hat{S})$, plus $y_2^{\#}$ to party 2 if $y_2^{\#}$ is preferred to x in challenge $A_1, y_1^{\#}$ to party 1 if challenge B is made, $\tilde{y}_2$ to party 2 for challenge C option (ii), $\tilde{y}_1$ to party 1 if challenge A_2 is successful, $\tilde{y}_{12}$ from party 1 to party 2 if challenge C is successful, plus fines and rewards for challenging or being challenged as defined above.[48]

The large fine implies that no party ever wants to be challenged (successfully or not). Let $S = (S_1, S_2)$ denote the gross surpluses associated with party 2's stage 1 proposal x. The existence of challenge A_1 ensures that $\hat{S}_2 = S_2$; for, assume that party 2 underreports his gross surplus. Then party 1 can offer some $y_2^{\#} \in (\hat{S}_2, S_2)$ in cash, to which party 2 prefers x at stage 3. At stage 2, party 1 will always prefer using a successful challenge A_1 to accepting x. And similarly if party 2 overreports his gross surplus.

Next, challenge B guarantees that $\hat{S}_1 \leq S_1$. Indeed, if party 2 overreported party 1's gross surplus from x party 1 would prefer to take any $y_1^{\#} \in (S_1, \hat{S}_1)$ in cash rather than accept x.

Second, note that party 2 can guarantee himself $S_2^*(F)$ (where F is the true feasible set) by announcing at stage 1 the true F and a decision x that yields the ex post efficient point $(S_1^*(F), S_2^*(F))$. Hence, $\hat{S}_2 = S_2 \geq S_2^*(F)$ and $\hat{S}_1 \leq S_1 \leq S_1^*(F)$. If $S_1 < S_1^*(F)$, simple geometry shows that party 1 can find a successful challenge C that yields him a higher utility than S_1. We conclude that in equilibrium party 2 announces the true set F as well as an action x that yields gross surpluses $(S_1^*(F), S_2^*(F))$.

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[48] It does not matter whether the transfers $y_1^{\#}, y_2^{\#}, \tilde{y}_1, \tilde{y}_2$ are paid by the other party or by a third party.

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