

Hart and Holmström's Contributions to Contract Theory*

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The Prize in Economic Sciences in Memory of Alfred Nobel 2016 was awarded jointly to Oliver Hart and Bengt Holmström for their contributions to contract theory. Contract theory is a field of applied game theory, bringing into focus the conflict between the owner – the principal – and the company's appointed manager – the agent. In this study, we present the Principal–Agent model proposed by Holmström and describe a few offshoots of the original model, before proceeding to discuss Hart's research on the aspects of ownership in Principal–Agent models. Although the two laureates are primarily known for their theoretical models, in our introduction we disregard the unnecessary formulas and illustrate the models with examples.

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1. Introduction

The Prize in Economic Sciences in Memory of Alfred Nobel 2016 was awarded jointly to Oliver Hart and Bengt Holmström for their contributions to contract theory. The term “contract” is often associated with law, but by the same token the concept may well belong to humanities; indeed, any arrangement needs to be phrased and the more important ones are also drawn up in writing. In essence, contract theory is an application of game theory; at most, it only concerns individuals with a specific theoretical interest or those who have signed or intend to sign a contract or undertaken – or have given – an assignment in the past. This encompasses even informal arrangements and does not necessarily involve an official document. The topic at hand, therefore, determines – either directly or indirectly – everyday

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life. Contract theory is concerned with the theoretical foundations of contractual arrangements and agreements; for instance, it seeks to investigate possible ways of ensuring the proper functioning of contractual arrangements or, even more importantly, that compliance with the terms of an agreement guarantees the implementation of its essence.

Below we present an overview of the main results of the theory on the basis of the summary written by the *Royal Swedish Academy of Sciences (2016)*. This is not the first time the Academy recognised research in the field of (applied) game theory; in fact, the concept is counted among the most successful approaches of recent times, as demonstrated, for example, by the 2014 Prize to Tirole and the 2012 Prize to Roth and Shapley (whose achievements were reviewed in *Biró et al. [2013]*), and the list could continue for a long while. Although plenty of complex models are featured in the literature on game theory in general and on contract theory in particular, in this paper, rather than intimidating interested readers, our goal is to merely offer a glimpse of the problems analysed by contract theory and their solutions.

While Holmström and Hart both applied themselves to contract theory, despite co-authoring a number of articles, they concentrated on clearly distinctive focal points and it is along the same guiding principles that we review first the results of Holmström, and then the findings of Hart.

2. The Principal–Agent problem

Contracts are often assignments, where a *principal* pays an *agent* for the performance of specific tasks. First of all, we review problems of this type by lining up a number of examples.

The conflict between an investor and a fund manager is, for instance, a principal-agent problem. The investor seeks to maximise her return, while the fund manager has a vested interest in collecting a secure income while minimising the amount of work or the number of employees needed. Due to the unpredictability of markets, it is extremely difficult to measure the fund manager's performance *ex post*.

A similar conflict may materialise between a company's owner and manager, although the controversy will be of a different nature. The owner only cares about her profit and the company's value, while the manager wants a high salary, a company car and other benefits. It is even worse when, with a view to achieving these gains, the manager enlarges the company to a larger-than-optimal size through expansion, acquisitions or capital increases. Unless the owner is a professional investor, in the case of listed companies or especially, state-owned enterprises, the manager's performance is measured far too late or not at all. While some market mechanisms may motivate the manager to make good decisions and act in the interests of investors, if the state, as the entity proceeding on behalf of

the owner is also an agent, performance measurement will itself be unreliable and the owner's – i.e. the state's – interests are likely to be compromised. Let us see the solutions proposed by the 2016 Nobel prize laureates.

2.1. The traditional Principal–Agent model and moral hazard

We assume, as is the case in economics in general, that decision-makers are rational, profit-maximising individuals. In the first, classical model the Principal wants to have a task accomplished. If she performed the work herself, she would strive to make an optimal decision to achieve the desired outcome with the least amount of time and capital expenditure. If, however, she chooses to hire an employee to perform the same work, the situation will be completely different. The agent can decide how much *effort* a he is willing to exert to accomplish the task, where a falls within the range of a given $[\underline{a}, \bar{a}]$ interval. We assume that the outcome

$$\beta = b(a) + \varepsilon$$

observed by the employer, i.e. the principal, is an increasing function b of the work performed, while ε is a random noise term with an expected value of 0, which captures environmental effects outside of the agent's control. The effort generates a cost for the employee, i.e. the agent, which is captured by the function c . The agent receives a benefit t for his work, the amount of which varies in function of the outcome.

In general, we assume that the Principal is risk neutral and that the payment of the transfer is well within her means. The agent is risk-averse and, with limited resources at his disposal, he is unable to pay a substantial negative t . The expected utility of principal P and agent A can be described, overall, as

$$U_p = b(a) - E(t)$$

$$U_A = -c(a) + E(t) - r\text{Var}(t),$$

where r measures the agent's degree of risk aversion.

Abstracting, for now, from the conflicts of interest between the parties, an optimal effort a^* can be defined both in case of the concavity or convexity of functions c and b . Optimal also means that risk is ruled out.

How do all these variables behave when this conflict is also factored in? If the effort is fully observable, the amount of the transfer can depend directly on the effort so that a^* is the ideal choice for the agent even if it involves an extra effort.

Unfortunately, most cases are not so ideal. In general, the agent's effort is unobservable or cannot be verified by a court and as such, the contract cannot or should not be drawn up on this basis. For the most part, only the outcome

of the agent's work can be observed, which already reflects the random effects considered above as a random factor. Thus, for example, in measuring the efforts of the investment fund mentioned in the introduction, in addition to the outcome, the role of luck and investment sentiment should also be considered. On the whole, the measure received is extremely imprecise. Obviously, this needs to be considered in determining remuneration; it is impossible to measure performance strictly on the basis of the outcome. In fact, *Grossman and Hart (1983)* warns that a better outcome may well yield a poorer payoff. We should only reiterate the biblical parable of the talents, where the servant burying the single talent entrusted to him is punished, while the servants entrusted with more talents and boldly but lucratively investing them receive praise.

Besides unobservable effort, the agent's *moral hazard* also comes into play. While a smaller effort increases the agent's utility, a lesser outcome might well be the result of other factors and he cannot be clearly accountable for the shortfall. The Principal-Agent problem is intriguing specifically because of this moral hazard.

This problem is reflected in real-life situations in countless forms and the interests of the parties can clash in numerous different ways. The most frequent controversy is the conflict between the owner and the manager. How can the owner ensure that the company works in favour of her interests? It can be generally assumed that the owner is competent; by contrast, the manager knows exactly how he could act in the interests of the owner, but this may not necessarily coincide with his own interests. The owner's interest is usually clear: she wants to see an increase in her company's value. This moral hazard problem can be easily alleviated by offering a block of shares/stock options to the manager that will also make him a shareholder.

2.2. Is there a need for executive bonus schemes?

Amid the media frenzy following the announcement of his Nobel prize, one of the first questions addressed to Bengt Holmström was whether he approved of special executive bonuses. Unfortunately, he replied, the answer is complicated. The previous section concluded that making the manager a shareholder approximates the interests of the principal and the agent: the manager will act as a principal and an agent simultaneously, and his optimal behaviour will be a mixture of the optimal behaviour of the principal and the agent, respectively. Obviously, the higher the compensation package, the less consideration is given to employees' interests, while incentivising will also become increasingly expensive. In extreme cases, the relationship becomes a franchise contract where the agent may retain the entire profit in exchange for a fixed transfer. In such cases, the agent assumes the entire risk which, however, can be undertaken only in the case of risk-neutral agents. If the agent is not risk-neutral, *Mirrlees (1999)* proposes a contract that penalises the agent very heavily when he realises outcomes that would have been highly unlikely had the agent's performance been adequate.

Due to the agent's insolvency, this approach can be rarely applied in practice; however, the idea of a model where payment depends on signals that provide information about the actual effort is worth exploring nevertheless. Such signals may comprise general market indicators or the performance of a firm relative to other firms. At the same time, the Informativeness Principle proposed by *Holmström (1979)* implies that payment should be a function of some additional signal s if and only if it carries new information. Thus, for example, all signals that contribute to separating effort a and noise ε can be of great assistance. Accordingly, any signal that is correlated strongly with the value of ε is useful, while s is unnecessary when it is not correlated either with the effort or with the noise. Consequently, executive bonuses should not only depend on the firm's stock price, but also with other observable indicators correlating with the stock price, such as the corresponding indicators of competitors. In consideration of the insights of the Informativeness Principle, *Holmström and Tirole (1993)* recommend the use of the stock price as a benchmark. The authors argue that stock price reflects a great deal of performance information, data and other aspects that cannot be extracted from the company's current accounting data.

In practice, such adjustments are often absent, and managers' performance is generally rewarded more in function of luck – a favourable economic environment – than based on his own merit and effort. *Bertrand and Mullainathan (2001)* found that this holds primarily for poorly governed – state-owned or listed – companies where the owners cannot stand up for their own interests and do not behave as true principals, while the managers of firms in majority or dominant ownership are less likely to be rewarded for luck. Interestingly, in a conducive market environment the migration of theoretically properly incentivised managers to firms where remuneration incorporates the lucky environment may lead to adverse selection. The situation is the opposite in an unfavourable environment, resulting in a countercyclical effect for the companies of properly incentivised managers.

2.3. Fixed pay or pay-for-performance?

Holmström and Milgrom (1987) compared fixed and performance or result based remuneration relying on a linear model where the transfer paid consists of a fixed component f and a component determined in proportion to outcome:

$$t(\beta) = f + k\beta,$$

where k is the incentive factor. The optimal value of k can be determined based on the functions available. Although the formula is somewhat crude, it is very informative in cases where risk is negligible – i.e. the agent is risk-neutral – because in that case $k = 1$; in other words, the highest possible value. In such cases the contract essentially becomes a franchise contract where the fixed component f is obviously negative. The other extreme is when the risk or the agent's risk aversion

tends to infinity, $k = 0$ and the agent receives a fixed salary. In general, *ceteris paribus*, the theory predicts a negative relationship between the agent's risk aversion and incentive power. In practice, however, the *ceteris paribus* ("all else equal") assumption may be violated by systemic selection as low-risk and high-risk assignments are not undertaken by the same agents. For example, *Akerberg and Botticini (2002)* studied agricultural contracts in Renaissance Italy and found that even though certain crops were riskier than others, the contracts related to them showed an unexpected pattern, which the authors attributed to the natural adjustment of the tenants.

2.4. Complex assignments

So far, we have examined situations where the agent was expected to perform a single task. In reality, however, most positions are diversified with multi-dimensional results. The agent's work may also involve activities the outcome of which can only be measured over time, imperfectly, or not at all. If remuneration is strictly based on measurable outcomes, all other activities are relegated to the background. As *Baker, Gibbons and Murphy (1994)* put it somewhat ironically, "Business history is littered with firms that got what they paid for". This is a recipe for making managers focus on the company's short-term earnings rather than taking its long-term interests to heart. Another example is when a university professor is paid on the basis of his teaching activity and the effectiveness of his research is reflected only indirectly, prompting the professor to take on even more teaching responsibilities at the expense of research. This might also be one of the explanations of why two ingenious European researchers awarded with a Noble prize were once again affiliated with American universities. Indeed, European universities are extremely reluctant to give recognition worthy of a superstar, state subsidies granted to Hungarian universities are only increasingly – albeit minimally – tied to the quality of research for the time being and the incentive hardly trickles down to the teaching staff.

What can the principal do in such a complex situation? If the agent is expected to perform multiple activities the outcome of which cannot always be measured in the short term and all other activities are also considered important, then incentivising the measurable activity/activities may encourage the agent to neglect the non-measurable activities. *Hong et al. (2013)* observed that piece-rate bonus schemes introduced in certain Chinese factories led to the deterioration of quality. *Bergstresser and Philippon (2006)* found that managers whose remuneration was tied to the value of stock were inclined to neglect the company's long-term goals.

Efforts should be made to strike a balance between various activities even without the presence of external incentives. An agent may prefer one task to another or may delegate a disproportionate amount of time and resources to it for some other reason. In such cases, supporting the disregarded activity may be considered. Thus,

for example, a phenomenon opposing the Hungarian practice can be observed at Western universities: since teachers receive a fixed salary, they tend to prefer research that strengthens their own profile and may be rewarded by a promotion over the long run; consequently, they may put teaching – the activity yielding short-term gains to the university – on the back burner.

2.5. Teamwork

We may face yet another array of problems when a task is to be performed by a team of agents. Naturally, the most interesting cases are those where the effort of individual team members cannot be measured, and the principal can only evaluate and reward aggregate output. In such situations it may be difficult to provide optimal incentives for each agent. *Holmström (1982)* maintains that in cases where the compensation of the agents is based on the sharing of some joint output, the outcome will always be inefficient. To resolve this problem, a third party needs to be involved who removes some output from the team in case of inferior performance. Through the liquidation of collateral, creditors are typically well-suited for this role.

When the performance of individual team members is to be evaluated, in line with the Informativeness Principle, the agent's relative performance compared to other agents working under similar conditions could be a useful point of reference.

2.6. Career

Fama (1980) and *Holmström (1999)* found that, under certain circumstances, moral hazard can be avoided even without the presence of incentives. If the agent considers the expected trajectory of its career, the promise of a good position and higher future pay may motivate him sufficiently to perform well today. In *Holmström's* model, however, an agent's performance depends both on his effort and on his ability; therefore, a good performance today signals to the principal or, as the case may be, to other potential principals, that the agent's ability is likely to be high. This signal can also be observed by other potential principals, as is the case with the university professor mentioned in the example above. Therefore, the agent's effort was worthwhile even if his employee fails to keep her promise of a pay rise or promotion. This is true to such a degree that, according to *Holmström*, the effort in fact exceeds the optimal α^* level. However, the power of career incentives decreases over time and in line with the agent's progress in the company hierarchy and explicit incentives should be provided for workers close to retirement. This can be also observed empirically, as demonstrated by the study of *Gibbons and Murphy (1992)*.

The career model can explain some of the idiosyncrasies exhibited in business life. For example, in studying the decisions of young analysts, *Hong and Kubik (2003)* found that they seldom deviated from the decisions of others. This might

be attributed to the high degree of uncertainty surrounding their ability: under such circumstances, a flawed decision may put an end to their entire career.

3. Incomplete contracts

While the most compelling problem in Bengt Holmström's models was the inability to measure performance precisely (or to separate the effects of luck and effort perfectly), Oliver Hart focused on cases where it is impossible to design a sufficiently detailed contract; in other words, where the contracts are incomplete. What can be done in a situation where it is utterly impossible to prepare for all eventualities at the conclusion of the contract? What are the attributes of a good contract amid such uncertainty?

It soon became clear that the main question is who is in control in cases that are not covered by the terms of the contract; i.e. who is in the position to make important decisions. The problem, then, arises as to how to allocate decision or control rights between the parties upon the conclusion of the contract. Since decision and control rights are closely related to property rights, the theory of incomplete contracts is partly dedicated to the issue of the assignment of ownership rights in a given situation.

Suppose there are two companies concluding a long-term contract with each other. One of the companies is the supplier of the other. At the beginning of their relationship, the parties stipulate the main terms and conditions in their contract, defining the quality, quantity and the price of the goods to be delivered by the supplier to the principal. Over time, however, the company ordering the goods may need – as a consequence of technological progress, for instance – products manufactured using a different technology. This, however, would require the supplier to make special investments, which were not covered in the original contract, as the parties could not foresee technological changes at the time. Moreover, under the contract the supplier might be entitled to produce goods that are of a lower quality from the perspective of the principal. If the relationship between the two companies is specific and the principal cannot easily replace the supplier, the supplier's bargaining position will become extremely strong and a *hold-up problem* occurs. For example, the supplier may only be willing to produce the goods in the required quality at a far higher price. Predicting this situation, the principal may not be willing to commit herself and depend on her supplier in the long run, even if this would be the efficient solution.

What is the right course of action in such cases? The obvious answer is that the principal should acquire the supplier at the start, thereby circumventing the problem mentioned above. The main benefit of acquisition/integration is the possibility of efficiency in managing the conflicts of interests arising in cases not covered by the

contract; in our example, the supplier functioning as part of the principal company cannot refuse to deliver special goods and to make the investments necessary for their production.

There are, however, drawbacks. If the manager of the supplier company is not an owner but simply an employee of the principal company, he is less likely to be incentivised for innovation. As an owner, the manager would reap all the benefits of the innovation on his own (e.g. higher profits with lower production costs), whereas the situation is completely different if he is only an employee: in that case, he will not exert any extra effort for making the company more efficient. Advantages and disadvantages should be weighed against each other before deciding whether the companies should continue to function as two separate entities or integration is the optimal solution.

More precisely, the theory (*Grossman – Hart 1986*) dictates that of the two companies the owner should be the one that is expected to make substantial investments in the future that cannot be covered by contractual terms. If such investments are equally important for both companies, they should continue to function as two separate entities. It can also be demonstrated that, as expected, integration or some other kind of joint operation is optimal in cases where the assets of the companies are highly complementary. It is also an intuitive theoretical result that the higher the competition between the suppliers (consequently, the emergence of a hold-up problem is less likely), the less likely it is for the companies to integrate.

The question arises: how realistic are these results? The empirical testing of this theory is problematic: it is not easy to identify the specific investments that are non-contractible but will end up determining the relationship between the parties down the road. *Acemoglu et al. (2010)* argue that technology intensity – the importance of R&D – may serve as a reasonable proxy. Consistent with the theoretical results, in their study analysing UK companies the authors found that the likelihood of the occurrence of hold-up problems stemming from technology intensity (i.e. the excessive reliance of a company on its suppliers) increases the likelihood of vertical integration.

Using data derived from the Mexican footwear industry, *Woodruff (2002)* examined patterns of integration among footwear manufacturers and retailers. Ownership has both upsides and downsides. Based on the theory we expect the manufacturer to sell the product elsewhere (as opposed to his own store) if the sale requires specific (and non-contractible) investments that the store would only be willing to make if proper incentives are in place; in other words, when it can reap the rewards of its efforts. This is the case in footwear segments with high fashion turnover where it

is imperative for the seller to respond quickly to changes in customer demand and high-quality services are required to attract customers.

4. Application: corporate finance

The general theoretical results have numerous applications. Below we present an example of a corporate finance application in the spirit of the article written by *Hart and Moore (1998)*. Suppose that a company needs funds for expansion and has no internal resources available for the project. The company seeks out potential investors with the promise of a certain share of future profits. The contract stipulating future profits, however, may not be attractive enough for the investor who may doubt that the expected profits will indeed be realised. After all, the company might squander the investor's money and make the profits disappear by way of creative accounting, spending the funds on paying higher wages or re-investing the money instead of repaying the investor as promised.

What can the investor do? As shown in the previous example, she may choose to buy the company. The decision and control rights will then be transferred to the investor and she can prevent the opportunistic behaviour described above. The investor, however, may also face disadvantages with ownership. The company's management will be less interested in improving the company's efficiency, as the gains from efficiency will be collected by someone else. From the aspect of investors, the main question is how to maximise the efficiency of the company while ensuring that the company uses the investor's funds in the interests of the investor. The answer may be a loan contract under which the company makes a fixed stream of payments to the investor irrespective of profits that ensure an adequate return for the investor. As long as these transfers are made as scheduled, control/decision rights remain with the company. However, if the company defaults, the rights will be transferred to the investor who may dismiss the management or liquidate the company at her discretion.

In fact, this is not only a theoretical result; bank loans, for example, work on the same principles. As long as the borrower can make his monthly instalments, he is entitled to enjoy the benefits of the asset purchased from the loan; if he fails to make his payments, the asset will be seized by the bank. Similarly, numerous securities include, in addition to the expected return and the instalment, clauses

that stipulate the transfer of control/decision rights to the creditor in the event of the company's poor performance.

4.1. Public or private provider?

Below we discuss another topic with respect to Hart's work. The costs and benefits of public versus private ownership are often pondered in relation to numerous public services (such as schools, hospitals or prisons). According to the study of Hart, Schleifer and Vishny (1997), private companies are expected to seek innovative solutions because the shareholders can realise more profits when their company can provide the same service with reduced costs. This causes a problem when cost-cutting is achieved at the expense of quality. By contrast, public sector service providers have little incentive to invest in improving the company's efficiency, but they also have less reason to be concerned about a deterioration in quality if the provider is the public sector. In other words, there is a trade-off between positive (efficiency improving) and negative (quality deteriorating) innovation. In the model of Hart and his co-authors, it is the nature of the given service that determines whether the service should be provided by a private or by a public company. In the authors' view, if high-quality service is a priority or the cost reduction is likely to entail a deterioration in quality, the service provider should be a public sector company, as is the case, for example, with prisons that require the highest level of security. By contrast, private enterprises may perform better in the case of waste collection services.

5. Conclusions

In our brief summary we attempted to present the main results of the two Nobel prize laureates without the mathematical formalisation that tends to characterise theoretical models. We hope that this paper made it clear why it is important and why it is difficult to write contracts that not only provide sufficient incentives to both parties but also lead to efficient results.

The contributions of the two Nobel laureates inspired nearly all branches of economics and have been integrated into numerous areas from finance to behavioural economics. The Figure below illustrates the evolution of the number of references to *contract theory* in the Web of Science database. It may be safe to assume that the sharply rising trend that illustrates the importance of the topic will continue in future.

Figure 1
„Contract theory” – The number of references



Source: Web of Science.

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