2016 Economics Nobel Prize Explained: Oliver Hart and Bengt Holmström

Stefano Bonini, Hamed Ghoddusi

SIT

27th October 2016

Bios

- Oliver Hart
  - British, born in 1948.
  - A math undergraduate at King's College, he obtained his PhD at Princeton in 1974. First appointed at LSE, he taught at MIT from 1984 to 1993 and then at Harvard as a full Professor.
- Bengt Holmström,
  - Finnish, born in 1949.
  - Also a math undergraduate at Helsinki, obtained an MS in Operations Research and a PhD in Economics from Stanford. after Kellog and Yale he went on to become full professor at MIT.

Why a Nobel prize?

A beautiful Nobel prize selection!

- Hart and Holmström (H&H) developed a comprehensive framework for analyzing many diverse issues in contractual design. This framework is called contract theory.
- Today's society is characterized by an intricate nexus of contractual relationships.
- Such relationships typically entail conflicts of interest and contracts must be properly designed to ensure that the parties take mutually beneficial decisions.

Why a Nobel prize?

- The machinery that H&H developed, has helped understanding several critical problems such as performance-based pay for top executives, deductibles and co-pays in insurance, the privatization of public-sector activities, firms capital structure, bankruptcy procedures.
- H&H contributions are almost perfectly complementary to each other even if they have often collaborated.
- Both explored how contracts work.

Why a Nobel prize?

- Holmström focused on the "complete": two parties are in a relationship regulated by a contract and one party (the Principal) imperfectly observes the actions of the other (the Agent).
- The classical moral hazard problem . The problem can be alleviated by, for example, designing a compensation package that provides the agent with adequate incentives to exert optimal effort.
- Such compensation package needs to be related to some measure of performance.
- The problem is that any performance measure is likely to be noisy, so in the end the optimal compensation schedule must trade off incentive-provision against risk-sharing.

Why a Nobel prize?

- Oliver Hart addressed the problem differently, by noting that all contracts are by construction imperfect, namely, incomplete because either is almost impossible to write full contracts (No Arrow-Debreu economy) or because performance is unobservable in a measurable manner.
- Hart's solutions exploit the ex-post allocation of decision rights.
- Decision rights are often determined by property rights –i.e., by ownership - and property rights generate bargaining power, which in turn determines incentives.

Holmström's Contribution to the Theory of Complete Contracts

Complete Contracts Theory in a Historical Context

- Information economics: 1960's and 1970's
  - Adverse selection: Akerlof, Stiglitz
  - Signaling games: Mirrlees, Spence
- Incentive problems inside organizations: Barnard (1930)
- Moral hazard: imperfect information and hidden actions
- Formal contract theory: early 1980's

Contract Theory and the Real World

- Examples: sharecropping, insurance, corporate governance, R&D, procurement, etc
- A Principal delegates some tasks to an Agent
  - Principal (P): owner, citizens, governance agency, etc
  - Agent (A): manager, worker, sales agent, faculty member, scientist, politician, etc
- Principal moves first and makes a take-or-leave offer to the agent

Contact Theory Models

- Clarifying the trade-offs:
  - Risk-sharing and high-powered incentives
  - Short-term and long-term contracts
  - Tangible and intangible targets
  - Commitment and flexibility
  - ...
- Investigating the informational value of signals.

A Summary of Holmstrom's Key Contributions

- Canonical models of moral hazard (with complete contracts)
- Dynamic moral hazard problems (in particular the career concerns model)
- Incentives in teams
- Multi-tasking
- Long-term contracts in the labor market

Canonical Model of Contract Theory

- Actions of agent are very costly to closely monitor
- Agen't utility $\underbrace{u(m,e)}_{\text{utility}} = \underbrace{m}_{\text{reward}} - \underbrace{v(e)}_{\text{effort}}$
- Principal's utility: $U(y-m)$
- Output: $y = g(e) + \epsilon$
  - Monotonicity condition: $f(y|e)$ first order stochastic dominance
    - $e > e^{'} \Rightarrow F(y|e) < F(y|e^{'})$
- Goal: induce the optimal level of effort: e^{*}

Benchmark: Solution with Observable Efforts

- $e^* = \text{argmax}_e \mathbb{E}(U(y - w(y))$
  - s.t. $\mathbb{E}[u(m(e))] > \overline{u}$
- Optimal contract: a function $s(e, y)$ of both e and y
  - If $e = e^* \Rightarrow m = \overline{w}(y)$ (a random payment!)
  - Otherwise, 0
- Optimal solution: $\frac{U'(y-w(y))}{u'(w(y))} = \underbrace{\lambda}_{\text{to induce agent to accept}}, \forall y$
- Special case of a risk-neutral principal: full insurance

Model with Hidden Actions (or Effort)

- Agent's effort is not observable.
- Thus, the contract $s(y)$ is just a function of output
- Two constraints to be satisfied:
  - Incentive compatibility (IC): agents should have incentive to select the "effort maximizing" option
  - Participation constraints (PC): the reward (of the optimized choice) must be higher than the outside option

Principal's Problem

- $\max_{e,w(y)} U(y - w(y))f(y|e)dy$
- s.t.
  - IR: $\int u(w(y))f(y|e)dy - v(e) \geqslant \underline{u}$
  - IC: $e \in \text{argmax}_{e'} \int u(w(y))f(y|e')dy - v(e')$

First Order Approach

- Replace the F.O.C of the agent
- $\frac{U'(y-w(y))}{u'(w(y))} = \lambda \underbrace{+\mu \frac{f_e(y|e)}{f(y|e)}}_{\text{Inefficiency due to unobservability}}$
- $\max_e \log f(y|e) \Rightarrow \frac{f_e(y|e)}{f(y|e)} = 0$

Tradeoff between Risk and Efficiency (Incentives) (Holmstron 1979)

- Full risk-sharing:
  - $\frac{U'(y-w(y))}{u'(w(y))} = \text{constant} \Rightarrow \lambda + \underbrace{\mu \frac{f_e(y;e)}{f(y;e)}}_{=0}$
  - The connect between effort and output is broken!
- High powered incentives $\Rightarrow$ close connection between pay and performance
  - $w(y) = x - a$
  - Very costly for the agent (and principal)
- The ex-post threat of punishment is necessary for the ex-ante effort choices.

Career Concerns (RES, 1989)

- Fama's conjecture: no incentive contracts are needed to solve moral hazard problems if managers care about their reputation
- Holmstron offered a signal jamming model with the reputation effect
- $y = \underbrace{\eta}_{\text{Talent}} + \underbrace{e}_{\text{Effort}} + \underbrace{\epsilon}_{\text{Noise}}$
  - Talent: $\eta \sim N(m_0, \sigma_0^2)$
  - Noise: $\epsilon \sim N(0, \sigma_\epsilon^2)$

Career Concerns (RES, 1989)

- Multi-period model
- Wage is a function of the $\underbrace{\text{history of performance}}_{\text{talent}} + \underbrace{\text{current performance}}_{\text{effort}}$
- Bayesian updating: $\mathbb{E}(\eta|y_1) = (\frac{\sigma_\epsilon^2}{\sigma_\epsilon^2+\sigma_0^2})m_0 + (\frac{\sigma_0^2}{\sigma_\epsilon^2+\sigma_0^2})(y_1 - \hat{a})$
- Share of current performance diluted over time
- No incentive to work hard in the last period
  - Payment of last period drives efforts of the previous periods

Career Concerns (RES, 1989)

- Conclusion 1: agent works too hard in the early years of career and not hard enough in later years.
  - Is not the optimal path of effort!
- Conclusion 2: market is not a perfect substitute for contracts in general.
- Conclusion 3: composition of optimal contract should change over time.

Incentives in Teams

- Key message: it might be impossible to achieve total value maximizing outcomes when joint output is measurable but individual output is not.
- free-riding as the main barrier to achieve the first best
- Model is similar to individual case

Incentives in Teams

- $S_i(y)$: share of agent i
- $\sum_{i=1}^{N} S_i(y) = y$
- Each agent maximizes $(S_i(y) - v_i(e_i)$
- FOC: $S_i^{'}(y)y_i(e) = v_i^{'}(e_i)$

Incentives in Teams

- Two contradicting conditions!
  - Efficient level of effort: $S_i^{'} = 1$
  - Balanced budget: $\sum_{i=1}^{N} S_i^{'} = 1$
- Breaking the Balanced Budget

$$s_i(y) = \begin{cases} b_i(y) & \text{if } \ y \geq y(e^*) \\ 0 & \text{if } \ y < y(e^*). \end{cases}$$

Applications: Finance

- Security design: financing contracts
  - Debt and equity
- Incentive contracts: compensation packages, sales agents (insurance, marketing, etc)
  - Fixed and variable components
- Investment banking (Baron and Holmstrom, 1980)

Other Applications

- Innovation and R&D management
- Utility regulation
- Insurance markets
- Resource extraction
- Labor market contracts

Some Research Themes That Followed Basic Models

- Examination of real-world contracts (especially from historical and legal perspectives)
- Empirical evidence on the performance of different contractual setups
- Behavioral view of contracts: effect of behavioral biases (inequality-aversion, loss-aversion, time-inconsistencies, cognitive limitations, etc) on the optimal contract design
- Dynamic contracts
  - Special case: contracts in continuous-time

Hart's Contribution to the Theory of Incomplete Contracts

A summary of Hart's contributions

- Recognition that contracts are incomplete because:
  1. Bounded rationality: Parties cannot write long-term state contingent
  2. Transaction cost: Conditioning long-term contract on all possible future states prohibitively costly.
  3. Nonverifiability: Some information observable but not verifiable
- If contracts cannot fully specify the usage of the asset in every state of the world, then who gets the right to choose?

A summary of Hart's contributions

- Proposes a simple tractable solution by noting that owenrship of an asset determines investment decisions
- The owner of an asset will have a stronger incentive to make asset-specific investments, knowing that he has residual property rights.
- Transferring ownership of an asset from one party to another has a benefit – encouraging investment by the acquirer – and a cost – discouraging investment by the acquired. The trade-off generates powerful implications regarding two classical economics/management theory problems:
  - Ownership structures: who needs to own assets (firms, rights, Ip etc.)?
  - Firm boundaries: what the boundaries of organizations should be?

An intuitive presentation of the model: the trivial case

- 2 players P and A
- Agent produces an output that has a value of $\beta = b(a)$ for P and an alternative value of $v(a)$ for A
- $a \in [\underline{a}; \overline{a}]$ is an indispensable factor contributed by A (think of it as effort) at a cost $c(a)$
- Problem is that $0 < v(a) < b(a)$ =for any a
- Crucially: if a and β cannot be contracted upon (and they can't for the reasons outlined before) ownership matters a lot in determining the outcome.

An intuitive presentation of the model: the trivial case

Under P ownership:

- A gets nothing of the output therefore optimally chooses $a = \underline{a}$ to minimize $c(a)$

Under A ownership

- A can deny P access to any output and gain a reserve value of $v(a)$
- Given that $v(a) < b(a)$ he offers P to divide the surplus by means of a trade determined as:

$$t = v(a) + \frac{1}{2}(b(a) - v(a)) = \frac{b(a)+v(a)}{2}$$

- P accepts because he's always better off (her alternative is 0)
- A maximizes the cost of effort with the benefits:

$$\max -c(a) + \frac{1}{2}(b(a) + v(a))$$

Application 1: integration

- In the trivial case there is only one production factor
- What if there are two production factors and each owns one? (e.g. P owns equipment; A owns patent)?
- The model predict that optimal ownership depends on the joint-effect of having the two assets work together. In other words by the degree of complementarity.
- Empirically tested by Acemoglu et al. (2010) "Vertical integration and technology: theory and evidence"
- They show that upstream integration is increasing in the buyer's technological intensity and decreasing in the supplier's one.

Application 2: privatization

- Hart, Shleifer and Vishny (1997) is a influential contribution that showed how privatization may lead to socially suboptimal results.
- Assume that A's activity a (think of it as innovation) may lead to cost savings $m(a)$ that reduce overall cost by $c_0 - m(a)$ but also profit contractions of $z(a)$ that reduce the value by $\beta_0 - z(a)$
- If the innovation is inefficient it will not be pursued. If it is efficient then $m(a) - z(a) > 0$

Application 2: privatization

- The key intuition here is that if A has ownership then he will have incentive in maximizing $-c_0 + m(a)$ this may lead to too much cost savings.
- Differently, under P ownership A will set a such that it maximizes $-c0 + \frac{m(a)-z(a)}{2}$ which clearly leads to an internal solution and more efficient a.
- This result provides support to concerns raised in the realm of privatization of services such as health care, school and correctional services.

Application 3: Corporate Finance

- Possibly the most fitting application.
- Agency theory (Jensen and Meckling, 1976) highlights how managers and shareholders may have conflicting interests. If contracts were complete, one could write a simple compensation contract that assigns *cash flow* rights to managers in good states and to shareholders in bad states.
- This can be achieved by assigning debt to investors and equity to managers.
- However securities have also different (and dynamic!) *control rights* i.e. rights to make decisions over assets. While some assets are transferable, others may not (e.g. knowledge, intangible assets).
- As we have seen before, though, the combination of assets generates value and an ex-ante determined allocation of rights may be ex-post suboptimal.

Application 3: Corporate Finance

- The property rights approach specifically look at control rights and are powerful in the design of securities.
  - For instance: the simple fact that debt is senior to equity is a consequence of contract incompleteness.
  - Securities are a LOT more complex and the way they get structured is primarily driven by the ex-post allocation of control rights rather than by the ex-ante cash flow rights distribution
- Some innovative cases of conflict or distress resolution such as debt-for-equity swaps and contingent securities (e.g. CoCo bonds) were simply impossible to analyze.
- The implications of this approach are especially powerful in designing optimal financing structure of new firms and the resolution of distress.

Application 4: Venture Capital

- Hart and Moore (1989, 1994, 1998) provide important contributions to understand what happens when true performance is difficult to use in a contract because the manager is able to divert the firm's profits.
- One particularly poignant case is when more than cash flows, managers can divert human capital, such as in a start-up.
- In this setup, entrepreneurs/managers are A and VCs are P.

Application 4: Venture Capital

- In such contracts what truly matters is the *different* allocation of control and cash-flow rights.
- These rights are allocated in a state-dependant fashion (e.g. conditional on milestones) and in a way that assigns investors maximum control when performance is poor but leaves it (along with cash flow rights) to entrepreneurs when the firm perform wells (follow-up rounds dilution).
- Kaplan and Stromberg (2003) provided a comprehensive empirical analyses of VC contracts and showed a surprising adherence of these with the Hart and Moore's model.

Application 5: Bankruptcy procedures

- Bankruptcy procedures around the world are plagued by several problems, the most important being inefficient continuation and inefficient liquidation.
  - In the US Chapter 7 is criticized for leading to inefficient liquidation, while Chapter 11 to inefficient continuation and leniency to the management.
  - In other countries, procedures may be excessively harsh on entrepreneurs leading to systematic underinvestment and inefficient continuation (a powerful example is the failure of existing procedures in dealing with financial institutions crises).
- The main problem with all procedures stem from the fact that the value of the firm in distress is unobservable.

Application 5: Bankruptcy procedures

- Aghion, Hart and Moore (1995) propose a solution within the property rights theory framework by formalizing an idea introduced by Bechuck (1988).
- Be F a financially distressed firm entering a bankruptcy procedure under a court supervision. Two task must be carried out by the judge:
  1. soliciting bids for the firm - both cash and non-cash - from outside bidders and management teams (included the existing one)
  2. allocating rights, i.e. defining priority amongst claim holders including Government (taxes are their claim), workers (unpaid salaries).

Application 5: Bankruptcy procedures

- Once bankruptcy is initiated, claimants are aggregated in homogeneous classes of priority.
- A new "all equity" firm is created composed by a number of "pseudo-stocks" called Reorganization Rights (RR) .
- Because V is unknown, a mechanism must be defined to induce all claimants to reveal correctly their valuation. The mechanism is as follows:

Application 5: Bankruptcy procedures

- Class 1 claimants (most senior) are virtually assigned 100% of the firm's *RR* (equity). The firm retains the right to "redeem" the equity at a price of $D_1 100\%$.
- Now class 2 is given the option to buy equity at a price equal to $D_1 100\%$.The firm retains the right to "redeem" at a price equal to $D_2 100\%$.
- More generally for any class i an option is given to buy equity at price identically equal to the superior class claim and a redemption rights is retained by the firm priced the class' claim.
- After enough time passes to allow sufficient bids, bids are revealed and option and redemption rights can be exercised.

Application 5: Bankruptcy procedures

- Trade takes place because revelation of bids allows individual positions optimization.
- When trades are over new firm's shareholders vote over which bid to choose and the bankruptcy procedure is closed.
- If no offer is considered eligible liquidation takes place.
- Bankruptcy procedures today are still inefficient although slowly changes are introduced that partially incorporate these ideas.