contract theory

This article offers a brief overview of contract. It focuses on the theory of complete contracts and the three associated paradigms of adverse selection, moral hazard and non-verifiability. By showing difficulties in allocating resources between asymmetrically informed partners, contract theory has deeply changed our view of the functioning of organizations and markets.

As with so many major concepts in economics, contract theory was introduced by Adam Smith who, in his monumental *Wealth of Nations* (1776, book III, ch. 2), considered the relationship between peasants and farmers through this lens. For instance, he pointed out the perverse incentives provided by sharecropping contracts, widespread in 18th-century Europe. However, it is fair to say that the issues of incentives and contract theory were largely ignored by economists until the end of the 20th century. By then, the focus of economic theory was on the working of markets and price formation. Firms were viewed only as production technologies, and the issue of the separation between ownership and control was most often put aside. This black-box approach was, of course, quite unsatisfactory. At the turn of the 1970s, with the methodological revolution of game theory, more emphasis was placed on strategic interactions between a small number of players in a world where informational problems matter. From this new perspective, the allocation of resources is no longer ruled by the price system but by *contracts* between asymmetrically informed partners. Contract theory has deeply changed our view of the functioning of organizations and markets.

This article aims to provide a brief overview of contract theory, stressing a few major insights and illustrating them with useful applications. Due to space constraints, it does not do justice to several aspects of contract theory, and will mostly reflect my own tastes in the field. In particular, I focus on the so-called *theory of complete contracts*, leaving aside the burgeoning theory of incomplete contracts which is covered elsewhere in this dictionary. Successive sections deal respectively, with adverse selection, moral hazard and non-verifiability: the three different paradigms which have been used in the field of complete contract theory. Since the distinction between complete and incomplete contracts is easier to draw once these notions have already been explained, I will postpone such discussion to the end of the article.

Adverse selection

Consider the following buyer–seller relationship as the archetypical example of contractual relationship between a principal (the buyer) and his agent (the seller) who produces some good or service on his behalf. The mere delegation of this task to the agent gives the agent access to private information about the technology. This *adverse selection* environment is captured by assuming that a technological parameter θ is known only by the agent. It is drawn from a distribution in an exogenous type space Θ which is common knowledge. Neither the principal nor a court of law observes this parameter. Contracts cannot specify outputs and prices as a function of the realized state of nature.

The buyer enjoys a net benefit $S(\theta,q)-t$ when buying q units of output at a price t. The seller enjoys a profit $t-C(\theta,q)$ from producing that good. We will assume that these functions are concave in q. Notice that the state of nature θ might affect both the agent's and the principal's utility functions. This can, for instance, be the case if this parameter also determines the quality of the good to be traded.

Under complete information, efficiency requires that the buyer and the seller trade the first-best quantity $q^*(\theta)$ such that the buyer's marginal benefit from consumption equals the seller's marginal cost of production:

$$\frac{\partial S}{\partial q}(\theta,q^*(\theta))=\frac{\partial C}{\partial q}(\theta,q^*(\theta)). \tag{1}$$

Many mechanisms or institutions lead to this outcome. Both the price mechanism and a take-it-or-leave-it offer by one party to the other would achieve the same allocation, although with different distributions of the surplus between the traders. If the principal retains all bargaining power (for instance, because there is a competitive fringe of potential sellers), he could offer a forcing contract stipulating an output $q^*(\theta)$ and a transfer $t^*(\theta)$ which just covers the seller's cost. This forcing contract maximizes the buyer's net gains from trade and leaves the seller just indifferent between participating or not.

In what follows, we mostly focus on the case where the uninformed principal has full bargaining power in contracting. In this framework, the *contract* between the buyer and the seller does not only have the allocative and distributive roles it has under complete information. It also has the role of *communicating information* from the informed party to the uninformed party. This communication role suggests that the informed party should be given a choice among different options and that this choice should reveal information about the adverse selection parameter.

A first step in the analysis consists of describing the set of allocations which are feasible under asymmetric information. The basic tool for doing so is the revelation principle (see Gibbard, 1973; Green and Laffont, 1977; Dasgupta, Hammond and Maskin, 1979; and Myerson, 1979, among others), which states that there is no loss of generality in restricting the analysis to *revelation mechanisms* that are *direct*, that is, of the form $\{t(\hat{\theta}), q(\hat{\theta})\}_{\hat{\theta}\in\Theta}$ with $\hat{\theta}$ a message ('report') sent by the informed seller to the uninformed buyer, and *truthful*, that is, such that the agent finds it optimal to report his true type.

Therefore, incentive feasible contracts satisfy the following *incentive constraints*

$$t(\theta) - C(\theta, q(\theta)) \geq t(\hat{\theta}) - C(\theta, q(\hat{\theta})) \qquad \forall(\theta, \hat{\theta}) \in \Theta^2. \tag{2}$$

To be acceptable, a contract must also satisfy the seller's participation constraints

$$t(\theta) - C(\theta, q(\theta)) \geq 0 \qquad \forall\, \theta \in \Theta \tag{3}$$

which ensure that, irrespective of his type, the agent by contracting gets at least his reservation payoff (exogenously normalized to zero).

Once the set of incentive feasible allocations is described, the analysis may proceed further. Keeping in mind that the uninformed buyer designs his offer under asymmetric information, we might characterize an *optimal contract*. Such a contract maximizes the uninformed buyer's expected net surplus subject to the feasibility constraints (2) and (3).

Much of the theoretical literature developed over the 1980s and early 1990s has investigated the structure of the set of incentive feasible allocations and its consequences for optimal contracting. A key property is the so-called Spence–Mirrlees condition (see Spence, 1973; 1974; and Mirrlees, 1971) for early contributions which put forward that condition). This condition is satisfied when the slope of the agent's indifference curves can be ranked with respect to his type. In our example, this condition holds when $\frac{\partial^2 C}{\partial\theta\partial q} > 0$, that is, when higher types also have higher marginal costs and should thus produce less. Therefore, the monotonicity condition

$$q(\theta) \geq q(\theta') \quad \text{for } \theta < \theta' \tag{4}$$

is a direct consequence of the incentive constraints. The Spence–Mirrlees condition can be viewed as a regularity assumption making the incentive problem well-behaved. It ensures that only incentive constraints between 'nearby' types matter in the optimization. Intuitively, this means that the seller with a given marginal cost may be tempted to overstate slightly its costs, receiving the higher transfer targeted to less efficient types but producing at a lower marginal cost. By so doing, this more efficient type receives an information rent. Once these local constraints are taken into account and when the Spence–Mirrlees condition holds, the incentives to mimic more distant types are no longer relevant. With this reduction of the set of relevant incentive constraints, the principal's optimization problem is significantly simplified.

The result of this optimization is straightforward. Inducing information revelation by the most efficient types requires giving up *an information rent* to those types. The basic intuition of most adverse-selection models is that reducing this rent requires production to be distorted. For instance, when efficient types want to mimic less efficient ones, the latter's allocation should be made less attractive. This is obtained by distorting their production downward and modifying transfers accordingly.

To see more formally the nature of the output distortion, consider the case where types are distributed over a compact set $[\underline{\theta},\overline{\theta}]$ according to the cumulative distribution function $F(\cdot)$ (with a positive density $f(\cdot)$). The second-best optimal output $q^{SB}(\theta)$ under adverse selection is the solution to:

$$\frac{\partial S}{\partial q}(\theta,q^{SB}(\theta))=\frac{\partial C}{\partial q}(\theta,q^{SB}(\theta))+\frac{F(\theta)}{f(\theta)}\frac{\partial^2 C}{\partial q\partial\theta}(\theta,q^{SB}(\theta)). \qquad (5)$$

Condition (5) states that, for any type θ, the buyer's marginal benefit must equal the seller's *marginal virtual cost* (see Laffont and Martimort, 2002, chs 2 and 3, for details). The virtual cost of a given type takes into account not only its cost of production but also the cost of deterring other types (here more efficient types) from mimicking that type. The allocation is no longer efficient, as under complete information, but *interim efficient* in the sense of Holmström and Myerson (1983).

Condition (5) is crucial, and is found in various forms in any adverse-selection model. It states that, under asymmetric information, there is a fundamental trade-off between implementing allocations close to efficiency and giving information rents to the most efficient types to induce information revelation. This trade-off calls for distortions away from efficiency.

Provided that the output schedule defined by (5) satisfies the monotonicity condition (4), this is the exact solution of our problem. To guarantee monotonicity, on top of assumptions on the concavity of $S(\cdot)$ and $\frac{\partial S}{\partial \theta}(\cdot)$, convexity of $C(\cdot)$ and $\frac{\partial C}{\partial \theta}(\cdot)$, $\frac{\partial^2 C}{\partial \theta \partial q}(\cdot) > 0$, $\frac{\partial^3 C}{\partial \theta^2 \partial q}(\cdot) > 0$ and $\frac{\partial^2 S}{\partial \theta \partial q}(\cdot) < 0$, one needs also to impose a property on the type distribution, the so-called *monotonicity of the hazard rate* $\frac{F(\theta)}{f(\theta)}$ (see Bagnoli and Bergstrom, 2005). Otherwise, the optimal contract may entail some area of pooling such that all types belonging to a set with positive measure produce the same amount and are paid the same price. The optimal solution may then be obtained using ‘ironing techniques’ (see for instance Guesnerie and Laffont, 1984).

Direct extensions

Adverse-selection methodology has been successfully extended in various directions allowing for multidimensional types (Armstrong and Rochet, 1999), and/or multiple outputs (Laffont and Tirole, 1993, ch. 3), and type-dependent reservation utilities (Lewis and Sappington, 1989; Jullien, 2000). There, the analysis is substantially more complex as types can no longer be ranked as easily as in the model sketched above. The Spence–Mirrlees condition might fail to hold and global incentive constraints may bind, leading to pooling allocations being optimal. Another interesting extension is the case of hidden knowledge, in which contracting takes place before the agent becomes informed. The logic of such models is very close to that we will discuss below in the section on moral hazard. In a nutshell, the trade-off between allocative efficiency and rent extraction is now replaced by the trade-off between insuring the agent against shocks on costs and inducing him to reveal his cost once it is known. Output distortions still arise (see Laffont and Martimort, 2002, ch. 2, for details). Others have endogenized the asymmetric information structure and examined the incentives to learn about the unknown parameter (see, for instance, Crémer, Khalil and Rochet, 1998). Finally, there exists a literature that considers the case where the principal is the informed party (Maskin and Tirole, 1990; 1992). New difficulties arise from the fact that the mere offer of the contract may signal information.

Multiagent organizations

The most important extensions of the adverse selection paradigm certainly concern multi-agent organizations. Such complex organizations emerge because of the need to share common resources, produce public goods, internalize production externalities or enjoy information economies of scale. Although any such reason calls for a specific analysis, a few common themes of the literature can be highlighted by remaining at a rather general level.

Regarding the implementation concept, different notions of incentive compatibility may be used depending on the context. First, agents may know each other's types and play a Nash equilibrium of the direct revelation mechanism offered by the principal (see Maskin, 1999, and the discussion of the non-verifiability paradigm below). Second, agents may only know their own type, form beliefs on each others' types and play a Bayesian-Nash equilibrium (see D'Aspremont and Gérard-Varet, 1979). Third, one may also insist on dominant strategy implementation because it does not depend on the specification of beliefs (see Gibbard, 1973; Groves, 1973; Green and Laffont, 1977). To each implementation concept corresponds a notion of incentive feasibility. Once the set of incentive feasible contracts is defined, one can proceed to optimization. It is a trivial observation that, the more restrictive the implementation concept, the lower is the principal's payoff at the optimum.

In some cases, such as the provision of public goods within a society of privately informed agents or in bargaining models between a buyer and a seller with equal bargaining power, the goal is no longer to design a multilateral contract which would extract the rents of all agents but, instead, to maximize some ex ante efficiency criterion under incentive constraints. Groves (1973) showed that dominant strategy mechanisms suffice to implement the first-best decision in a public good context. One caveat is that the budget generally fails to be balanced. D'Aspremont and Gérard-Varet (1979) proposed a Bayesian incentive-compatible mechanism which implements the first-best and still satisfies budget balance. As argued by Laffont and Maskin (1979), such a mechanism may conflict with the agents' participation constraint. In a bargaining environment, Myerson and Satterthwaite (1983) showed in a similar vein that there exists no Bayesian bargaining mechanism that is efficient, budget-balance and individually rational.

The optimal multilateral contract can be very sensitive to the information structure. In environments where risk-neutral agents have correlated types but know only their own type, the principal can condition one agent's compensation on another's report. By doing so, the principal can fully extract the rent from both agents in a Bayesian-Nash equilibrium. One may view this result as a strong rationale for relative performance evaluation, yardstick competition, benchmarking and internalization of similar activities within the same organization. This puzzling insight of Crémer and McLean (1988) no longer holds when one introduces risk-aversion, *ex post* participation constraints or limited liability constraints. These assumptions reintroduce information rents in the multi-agent organization, and the standard trade-off between efficiency and rent extraction reappears.

When the agents' types are independently distributed, yardstick competition is ineffective and the agents derive information rents. However, the externality that one agent's task may exert on another can shape the distribution of these rents. In competitive environments, such as procurement auctions among sellers, it is no longer the distribution of the agents' marginal costs but the distribution of their virtual marginal costs (see Myerson, 1981) which determines who should produce and how much. Because virtual costs may be ranked differently from true costs, inefficiencies arise under asymmetric information. Moreover, competition may help reduce rents by putting each agent under the threat of being excluded from production if he overstates his cost too much. There is then a positive externality among competing agents. Instead, more cooperative environments, such as public good problems or procurement of complementary inputs by several suppliers, involve negative externalities between agents. Given that each agent has a limited impact on the organization's overall production, the incentives to overstate costs and thereby receive greater transfers are exacerbated. 'Free riding' arises in such organizations (see Mailath and Postlewaite, 1990).

When competition between agents or between agents and the supervisors supposed to monitor them would benefit the principal, one must consider the possibility of collusion aimed at securing more rent. Reducing the scope for collusion requires using mechanisms that are less sensitive to information and reducing supervisory discretion. Incentive contracts look more like inflexible bureaucratic rules (see Tirole, 1986; Laffont and Martimort, 2000). The optimal response to collusion may also entail more delegation to lower levels of the hierarchy, as in Laffont and Martimort (1998) and Faure-Grimaud, Laffont and Martimort (2003).

Dynamics

Different extensions of the static framework correspond to different abilities of the contractual partners to commit themselves inter-temporally and/or different ways for the cost parameters to vary over time. Under full commitment, the lessons of the static rent–efficiency trade-off can be easily extended, although the precise features of the optimal contract depend on how types evolve over time (see, for instance, Baron and Besanko, 1984, for the case of persistent types). The case of limited commitment is more interesting. Long-term contracts may either be renegotiated (Dewatripont, 1989; Hart and Tirole, 1988; Laffont and Tirole, 1990) or even are not feasible, in which cases the parties resort to spot contracts (Laffont and Tirole, 1988). The rent–efficiency trade-off must be adapted to take into account how information is revealed progressively over time. However, the basic idea still holds. As past performances reveal information about the agent's type, the optimal contract trades off *ex post* efficiency gains in contracting against the agent's desire to hide information in the earlier periods of the relationship so as to secure more rent in the later periods.

Applications

Since the mid-1980s, models of optimal contracting under adverse selection have spanned the economic literature. Let us quote only a few major applications. Mirrlees (1971) analysed optimal taxation schemes when the agent's productivity is privately observed. He introduced the Spence–Mirrlees condition and derived the implementability conditions. He also used optimal control techniques (Pontryagyn Principle) to compute the optimal taxation scheme. (The taxation problem differs from our buyer–seller example because participation in the mechanism is mandatory and the state's budget constraint must be added to the characterization of feasible allocations.)

Mussa and Rosen (1978) studied the problem of a monopolist selling one unit of a good to a continuum of consumers vertically differentiated with respect to their willingness to pay for the quality of this good. This was the first model using adverse selection techniques in a framework without income effect. Maskin and Riley (1984) were interested in characterizing the optimal nonlinear price used by a monopolist in a second-degree price discrimination context.

Baron and Myerson (1982) applied the methodology to the regulation of natural monopolies privately informed about their marginal costs of production. Laffont and Tirole (1986) extended this analysis to allow for cost observability but also introduced moral hazard elements (the possibility for the regulated firm to reduce its costs by undertaking some non-observable effort). They derived cost-reimbursement rules and pricing policies. They showed that menus of linear contracts might implement the optimal contract.

Green and Kahn (1983) and Hart (1983) studied labour market contracts and discussed distortions towards overemployment or underemployment that may arise depending on the contractual environment considered.

Finally, Townsend (1979) and Gale and Hellwig (1985) analysed optimal financial contracts in a framework where the borrower's income is observable only *ex post* and at a cost. Optimal contracts may look like debt in such environments.

Moral hazard

To return to our buyer–seller example, we now assume that there is only one unit of a good to be traded whose quality q is random and which yields a surplus $S(q)$ to the buyer. The distribution of quality is affected by an effort e undertaken by the agent at a cost $\psi(e)$ (where $\psi' > 0$ and $\psi'' > 0$). The cumulative distribution is $F(q \mid e)$ (with density $f(q \mid e)$) on a support $Q = [\underline{q}, \overline{q}]$ independent of the agent's effort. To simplify, the agent's preferences are separable in money and effort: $U = u(t) - \psi(e)$ where $u(\cdot)$ is increasing and concave $(u' > 0, u'' \leq 0)$. The agent's outside option is not to produce, which gives him a payoff normalized to zero.

The agent's effort is observable neither by the principal nor by a court of law. This is a *moral hazard* setting. Contracts stipulate the agent's payment as a function of the realized quality assumed to be observable and verifiable (contractible) by a court of law. Therefore, contracts are of the form $\{t(\tilde{q})\}_{\tilde{q} \in Q}$.

If the effort were observable, its value could also be specified by contract. Therefore, the seller can at the same time be forced to exert the first-best level of effort and be fully insured against uncertainty on realized quality with a flat payment independent of his performance:

$$u(t^*) = \psi(e^*).$$

This is no longer the case when the agent's effort is non-verifiable. The first step of the analysis is to describe the set of feasible incentive contracts implementing a given level of effort e.

In a moral hazard setting, incentive constraints write as:

$$\int_{\underline{q}}^{\overline{q}} u(t(q))f(q\,|\,e)dq-\psi(e)\geq\int_{\underline{q}}^{\overline{q}} u(t(q))f(q\,|\,e^{'})dq-\psi(e^{'})\quad\forall(e,e^{'}).\quad(6)$$

The agent's participation constraint is:

$$\int_{\underline{q}}^{\overline{q}} u(t(q))f(q\,|\,e)dq-\psi(e)\geq 0.\qquad(7)$$

Risk-neutrality

A first case of interest is when the agent is risk-neutral $(u(t)\equiv t)$. The simple 'sell-out' contract, $t(q)=S(q)-C$ where *C* is a constant, implements the first-best level of effort *e**. Provided that $C=\int_{\underline{q}}^{\overline{q}} S(q)f(q\,|\,e^{*})-\psi(e^{*})$, this scheme also extracts all the surplus from the agent who is just indifferent between producing or not.

Intuitively, with such a 'sell-out' contract, the agent's private incentives to exert effort are aligned with the social incentives. This efficient outcome is obtained by, first, having the agent pay a bond worth *C* for the right to serve the principal, and second, having the principal pay an amount *S*(*q*) contingent on the quality realized.

Such a 'sell-out' contract requires that the agent bear the full consequences of a bad performance. It might not be feasible when the agent has limited liability and cannot be punished for bad performances. (For details, see Laffont and Martimort, 2002, ch. 4). The conjunction of moral hazard and limited liability allows the agent to derive a limited liability rent. Intuitively, only rewards, not punishments, can be used to provide incentives, and this restriction on instruments is costly for the principal. This rent creates a trade-off between efficiency and rent extraction, as in the adverse selection framework. Effort is distorted below the first-best level.

Risk-aversion

Let us turn to the more complex case of risk-aversion. A first concern of the literature has been to 'simplify' the set of incentive constraints (2) by replacing it with a first-order condition:

$$\int_{\underline{q}}^{\overline{q}} u(t(q))f_{e}(q\,|\,e)dq=\psi'(e).\qquad(8)$$

Denoting by λ (resp. μ) the positive multiplier of the incentive (resp. participation) constraint (8) (resp. (7)), the optimal second-best schedule $t^{SB}(q)$ satisfies

$$\frac{1}{u'(t^{SB}(q))}=\mu+\lambda\frac{f_{e}(q\,|\,e)}{f(q\,|\,e)}.\qquad(9)$$

This condition yields two important insights. First, the contract must simultaneously provide the risk-averse agent with insurance, which requires a fixed payment, and with incentives to exert effort, which requires that payments be linked to performance. There is now a trade-off between *insurance* and *incentives*.

Second, the monotonicity of the agent’s compensation with respect to the quality level (a priori a quite intuitive property) is obtained only when the *monotone likelihood ratio property* holds, namely, when $\frac{\partial}{\partial q}\left(\frac{f_e(q|e)}{f(q|e)}\right) > 0$. This property means that higher levels of performance are more informative about the agent’s effort.

Finally, the optimal contract must use all signals which are informative about the agent’s effort but no uninformative signals. Using them would only let the agent bear more risk without any beneficial impact on incentives. This is the so-called informativeness principle of Holmström (1979).

Extensions

In a model with a finite number of quality and effort levels, Grossman and Hart (1983) offered a careful study of the set of incentive constraints and its consequences for the shape of optimal contracts. There is no general result on the ranking between the first-best and the second-best effort levels in such environments. The discrete version of the first-order approach requires that only nearby constraints matter in the agent’s problem. This concavity of the agent’s problem is ensured when $F(q \mid e)$ is itself convex in q. In models with a continuum of effort levels and outcomes, this first-order approach was suggested in Mirrlees (1999), more rigorously justified in Rogerson (1985) and Jewitt (1988) and applied in Holmström (1979) and Shavell (1979).

The moral hazard methodology has been used to justify the optimality of linear incentive schemes in well-structured environments (Holmström and Milgrom, 1987); an often found feature of real world contracts. Equipped with this tool, Holmström and Milgrom (1991; 1994) investigated how multiple tasks and jobs should be arranged in an organization.

To avoid the complexity of models with a continuum of effort levels, modellers have found it useful to focus on simplified environments with two levels of effort. This approach was instrumental in the work on corporate finance of Holmström and Tirole (1997).

Multi-agent organizations

When applied to multi-agent organizations, the 'informativeness principle' suggests that an agent's compensation should be linked to another's performance if it is informative about his own effort (see Mookherjee, 1984). Relative performance evaluation and benchmarking can help eliminate common shocks affecting all agents' performances. Of particular importance in this respect are tournaments which use only the ranking of the agents' performances to determinate their compensations. Tournaments provide agents with insurance against common shocks, which has a positive incentive effect. More generally, the properties of tournaments and how they compare with (a priori suboptimal) linear schemes have been investigated in Nalebuff and Stiglitz (1983) and Green and Stokey (1983).

In more cooperative environments where different agents contribute to a joint project, the fundamental difficulty is how to share the proceeds of production among agents of the team and still provide some incentives. Since each agent enjoys only a fraction of those proceeds but bears the full cost of his effort, he reduces his effort supply. This leads to a free-rider problem within teams, which is analysed in Holmström (1982).

If we remain in cooperative environments but allow now for a principal acting as a budget breaker, this principal may find it worthwhile to reduce the agency cost of implementing a given effort profile by having agents behave cooperatively (Itoh, 1993). Even when agents do not cooperate, mutual observability of effort levels can also help to eliminate agency cost, as in Ma (1988). This last argument relies on the logic of non-verifiability models, developed below.

Dynamics

The basic issue investigated by dynamic models of moral hazard is the extent to which repeated relationships alleviate the moral hazard problem. The intuition is that the principal should filter out the agent's effort by looking at the whole history of his performances. This may eliminate any agency problem, at least when parties do not discount too much the future (see Laffont and Martimort, 2002, ch. 8, for an example). More generally, the insurance–incentives trade-off may be relaxed when the risk-averse agent's rewards and punishments can be smoothed over the whole relationship, as shown in Spear and Strivastava (1987). A direct consequence of inter-temporal smoothing is that the optimal dynamic contract exhibits *memory*; good (resp.

bad) performance today will also affect positively (resp. negatively) future compensations. This insight has been used to formalize a theory of the wage dynamics inside the firm (Harris and Holmström, 1982).

Fama (1980) argued that reputation in the labour market exerts enough discipline on managers to alleviate moral hazard even in the absence of explicit contracts. Holmström (1999) built a model of career concerns where the manager's interest in influencing the labour market's beliefs concerning his or her quality provides incentives to exert effort. Career concerns are nevertheless in general not enough to induce first-best effort levels, and some inefficiencies remain.

Non-verifiability

Let us return to the buyer–seller model above. Although we now assume that it is observable by both the principal and the agent, the state of nature θ may still not be verifiable by a court of law, in which case it cannot be part of the contract. This shared knowledge stands in sharp contrast with the asymmetric information structures examined in previous sections.

The first difficulty consists of building a mechanism based only on verifiable variables (namely, the quantities traded and corresponding payments) which implements the first-best quantity $q^*(\theta)$ and transfers $t^*(\theta)$. This problem was addressed by Maskin (1999). He demonstrated that the first-best quantities and transfers can easily be implemented with a direct revelation mechanism $\{t(\hat{\theta}_a, \hat{\theta}_b), q(\hat{\theta}_a, \hat{\theta}_b)\}_{(\hat{\theta}_a, \hat{\theta}_b)\in\Theta^2}$ where both the buyer and the seller report simultaneously the state of nature they commonly know. Truth-telling is obviously a Nash equilibrium of this mechanism provided that both traders are severely punished when making different reports, since such cases would be inconsistent with the underlying information structure.

A more subtle issue is how to design a mechanism such that this truthful Nash equilibrium is unique. Maskin (1999) proposed a condition for players' preferences such that this is the case. Moore and Repullo (1988) significantly extended the domain of preferences by hardening the implementation concept, replacing Nash behaviour by subgame-perfection in a sequential moves mechanism (see Laffont and Martimort, 2002, ch. 6, for an example, and Moore, 1992, for an exhaustive survey of the literature).

The basic thrust of the non-verifiability paradigm is that a court of law can get around non-verifiability by building such revelation mechanisms, at least as long as the non-verifiable state is payoff-relevant. If one sticks to that interpretation, non-verifiability does not present a significant limit on contracting.

A second issue of the literature is the impact of non-verifiability on the incentives of traders to perform specific and non-verifiable investments. Given our previous claim that non-verifiability is generally not a constraint, the model resembles the standard moral hazard model. Providing incentives for investments meets the same difficulties as in the previous section.

Extensions

In practice, revelation mechanisms have been criticized as overly complex, as relying on threats which may either be non-credible or violate limited liability constraints. The so-called incomplete contracts literature has thus focused on cases where such revelation mechanisms are not feasible. In such environments, either no contract at all or only a very rough one can be written *ex ante*. For instance, parties can agree *ex ante* on a simple fixed-price/fixed quantity contract which serves as a threat point for the bargaining which takes place *ex post* when the state of nature is realized (see Edlin and Reichelstein, 1996, among others).

Alternatively, this threat point may be determined by the allocation of ownership rights where such a right gives the owner the opportunity to use assets as he prefers in case bargaining fails (see Grossman and Hart, 1986; Hart and Moore, 1988). The issue is then to derive from those exogenous constraints distortions of investments and optimal organizations which may mitigate those distortions.

The incomplete contracts paradigm is similar to the complete contracts one (adverse selection, moral hazard and non-verifiability) in the sense that it also imposes limits on what a court may verify. It differs from it because it also imposes exogenous restrictions on the set of mechanisms available to the parties. The justification for these restrictions is found either in the bounded rationality of players or the difficulties in describing or foreseeing contingencies, all theoretical issues which remain high on the agenda of economic theorists and are still unsettled. The relevant literature on incomplete contracts is too large to be summarized in this short article. The interested reader may refer to Tirole (1999) for an overview or elsewhere in this dictionary or to the entry for this term in this Dictionary.

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See also adverse selection; agency problems; incentive contracts; incomplete contracts; mechanism design; mechanism design (recent developments); moral hazard.

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