Vertical Integration

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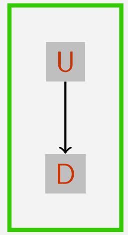
What is vertical integration?



All firms are vertically integrated. It is a question of degree.

The organizational problem

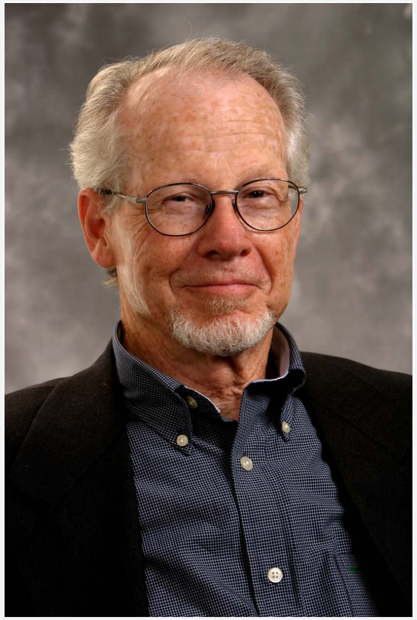
There are two types of considerations that might induce firm D to buy firm A (we will always assume that it is the downstream firm that buys the upstream firm):

- It might want to use the combined weight of the two firms for strategic purposes.
  - This topic is explored in courses in industrial organization, very often under the name of vertical restraint.
  - Antitrust authorities forbid this type of mergers.
- There might be some efficiency gains to running the two firms as one unit, and the aim of the merger is to take advantage of this efficiency gains.
  - This type of merger could arise in a competitive market, whereas the first type could not.
  - Antitrust authorities have no reason to forbid this type of mergers.

It is this kind of vertical integration that we study here.

A brief history

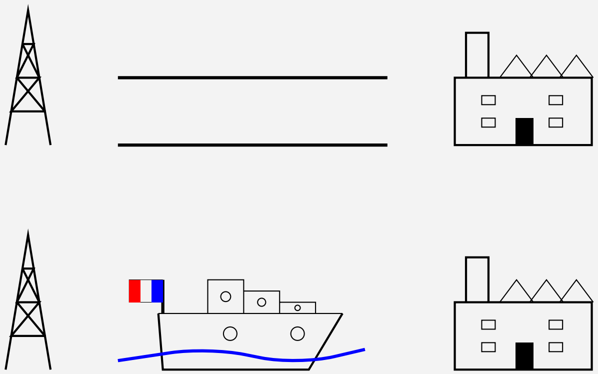
- Coase
- Alchian & Demsetz
- Klein, Crawford and Alchian
- Williamson
- Grossman & Hart
- now.



Two examples

- In the Maigret movies Bruno Crémer always has a pipe in his mouth. Does it make sense for the producer of Maigret movies to buy a manufacturer of pipes to ensure a study supply?
- . . .

- . . .
- When should the well, the refinery and the transportation method be owned by the same firm?



Case study: GM and Fisher Body

Classical case study from a paper by Klein, Crawford and Alchian.

- Around end WWI, new technology to create car bodies in metal.
- In 1919 GM signs contract with Fisher Body; ten years, exclusivity.
- To protect parties contract very precise:
  - price = variable cost + 17.6%.
  - FB could not charge more to GM than to any other manufacturer
  - price had to be smaller than price charged by other companies.
  - arbitration clauses.

End of story

Contract did not last 10 years.

- ☞ Demand for cars ↗
- ⟹ increasing returns to scale kicks in
- ⟹ cost ↘ as capital cost decreases,
- ☞ but capital cost not included in contract costs.
- ☞ Also FB refused to move its factories close to GM's.
- ⟹ GM buys FB in 1926.

Vertical Integration and the characteristics of transactions

The notion of transactions

Literature analyzes types of transactions, and tries to understand which ones are better organized internally, and which ones are better organized through markets.

Three important attributes:

- ☞ Frequency;
- ☞ Degree of uncertainty.
- ☞ Presence of specific investments.

A typology

	Characteristics of capital		
	Non specific	Intermediate	Specific
Occasional purchases	Standard equipment	Custom made equipment	Turnkey factories
Repeated purchases	Standardized inputs	Custom made inputs	High transport costs inputs

Standard markets; Complex contracts; Integration.

Vertical Integration: Williamson

We are following chapter 4 of Williamson's *The Economic Institutions of Capitalism*.
Vertical integration is dictated by technology only if

- there is one technology much superior to others
- this technology dictates a form of organization

In general, it will be the necessity to protect specific capital through contracts that will dictated technology

Forms of specifity

- locational
- Physical (specific machines)
- human capital
- there are different degrees of specifity: some machines constructed for a client might be used for someone else.

The fundamental tradeoff

Incentives vs. cost of production

- Vertical integration facilitates the writing of contracts and the use of specific capital: it decreases the cost of production
- but it decreases the "power" of incentives.
- benefits of vertical integration increases with specificity of capital, but costs do not.

$\Longrightarrow$ with highly specific capital, we will see more vertical integration.

although some people disagree...

As automobile buyers were becoming more sophisticated, GM began offering a larger number of models ... *This strategy required extensive exchange of information between the assembling plants and Fisher Body. The greater complexity of automobile production technology that accompanied the higher scale of operations increased the need for information transfer between the companies.* ... *Vertical information permitted GM to realize cost economies from coordinating production decisions and sharing resources.*

Ramon Casadesus-Masanell & Daniel F. Spulber, "The fable of Fisher Body", *Journal of Law and Economics*, 2000.

Three puzzles

First puzzle: the pin factory

- In the *Wealth of Nations*, Adam Smith argues that the benefit of creating a firm is that it allows for specialization of labour, and he gives the example of the pin factory.
- The story sounds convincing, but upon analysis it is clear that something is missing. Even if we take at face value Smith's description of the increased skill due to specialization, there is a priori no reason why the different workers could not each run a different firm and trade through markets. After all, the invisible hand should lead to efficiency.
- One of the objectives of these lectures is to understand better why markets or contractual relationships between firms would not be satisfactory in this case.

Puzzle 2: Coase's theorem

- We use an approach inspired by Coase's theorem (Coase 1961).
- Adapted to the problem of vertical integration, Coase's theorem states that there is never any efficiency gain from the merger of two firms.
- If there are efficiency gains, these gains could be obtained without merger: the firms would sign a contract committing themselves to take the efficient actions that they would have taken as division of the merged firm.
- The firms have no reason to come to an inefficient solution, as they have a joint interest in maximizing the surplus that they can divide between themselves.

$\Longrightarrow$ Any efficiency gain which would come from a merger can be obtained without it.

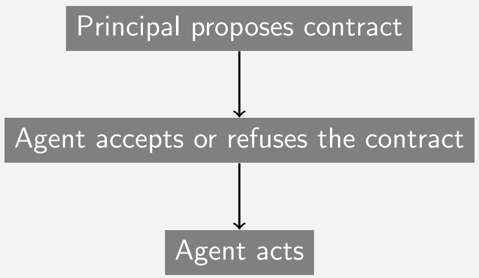
Puzzle 3: selective intervention

- Introduced by Williamson (1986);
- It shows that mergers can never be costly, and will in general be profitable.
- We should therefore eventually see one big firm appear.

- ☞ Consider our two firms A and D. We are thinking of merging them.
- ☞ Do this by putting the resources of the two firms in two different divisions of the new merged firm, and tell the head of these two divisions to act as they would have acted if they were independent firms.
- ☞ No gain to the merger, but also no loss.
- $\Longrightarrow$ There is an upper bound of 0 on the cost of merger between any two firms.
- ☞ In general, it will be possible to find some small gains. For instance, the two divisions could share a parking lot.
- ☞ Seems to always be gains to merger.
- ☞ Of course, we know as an empirical fact that very large firms are difficult to manage.

-So, you are getting more responsiveness from outsiders than you got from insiders?
-Right.
-Doesn't that mean that you didn't have the proper incentives for the insiders?
-Probably. But I am not sure you can duplicate those incentives internally.

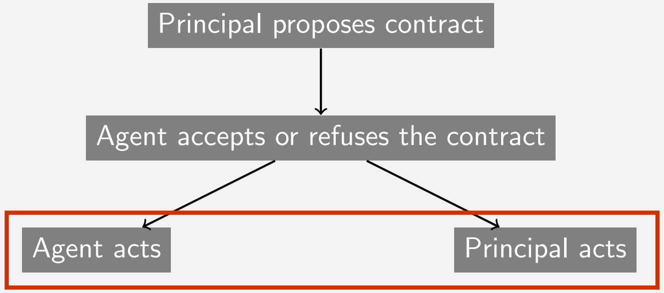
The selective intervention puzzle cannot be solved by traditional contract theory



With vertical integration, owner has more instruments, chooses in a larger set of contract, and hence is better off.

But the principal cannot NOT intervene

Masten: " Unable to use the courts to enforce promise to intervene selectively, management would be drawn to intervening even when joint benefits are not realized. Without effective assurances that owners will not appropriate performance enhancements, the incentives of division managers . . . are ineluctably compromised."



	"Traditional" contract theory	"Modern" contract theory
❶	Principal offers contract	Principal offers contract
❷	Agent accepts/refuses	Agent accepts/refuses
❸	Agent acts	Principal & agent act

- ☞ In "traditional" game theory, the principal is the party on behalf of which the agent takes some actions.
- ☞ In "modern" game theory, the principal is the party who offers the contract.

Grossman & Hart

Grossman & Hart's (1986) model

Very influential model in the 1980's and the 1990's.

The ingredients

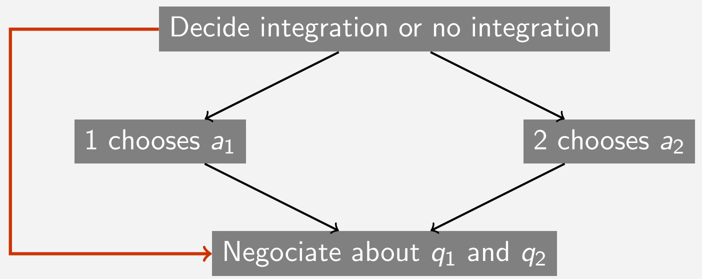
- ☞ Incomplete contracts.
- ☞ The principal is an agent.
- ☞ Investment in specific capital not protected by a contract
- ☞ Property rights.

What they do and do not do:

- Do not try to describe bounded rationality phenomena that lead to incomplete contracts.
- Show how property rights "complete" contracts in different ways under different structures.

The model

- 2 firms.
- Benefits of firm i's manager is $B_i(a_i, \phi_i(q_1, q_2))$, with B_i increasing in ϕ_i.
- Timing
  1. the decision to integrate or not is made,
  2. the a_is are chosen independently by each agent,
  3. the q_is are chosen after negotiation between the two agents,
- Vertical integration changes the status quo in the negotiation.



First best solution

With no incentive problem, one would solve

$$\max_{a_1, a_2, q_1, q_2} B_1(a_1, \phi_1(q_1, q_2)) + B_2(a_2, \phi_2(q_1, q_2))$$

Let $a_1^*, a_2^*, q_1^*, q_2^*$ be the unique solution to this problem.

Remark If q_1 and q_2 are contractible, then the first best can be obtained even if a_1 and a_2 are not contractible.
Indeed a_1^* is solution of

$$\max_{a_1} B_1(a_1, \phi_1(q_1^*, q_2^*)).$$

Non Integration

Assumption There exists a unique Nash equilibrium to the game (ϕ_1, ϕ_2) — there exists a unique $(\hat{q}_1, \hat{q}_2)$ such that

$$\begin{aligned} \phi_1(\hat{q}_1, \hat{q}_2) &\geq \phi_1(q_1, \hat{q}_2) \qquad \forall q_1, \\ \phi_2(\hat{q}_1, \hat{q}_2) &\geq \phi_2(\hat{q}_1, q_2) \qquad \forall q_2. \end{aligned}$$

If there is no contract, the firms will choose $(\hat{q}_1, \hat{q}_2)$ whatever the a_is.
Therefore, firm i will choose $\hat{a}_i$ to maximize $B_i(a_i, \phi_i(\hat{q}_1, \hat{q}_2))$.

Non integration: the role of renegotiation

We assume that the a_is are not contractible, but that the q_is are, although only at the start of the second period.
The agents have incentives to sign contracts before choosing the q_is.
Given a first period vector of a_is, this leads them to choose $q(a) = (q_1(a), q_2(a))$ and transfers p from 1 to 2 such that

$$\begin{aligned} B_1(a_1, \phi_1(q(a))) - p \\ &= B(a_1, \phi_1(\hat{q})) \\ &\quad + \frac{1}{2}\{[B_1(a_1, \phi_1(q(a))) + B_2(a_2, \phi_2(q(a)))] \\ &\qquad - [B_1(a_1, \phi_1(\hat{q})) + B_2(a_2, \phi_2(\hat{q}))]\} \\ &= \xi_1(a) \end{aligned}$$

Nash equilibrium

The Nash equilibrium of this game are the $\tilde{a}_i$s that satisfy

$$\begin{aligned} \xi_1(\tilde{a}_1, \tilde{a}_2) &\geq \xi_1(a_1, \tilde{a}_2) \qquad \forall a_1 \\ \xi_2(\tilde{a}_1, \tilde{a}_2) &\geq \xi_2(\tilde{a}_1, a_2) \qquad \forall a_1. \end{aligned}$$

This is inefficient because

$$\xi_1(a) = \frac{1}{2}B_1(a_1, \phi_1(\hat{q})) + \frac{1}{2}B_1(a_1, \phi_1(q(a))) + \text{terms in } a_2.$$

Firm 1 thinks about its bargaining position as well as increasing total surplus when choosing a_1.

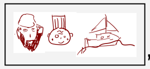
Control by firm 1

Assumption There exists a unique $(\bar{q}_1, \bar{q}_2)$ which maximizes $\phi_1(q_1, q_2)$.
Techniques are easy, but economics are subtle, so be careful.

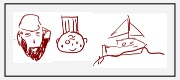
- ☞ Still no way to control a_2, and incentives not to choose the best q_is only according to 1's objective, $\Longrightarrow$ renegotiation.
- ☞ Same formulas as with no integration, but replace the $\hat{q}_i$s by the $\bar{q}_i$.
- ☞ Note importance of the definition of property rights.

An example

It is a story with a skipper, a chef and a boat.
This example is coming from Hart (1995)
by way of De Meza and Lockwood (1998).

If they all work together , then they obtain a payoff of 80.

If on top of that, the skipper learns about the history of the region, which cost him 11,

 + ,

then the payoff is 100.

Who should own the yacht?

Learning the history is an efficient non contractible investment by the skipper.

Without agreement

-  ⟶ 50;
-  ⟶ 55;
-  ⟶ 20;
-  ⟶ 20;

Without agreement

-  ⟶ 50;
-  ⟶ 55;
-  ⟶ 20;
-  ⟶ 20;

-  ⟶ 55;
-  ⟶ 25;

If skipper owns the yacht

- If skipper does not invest his payoff is

$$50 + \frac{1}{2}(80 - 50 - 25) = 52.5;$$

- If he invests his payoff is

$$55 + \frac{1}{2}(100 - 55 - 25) = 65.$$

$\Longrightarrow$ He will choose to invest as benefit $65 - 52.5 = 12.5$ greater than cost.

If chef owns the yacht

- If skipper does not invest his payoff is

$$20 + \frac{1}{2}(80 - 20 - 55) = 22.5;$$

- If he invests his payoff is

$$20 + \frac{1}{2}(100 - 20 - 55) = 32.5.$$

$\Longrightarrow$ He will choose not to invest as benefit $32.5 - 22.5 = 10$ less than cost.

It is efficient for the skipper to own the yacht, as this is the only way to get him to invest.

General lesson

It is generally efficient to give property rights to the party who we are trying to convince to invest.

Incomplete contracts

- A list of states?
- Are the models internally coherent?
- Consequences for vertical integration seem to be sensitive to assumptions about bargaining protocol (we will discuss this later).
- Do they really prevent efficient contracting? (Evans, *Econometrica*, 2008)

Riordan's contribution

- ☞ Riordan provides a critique of Grossman & Hart, specially of their definition of property rights and of vertical integration,...
- ☞ and proposes a theory of vertical integration of his own.

Mike Riordan's critique of the definition of property rights

A "A firm buys material inputs and contracts for the specific rights to employ labour and capital services in an upstream production process".

B "A firm contracts for output from a supplier but leases to the supplier some specialized asset used in its production".

Vertical Integration?

	A	**B**
G&H	no	yes
R	yes	no

The tradeoff in Riordan's theory

Vertical integration is "the organization of two successive production processes by the same firm". It gives the right to control the management and the information system of your supplier. ... "Informational structure defines organization modes".

Vertical integration

- ☞ provides better information to the downstream firm; it solves the "adverse selection" problem.
- ☞ but prevents the "principal" to commit to an incentive scheme; it creates a large "moral hazard" problem.

As a consequence,

- ☞ vertical integration gives better information and less powerful incentives
- ☞ no integration gives poor information but strong incentives.

Choices and timing

A firm can use either a standard component or specialized component (manufactured by the upstream firm) in order to produce a good.
Using a specialized component saves $\nu > 0$.

Timing is as follows:

1. effort $e \geq 0$ chosen by the manager/owner of the upstream firm.
2. cost c is realized; it is a function of effort and of a random variable.
3. the decision is made to use or not to use the specialized component.

What difference does vertical integration make?

- With vertical integration:
  - effort e equal to 0;
  - cost c perfectly well observed
- Without vertical integration:
  - the downstream firm makes a take it or leave it offer at a price p (to be determined)

Profits with vertical integration

Specialized component is used if $c \leq \nu$; hence value

$$\int_{c=0}^{\nu} (\nu - c)\, dF(c \mid 0)$$

Profits without vertical integration

- Notice that (p, e) is the Nash equilibrium of a simultaneous move game.
- Given the equilibrium p^*, the agent chooses the effort $e*$ that maximizes
$$\int_{c=0}^{p^*} (p^* - c)\, dF(c \mid e) - e.$$
- Given e^*, the principal chooses the price that maximizes
$$(v - p)F(p \mid e^*).$$

Summary of Riordan

With vertical integration, the principal acts after the contract is signed when he manipulates the measures of performance.

Vertical separation is the only way to prevent this manipulation.

De Meza - Lockwood
Other model of bargaining

De Meza & Lockwood argue that other models of bargaining are sometimes appropriate and lead to fundamentally different results.

Before studying the way their theory works, we need to think about the bargaining solutions. We will begin by considering the following example:

- Parties A & B bargain about a joint project, whose value is 1000;
- On his own, A has a payoff of 400 and B a payoff of 200;
- The Nash bargaining solutions gives $600 = 400 + (1000 - 400 - 200)/2$ to A and 400 to B.
- This is appropriate if the parties are ex ante whether to do the joint project or to go on their different ways.

Bargaining with outside options

Assume that the parties are already engaged in independent production when they come to the bargaining table, then De Meza & Lockwood argue that they would not split the increase in aggregate payoff, but the value of the joint project. Each party will get 500.

But, assume that the independent payoffs are 600 (instead of 400) for A and 200 for B.

- The Nash bargaining solution will give 700 to A and 300 to B.
- The outside option solution will give 600 to A (just enough to compensate him) and 400 to B.

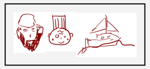
In both cases, efficient joint production is chosen by the two parties.

These different bargaining solutions can be defended more convincingly as the solutions of different "alternating offer games".

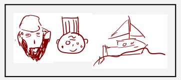
Organizational consequences

De Meza & Lockwood show that changing the bargaining solutions changes the optimal allocation of assets.

Remember that the payoffs for joint action are

 $\longrightarrow$ 80,

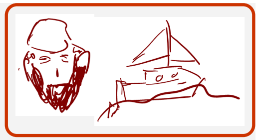
and

 +  $\longrightarrow$ 100.

The payoffs if they act on their own are

-  $\longrightarrow 50;$
-  $\longrightarrow 55;$
-  $\longrightarrow 20;$
-  $\longrightarrow 20;$
-  $\longrightarrow 55;$
-  $\longrightarrow 25;$

If skipper owns the yacht



- If skipper does not invest his payoff is

$$\max 50, 80/2 = 50;$$

(The chef get $80 - 50 = 30$, which is above his reservation utility of 25.)

- If the skipper invests his payoff is

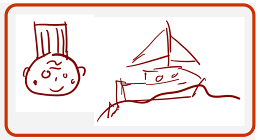
$$\max 55, 100/2 = 55.$$

(The chef get 10

$\Longrightarrow$ The skipper choo
less than cost.

Because it is the outside option that determines the payoff of the skipper, he does not directly benefit from the increase in the value of the joint project, and hence does not have sufficient incentives to invest.

If chef owns the yacht



- If skipper does not invest his payoff is

$$80 - 55 = 25;$$

(Note that a) this is higher that his reservation utility of 20 and b) the chef gets his reservation payoff of 55.)

- If he invests his payoff is

$$100 - 55 = 45.$$

$\Longrightarrow$ The skipper will choose to invest as benefit $45 - 25 = 20$ is greater than cost.

In words...

- When the skipper owns the yacht, his payoff is always equal to his reservation utility, which is only increased by 5 when he invests. Hence, he has no incentives to invest.
- When the chef owns the yacht, it is his payoff that is equal to his reservation utility. Because the chef's reservation utility does not depend on the investment, the skipper is the residual claimant and hence has the appropriate incentives to invest.

It is efficient for the chef to own the yacht, as this is the only way to get the skipper to invest.

Hart & Moore

Introduction to the Shapley value

Bargaining with three agents

- Assume that we have three agents, a, b and c.
- A game is represented by its value function that gives for each subset of players their aggregate payoff if they collaborate with each other.
- In our case,
  - $v(a,b,c)$ is the total profit of the three agents if they cooperate:
  - $v(a,c)$ is the payoff that a and c can obtain by cooperating with each other, in the absence of agent a;
  - $v(b)$ is the payoff that agent b can obtain on her own.
- We assume $v(\emptyset) = 0$ and that "working together" is always better. For instance

$$v(a,b,c) \geq v(b,c) + v(a).$$

Shapley value

	a	b	c
abc	$v(a)$	$v(ab) - v(a)$	$v(abc) - v(ab)$
acb	$v(a)$	$v(abc) - v(ac)$	$v(ac) - v(a)$
bac	$v(ab) - v(b)$	$v(b)$	$v(abc) - v(ab)$
bca	$v(abc) - v(bc)$	$v(b)$	$v(bc) - v(b)$
cab	$v(ac) - v(c)$	$v(abc) - v(ac)$	$v(c)$
cba	$v(abc) - v(bc)$	$v(bc) - v(c)$	$v(c)$

Payoff of a: $1/6$ of the sum of the first column:

$$\frac{v(abc) + v(a) - v(bc)}{3} + \frac{v(ab) + v(ac) - v(b) - v(c)}{6}$$

$$\frac{v(abc)+v(a)-v(bc)}{3}+\frac{v(ab)+v(ac)-v(b)-v(c)}{6}$$
$$=\frac{v(abc)}{3}+\frac{2v(a)-v(b)-v(c)}{6}+\frac{v(ab)+v(ac)-2v(bc)}{6}.$$

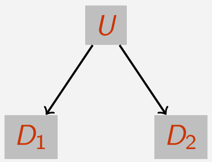
The sum of the payoffs of the three agents is $v(abc)$.

Why Shapley value?

Because there is an axiomatic defense if we ask for

- Efficiency;
- Symmetry;
- No profit for a phantom player;
- Additivity.

An example



U can invest in a first stage. If its investment is equal to I, and if D_1 uses I_1 while D_2 uses I_2, $I_1+I_2=I$, then total production is $\sqrt{I_1}+\sqrt{I_2}$.
Efficiency would require $I_1=I_2=1/4$.

Ex-post bargaining

By concavity of the production function, and because the two downstream firms are symmetric, after an investment of I, efficiency requires $I_1=I_2=I/2$, which yields an aggregate production of $\sqrt{2}\sqrt{I}$.

	U	D_1	D_2
UD_1D_2	0	$\sqrt{I}$	$(\sqrt{2}-1)\sqrt{I}$
UD_2D_1	0	$(\sqrt{2}-1)\sqrt{I}$	$\sqrt{I}$
D_1UD_2	$\sqrt{I}$	0	$(\sqrt{2}-1)\sqrt{I}$
D_1D_2U	$\sqrt{2}\sqrt{I}$	0	0
D_2UD_1	$\sqrt{I}$	$(\sqrt{2}-1)\sqrt{I}$	0
D_2D_1U	$\sqrt{2}\sqrt{I}$	0	0

Second period profits

$$U:\frac{1}{3}\sqrt{2}\sqrt{I}+\frac{1}{3}\sqrt{I};\qquad D_1\ \&\ D_2:\frac{1}{3}\sqrt{2}\sqrt{I}-\frac{1}{6}\sqrt{I}$$

Investments

Remember the profits:

$$U : \frac{1}{3}\sqrt{2}\sqrt{I} + \frac{1}{3}\sqrt{I}; \qquad D_1 \;\&\; D_2 : \frac{1}{3}\sqrt{2}\sqrt{I} - \frac{1}{6}\sqrt{I}$$

U maximizes

$$\frac{1}{3}\sqrt{2}\sqrt{I} + \frac{1}{3}\sqrt{I} - I,$$

which yields.

$$I = \frac{(\sqrt{2}+1)^2}{36} \simeq 0.162$$

Notice that the equilibrium investment is much larger than the investment with only one downstream firm, where it was $1/16 = 0.0625$.

General formula

We have a set $\underline{S}$ of I agents, $i = 1, 2, \ldots, I$. Let $v(S)$ be the value that a coalition S of agents can obtain "on its own". Assume

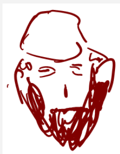
- $v(\emptyset) = 0$;
- $v(S \cup T) \geq v(S) + v(T)$.

Then the Shapley value is a way to distribute the gain from the coalition of the whole working together, by giving agent i

$$\sum_{\{S | i \in S\}} \frac{(s-1)!(I-s)!}{I!} \left[v(S) - v(S \backslash \{i\}) \right],$$

where s is the number of agents in S.
The fractional term is the proportion of orderings of the agents which begin by the $(s-1)$ agents of S in some order or the other, put agent i in s^{th} position, and the other agents afterwards.

The ownership of different assets: an example



It is a story with a boat, a skipper, a chef and a tycoon.

The example is drawn from Hart & Moore (1990).

Payoffs

- There is a service, learning how to cook Caribbean cuisine, which can be provided to the tycoon at cost 100 to the chef, and whose value is 240.
- There are lots of other skippers around; only one tycoon.

Who should own the yacht?

Learning Caribbean cuisine is an efficient non contractible investment by the skipper.

Investment and ownership

- If the skipper owns the yacht
  - If the chef invests, he will get benefits of $240/3 = 80$.
  - $\Longrightarrow$ The chef will not invest.
- If the tycoon owns the yacht
  - If the chef invests, he will share the benefits only with the tycoon and get $240/2 = 120$.
  - $\Longrightarrow$ The chef will invest.
- Similarly, the chef will invest if he himself owns the yacht.

What if we also need an investment from the skipper?

Assume that the skipper can also increase the value of the cruise to the tycoon, by learning the history of the islands, under the same condition as the chef (cost of 80, yields benefits of 240 — if both chef and skipper invest total benefit is 480).

- By the same reasoning as above, the skipper will invest only if the tycoon or the skipper own the yacht.

$\Longrightarrow$ We can get the efficient solution, both skipper and chef investing, only by having the tycoon own the yacht.

> It may be optimal to give ownership to an indispensable agent, even if he does not invest.

Complementary assets

We change the model in four directions:

- The tycoon can also take an action, which brings him benefits 240 if he has access to the yacht (inviting friends).
- We parametrize the costs: c_c, c_s, c_t.
- We assume that the boat can be separated in two parts: the hull and the galley, whose ownership can be giving to different agents, but who must be used together.
- We assume that the services of the chef and the skipper are not specific to the tycoon.

Incentives for investment

	chef/galley - skipper/hull	chef owns all
chef	$240/2 - c_c$	$240 - c_c$
skipper	$240/2 - c_s$	$240/2 - c_s$
tycoon	$240/3 - c_t$	$240/2 - c_t$

> It is optimal to give ownership of complementary assets to the same agent.

The productivity of a coalition depend on the assets it controls and the investment of its members.

Hart & Moore assume that the benefit of agent i is

$$B_i(x \mid \alpha) = \sum_{\{S \mid i \in S\}} p(S)\left[v(S, \alpha(S) \mid x) - v(S \backslash \{i\}, \alpha(S \backslash \{i\} \mid x)\right],$$

with

$$p(S) = \frac{(s-1)!(I-s)!}{I!},$$

and

- ☞ $\alpha(S)$ is the set of assets that the coalition controls;
- ☞ $x = (x_1, x_2, \ldots, x_I)$ is the vector of investment in human capital of the agents.

Assumptions

1. $C_i(x_i)$, the cost of investing x_i has all the nice properties.
2. $v(S, A \mid x) \geq 0$ is twice differentiable in x, with $v(\emptyset, A \mid x) = 0$.
3. $v^i(S, A \mid x) \equiv \dfrac{\partial}{\partial x_i} v(S, A \mid x) = 0$ if $i \notin S$.
4. $(\partial / \partial x_j) v^i(S, A \mid x) \geq 0$ if $j \neq i$.
5. $S' \subseteq S$, $A' \subseteq A$ imply $v(S, A \mid x) \geq v(S', A' \mid x) + v(S \backslash S', A \backslash A' \mid x)$.
6. $S' \subseteq S$, $A' \subseteq A$ imply $v^i(S, A \mid x) \geq v^i(S', A' \mid x)$.

Control structure

An ownership structure is a function from the set of coalitions to the set of assets that the coalition controls. It satisfies

- ☞ $\alpha(S) \cap \alpha(\underline{S} \backslash S) = \emptyset$;
- ☞ $S' \subseteq S \implies \alpha(S') \subseteq \alpha(S)$.

Investment choice by agents

Agent i maximizes

$$B_i(x \mid \alpha) = \sum_{\{S \mid i \in S\}} p(S)\left[v(S, \alpha(S) \mid x) - v(S \backslash \{i\}, \alpha(S \backslash \{i\} \mid x)\right],$$

which yields

$$B_i' = \sum_{\{S \mid i \in S\}} p(S) v^i(S, \alpha(S) \mid x) = C_i'(x_i).$$

This implies that there is suboptimal investment.
Note that investment by i increases when the coalitions to which he belongs control more assets.

Assumption 6 :$S' \subseteq S$, $A' \subseteq A$ imply $v^i(S, A \mid x) \geq v^i(S', A' \mid x)$.

Some results

Proposition 2 If only agent i invests, then it should own all the assets (*i.e.*, $a_n \in \alpha(S) \iff i \in S$).

Proposition 3 Take any coalition S. One always (weakly) gain by making sure that an asset is always controlled by either S or $\underline{S} \backslash S$. *Proof: if not true give control of asset to S and any coalition that contains S.*

Indispensable agent

Agent i in indispensable to asset a_n if

$$v^j(S, A^| x) = v^j(S, A \backslash \{a_n\} \mid x) \text{ if } i \notin S.$$

A stronger condition is that a_n is indiosyncratic to i:

$$v^j(S, A^| x) = v^j(S, A \backslash \{a_n\} \mid x) \text{ for all } j \neq i.$$

Proposition 6 An agent should own an asset for which he is indispensable. *Proof: replace the control structure by one in which i owns a_n.*

Note that text of proposition should be amended to take into account the fact that two, or more, agents could be indispensable for an asset - this is done in proposition 7 which shows that the entire group should own the asset.

Assets which should be owned together

Assets a_m and a_n are strictly complementary if

$$v^i(S, A \backslash \{a_m\}) = v^i(S, A \backslash \{a_n\}) = v^i(S, A \backslash \{a_m, a_n\}) \text{ if } i \in S.$$

Proposition 8 If two assets are complementary they should be owned/controlled together.

Dispensable agents and control rights

Agent k has some **control rights** is there is a_n and S, with $k \in S$ such that

$$a_n \in \alpha(S) \text{ and } a_n \notin \alpha(S \backslash \{k\}).$$

Agent k is **dispensable** if

$$v^j(S, A) = v^j(S \backslash \{k\}, A) \text{ when } j \in S \ (j \neq k).$$

Proposition 9. If stochastic control is feasible, then an agent who is dispensable and who has no investment should have no control right.

Relational contracts

Relational contracts theory study the link between informal and formal contracts

The study of relational contracts was launched by George Baker, Robert Gibbons & Kevin J. Murphy in a 2001 *QJE* paper.
Several ways to see it:

- A dynamic extension of Grossman & Hart;
- An analysis of the ways in which informal and formal contracts interfere with each other;
- A solution to the "selective intervention" paradox

A very nice theoretical exploration of the contractual properties of relational contracts can be found in Jonathan Levin's 2003 *AER* paper.

Preliminary: the role of threats in repeated games

Two players come to an arrangement for a joint project. The total payoff from the project is S, so that each player obtains a surplus of $S/2$.
Assume now that they realize that this is repeated situation, and that if they cooperate to obtain the first best, they obtain a total surplus of S^* per period. Each player can get P by "cheating".
They share the surplus equally and cooperation is feasible if

$$\sum_{0}^{+\infty} \delta^t (S^*/2) \geq P + \delta \sum_{1}^{+\infty} \delta^t (S/2)$$

$$\iff S^* \geq 2(1-\delta)P + \delta S.$$

S^* and P do not depend on the institutional arrangement, but S does!

> The worse arrangement from a static viewpoint is the best from a dynamic viewpoint. (Halonen)

BGM use a setup inspired by Grossman & Hart

In each period

- U chooses actions $a = (a_1, \ldots, a_n)$ at cost $c(a)$.
- Downstream value can be
  - high (equal to Q_H) with probability $q(a)$;
  - high (equal to Q_L) with probability $1 - q(a)$.
- Alternative-use value can be
  - high (equal to P_H) with probability $p(a)$;
  - high (equal to P_L) with probability $1 - p(a)$.
- $P_L < P_H < Q_L < Q_H$.
- $c(0) = 0$; $p(0) = q(0) = 0$.

The first best action, a^*, yields total surplus

$$S^* = Q_L + q(a^*)\Delta Q - c(a^*)$$

Institutional arrangements

- First, The upstream party uses the asset to produce a good.
- Second, the parties negotiate over the use of the good
  - The party who owns the asset can take the good and uses it however it sees fit (the use of the good is not contractible)

BGM consider four institutional arrangements

	Ownership Environment	
Governance Environment	Non-Integrated Asset Ownership	Integrated Asset Ownership
Spot	Spot Outsourcing	Spot Employment
Relational	Relational Outsourcing	Relational Employment

Spot Outsourcing

- Static;
- Upstream owns asset

This implies

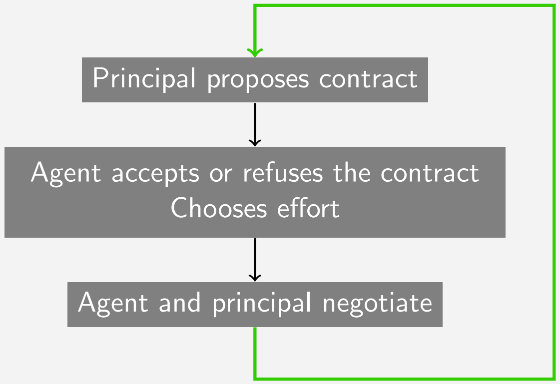
- Upstream payoff is $(Q_i + P_j)/2$.
- a^{SO} solves

$$\max_a \frac{Q_L + q(a)\Delta Q}{2} + \frac{P_L + p(a)\Delta P}{2} - c(a).$$

$\Longrightarrow$ a in general inefficient.

- Downstream payoff is $(Q_i - P_j)/2$. Expected payoff is $D^{SO} = E[Q_i - P_j \mid a = a^{S0}]/2$.
- Payoff is

$$S^{SO} = D^{SO} + U^{SO} = Q_L + q(a^{SO})\Delta Q - c(a^{SO}).$$



Spot Employment

- ☞ Static;
- ☞ Upstream owns asset

As in Riordan, with spot employment, U makes 0 effort.

Note: there are circumstances in which SE dominates SO.

Relational employment: surplus

A relational employment contract is an object of the form

$$(s, \{b_{ij}\}_{(ij)=\{HH,HL,LH,LL\}})$$

where s is contractible fixed salary and the b_{ij}s are non-contractible contingent salaries.
If U accepts contract, it chooses a^{RE} that maximizes

$$s + b_{LL}(1-q(a))(1-p(a)) + b_{HL}q(a)(1-p(a)) \\ + b_{LH}(1-q(a))p(a) + b_{HH}q(a)p(a) - c(a) \equiv U^{RE}.$$

We also have

$$D^{RE} \equiv E[Q_i - s - b_{ij} \mid a = a^{RE}] = Q_L + \Delta Q q(a^{RE}) - [U^{RE} - c(a^{RE})]$$
$$S^{RE} \equiv U^{RE} + D^{RE} = Q_L + \Delta Q q(a^{RE}) - c(a^{RE})$$

Relational employment: self-enforcement

- ☞ D reneges on the contract by taking the good and refusing to pay b_{ij} (by our definition of owning the asset, he can do that);
- ☞ U reneges by refusing to accept/make a payment.

After one party has reneged, the parties go in a repeated static equilibrium, after renegotiating ownership.

Relational employment: self-enforcement when $S^{SE} > S^{SO}$

- D honor contract if

$$-b_{ij} + \frac{1}{r}D^{RE} \geq \frac{1}{r}D^{SE}$$

- U honor contract if

$$b_{ij} + \frac{1}{r}U^{RE} \geq \frac{1}{r}U^{SE}$$

$\Longrightarrow$ Sufficient and necessary condition for enforcement is

$$\max b_{ij} - \min b_{ij} \leq \frac{1}{r}(S^{RE} - S^{SE}).$$

Relational employment: self-enforcement when $S^{SE} < S^{SO}$

Same analysis than for case $S^{SE} > S^{SO}$, replacing SE by SO, except for the case that we must be careful about the fact that there is a payment linked to the fact that the asset is sold. In the end, it makes no difference.

$\Longrightarrow$ Sufficient and necessary condition for enforcement is

$$\max b_{ij} - \min b_{ij} \leq \frac{1}{r}(S^{RE} - S^{SO}).$$

$\Longrightarrow$ Enforcement is feasible iff

$$\max b_{ij} - \min b_{ij} \leq \frac{1}{r}(S^{RE} - \max\{S^{SE}, S^{SO}\}).$$

Relational outsourcing: surplus

The analysis of the surplus is exactly the same as in the case of relational employment (this slide was build by copy and paste!) If U accepts contract, it chooses a^{RO} that solves

$$s + b_{LL}(1 - q(a))(1 - p(a)) + b_{HL}q(a)(1 - p(a)) + b_{LH}(1 - q(a))p(a) + b_{HH}q(a)p(a) - c(a) \equiv U^{RO}.$$

We also have

$$D^{RO} \equiv E[Q_i - s - b_{ij} \mid a = a^{RO}] = Q_L + \Delta Q q(a^{RO}) - [U^{RO} - c(a^{RO})]$$
$$S^{RO} \equiv U^{RO} + D^{RO} Q_L + \Delta Q q(a^{RO})$$

The only difference between RE and RO is in the incentives to renege.

Relational outsourcing: self-enforcement

- D reneges on the contract by refusing to take possession of the good and paying b_{ij}. Then, he renegotiates with U to purchase the good at price $(Q_i + P_j)/2$;
- U reneges by refusing to accept/make a payment, and renegotiating with D to sell the good at price $(Q_i + P_j)/2$

After one party has reneged, the parties go in a repeated static equilibrium, after renegotiating ownership. There are two renegotiations.

Relational outsourcing: self-enforcement when $S^{SE} < S^{SO}$

- D honors contract if

$$Q_i - b_{ij} + \frac{1}{r}D^{RO} \geq \frac{Q_i - P_j}{2} + \frac{1}{r}D^{SO}$$
$$\iff b_{ij} - \frac{Q_i + P_j}{2} \leq \frac{1}{r}(D^{RO} - D^{SO}).$$

- U honors contract if

$$b_{ij} - \frac{Q_i + P_j}{2} \geq \frac{1}{r}(U^{SO} - U^{RO})$$

$\Longrightarrow$ Sufficient and necessary condition for enforcement is

$$\max(b_{ij} - \frac{Q_i + P_j}{2}) - \min(b_{ij} - \frac{Q_i + P_j}{2}) \leq \frac{1}{r}(S^{RO} - S^{SO}).$$

Relational outsourcing: self-enforcement when $S^{SE} > S^{SO}$.

Reasoning is same as for relational employment when the asset changes hands.
We get the following necessary and sufficient condition:

$$\max(b_{ij} - \frac{Q_i - P_j}{2}) - \min(b_{ij} - \frac{Q_i - P_j}{2}) \leq \frac{1}{r}(S^{RO} - \max\{S^{SO}, S^{SE}\}.$$

The answer to the selective intervention puzzle

It is impossible to replicate the outcome from spot outsourcing with relational employment.

To replicate the outcome of spot outsourcing, one would use the contract $(s = 0, \{b_{ij} = (Q_i - P_j)/2\})$. But this cannot satisfy the self enforcement equation of relational employment

$$\max b_{ij} - \min b_{ij} \leq \frac{1}{r}(S^{RE} - \max\{S^{SE}, S^{SO}\}),$$

as the rhs would become

$$\frac{1}{r}(S^{SO} - \max\{S^{SE}, S^{SO}\}) \leq 0,$$

whereas the lhs is positive.

Simplifying the model to get further results.

To get more results BGM simplify the model by assuming

$$q(a) = q_1 a_1 + q_2 a_2,$$
$$p(a) = p_1 a_1 + p_2 a_2,$$
$$c(a) = \frac{a_1^2}{2} + \frac{a_2^2}{2}.$$

This implies

$$a_i^{FB} = q_i \Delta Q$$
$$a_i SO = \frac{1}{2} q_i \Delta Q + \frac{1}{2} p_i \Delta P$$
$$a_i^{SE} = 0.$$

Restricting the payoffs

BGM also assume that we can write the b_{ij}s under the form

$$b_{ij} = b_i + \beta_j.$$

This gives us four equations in four unknowns, the two b_is and the two β_js. Why is this a restriction?

We must have

$$b_{HH} - b_{HL} = b_{LH} - b_{LL} \iff b_{HH} - b_{LH} = b_{HL} - b_{LL}.$$

New formulation for self-enforcing conditions

$$|\Delta b| + |\Delta \beta| \leq \frac{S^{RE} - \max\{S^{SO}, S^{RE}\}}{r} \quad \text{(RE)}$$

$$|\Delta b - \frac{\Delta Q}{2}| + |\Delta \beta - \frac{\Delta P}{2}| \leq \frac{S^{RO} - \max\{S^{SO}, S^{RE}\}}{r} \quad \text{(RO)}$$

Notice: To implement high powered incentives will be easier with *RO* than *RE* (result 2): For given Δb and $\Delta\beta$ (which determine output), the renegotiation of the deal if it is broken makes reneging less attractive.

The optimal organizational structure

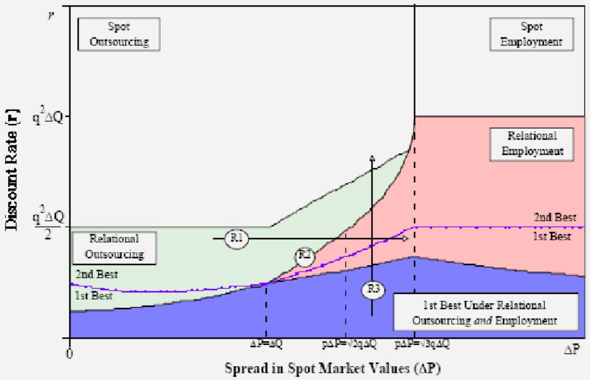


Figure II: Efficient Organization Form as a Function of r and ΔP
($q(a) = qa_1$, $p(a) = pa_2$, and $c(a) = \frac{1}{2} a_1^2 + \frac{1}{2} a_2^2$)

The figure shows how the efficient organizational form varies with the discount rate (r) and the difference between the high and low market valuations (ΔP), assuming that p=q=1. Our first three results are illustrated in (R1) through (R3) (see the text for a complete discussion).

Supply prices

Vertical integration is favored by "widely varying supply prices" (result 1)

BGM interpret a high ΔP as widely supply prices, although no good is bought at this price. It is more "widely varying outside opportunities".
Formal reason is that *RO* becomes non self-enforcing as ΔP becomes very large:

$$|\Delta b - \frac{\Delta Q}{2}| + |\Delta \beta - \frac{\Delta P}{2}| \leq \frac{S^{RO} - \max\{S^{SO}, S^{RE}\}}{r} \quad \text{(RO)}$$

...

...

$$|\Delta b - \frac{\Delta Q}{2}| + |\Delta\beta - \frac{\Delta P}{2}| \leq \frac{S^{RO} - \max\{S^{SO}, S^{RE}\}}{r} \qquad \text{(RO)}$$

Informally: an increase in ΔP translates in an increase in $\Delta\beta$, so has to decrease the incentives to renege. But this implies that lots of effort will be place in getting P_H, which is bad for efficiency. Note difference with G & H, where it is the level of prices which determine incentives.

Optimal integration decision depends on payoff levels, not just on the expected payoffs (result 4)

In a static G & H type framework, the incentives would depend on the expected values of ΔP and ΔQ. For BGM, the levels obtained affect incentives to cooperate even if expected values are constant.

Application to regulation

Costs and benefits of separate ownership

In *A theory of Incentives in Procurement and Regulation* par Jean-Jacques Laffont et Jean Tirole wrote:

“An important question in regulatory theory is to identify the costs and benefits of breakups in a regulatory situation. Among these costs are those emphasized in the literature on incomplete contracts and ownership structure in unregulated industries: reduction of coordination, possible expropriation of specific investment. . .

. . . Divestiture . . . would reduce the incentives of the producer of the intermediate good to favor one final good producer over the others. We feel that the integration of the literatures on market foreclosure and on regulation will help reframe the policy debate."

How can we think about this?

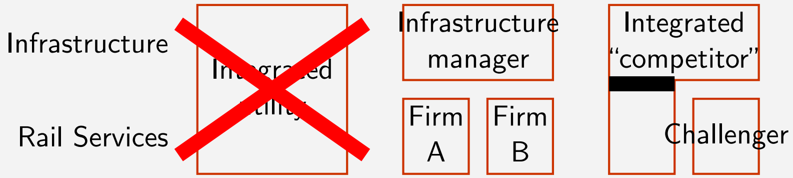
Railroads

COUNCIL DIRECTIVE 91/440/EEC of 29 July 1991

. . .
"Whereas the future development and efficient operation of the railway system may be made easier if a distinction is made between the provision of transport services and the operation of infrastructure; whereas given this situation, it is necessary for these two activities to be separately managed and have separate accounts;"
. . .
The aim of this Directive is to facilitate the adoption (*sic*) of the Community railways to the needs of the single market and to increase their efficiency;. . . by separating the management of railway operation and infrastructure from the provision of railway transport services,separation of accounts being compulsory and organizational or institutional separation being optional;
. . .

DIRECTIVE 91/440/EEC of 29 July 1991 (cont.)

. . . **SECTION III** :Separation between infrastructure management and transport operations
Article 6
1. Member States shall take the measures necessary to ensure that the accounts for business relating to the provision of transport services and those for business relating to the management of railway infrastructure are kept separate. . . .
2. Member States may also provide that this separation shall require the organization of distinct divisions within a single undertaking or that the infrastructure shall be managed by a separate entity.



Historical experience

Different countries have had widely varying levels of integration of the management of the infrastructure with the provision of services.

We will not review it here; just look at an example and briefly at some data.

Efficiency costs - round wheels

- The wheels of railroad wagons and locomotives work best when they are round, but the longer a wagon is operating, the more irregular the shape of wheels becomes. This increases wear-and-tear on track and the risk of accidents.
- Novel technologies can help identify irregularities through sensors in the track and transponders on the wagons and locomotives. This generate precise data and help focus maintenance efforts on irregular wheels.
- This requires new technologies at the train level and at the track level and standardized data.
- How do we do encourage use of such technologies in a non integrated framework?

Efficiency costs - data

- Using US data, Ivaldi and McCullough (2002) tests for sub-additivity in the cost function for infrastructure and freight operations. The results indicate that firms running each activity separately have 2.42% higher operational costs than a vertically integrated firm.
- Mizutani and Shoji (2001) studied the Kobe-Kosoku Railway in Japan and found that vertically separated firms cost 5.6% more than an integrated system.
- Shires et al. (1999a) compared the cost of the Swedish operator after a reform involving vertical separation, and found that operating costs had been reduced by 10% (but due to other aspects of the reforms?).

 and : What is the difference?

- If separate accounting implies that the regulator has enough instruments to force the downstream unit of the integrated firm to be run in a totally independent manner, there is no difference.
- For our purposes, we will make at times the extreme assumption that
  - The regulator can enforce non-discrimination in the short run;
  - Investments are made by both parts of the integrated entity to maximize global profits.
- Of course, in reality the regulator does not have enough power to fully prevent non-discrimination in the short run, and could prevent some investments that are too biased.

The benefits of 

- Integration might encourage some investments by the upstream component that serve both the downstream component and its competitor;
- The downstream firm will take into account the interests of the upstream firm in its investment decisions.
- Information about the downstream market might be better accessible to the upstream firm.

Optimistic scenario for the wheel example

- Because the upstream and downstream components of the integrated firm both take into account the long run interests of the whole firm, they are able to coordinate on their respective share of the investments;
- because the rail network is equipped it is worthwhile for the downstream competitor also to invest in its share of the monitoring equipment;
- Yes! there are more pessimistic scenarios.

A sketch of a simple model: the actors

- One upstream firm.
- Two downstream firms.
- The upstream firm chooses the size of the network, which is an essential facility.
- The downstream firms compete in a market — mostly Bertrand competition with perfect substitutes.

The game

1. The upstream firm chooses the size of the network.
2. The downstream firms choose their prices, taking as given the price of using the network.

Results

- ☞ Model is biased: best structure is always to have the upstream firm own both downstream firms (because they compete!).
- ☞ We show that it is better to have the upstream firm own one downstream firm rather than 0, even when investment is biased towards the firm it owns.

Levin

This is a fantastic paper

We now look at Levin's 2003 *AER* paper:

1. It is great and a good example on how to do theory.
2. It generalizes the analysis of relational contract of BGM.
3. It provides an interesting views of relationships within repeated contracts.

Major results

Basic idea: study the enforceability of implicit contracts, and develop techniques to study their propoerties.
Major results can be divided in two categories

- General methodological results:
  - Stationarity of optimal contracts.
  - Bounds on (variations on) payments.
- Applications:
  - Adverse selection *à la* Baron-Myerson.
  - Moral hazard.
  - "Subjective performance measure".

The set-up

- A principal and an agent.
- $t = 0, 1, \ldots$.
- y_t, benefit to the principal, generated by $F(y_t \mid e_t)$ at cost $c(e_t, \theta_t)$. (Note that F and c are stationary.)
- Principal observes $\phi_t \subseteq \{\theta_t, e_t, y_t\}$, which contains y_t and may contain e_t and θ_t.
- In each period contract $(w_t, b_t(\phi_t))$, where only w_t is enforceable by law.
- If contract refused in any period, fall back utilities $\overline{u}$ (for agent) and $\overline{\pi}$ (for principal).

The principal has incentives to/can renege when $b_t(\phi_t) > 0$ and the agent when $b_t(\phi_t) < 0$.

Self enforcing contracts

They must satisfy

1. $u \geq \overline{u}$ & $\pi \geq \overline{\pi}$.
2. Let $W(\phi) \equiv w + b(\phi)$, relax about time subscript, then

$$e(\theta) \in \arg\max_e E_\phi \left[W(y) + \frac{\delta}{1-\delta} u(\phi) \mid e \right] - c(e, \theta).$$

   (Notice strange accounting of discounts.)
3. Parties are willing to make discretionary payments

$$(1-\delta) \times (-b(\phi)) + \delta\pi(\phi) \geq (1-\delta) \times 0 + \delta\overline{\pi}$$
$$\iff -b(\phi) + \frac{\delta}{1-\delta}\pi(\phi) \geq \frac{\delta}{1-\delta}\overline{\pi}$$

   (and same thing on agent's side).
4. Each continuation contract is self-enforcing.

Stationarity

Levin proves that there exists an stationary optimal contract.

- Important: simplifies analysis.
- Not obvious: why isn't there accumulation of debt or credit across time.

A preliminary remark

If $\exists$ a self enforcing contract that generates surplus

$$s > \bar{s} \equiv \bar{u} + \bar{\pi},$$

then $\exists$ self-enforcing contracts that give any pair of expected payoff (u, π) with

$$u + \pi = s,\ u \geq \bar{u},\ \pi \geq \bar{\pi}$$

.

Proof: change first period payoff.

Stationarity

If $\exists$ optimal contract, $\exists$ *stationary* optimal contract.

Proof. Call s^*, π^* and u^* the surpluses generated by the optimal contract. Write another contract

$$b^*(\phi) = b(\phi) + \frac{\delta}{1-\delta}u(\phi) - \frac{\delta}{1-\delta}u^*$$
$$\iff b^*(\phi) + \frac{\delta}{1-\delta}u^* = b(\phi) + \frac{\delta}{1-\delta}u(\phi)$$

(gives same incentives to agents) and w^* set so that utilities are the same.
This is a self enforcing stationary contract that gives the same payoffs to the agents.

Renegotiation

Problem: After deviation, payoffs go back to $\bar{u}$ and $\bar{\pi}$ $\Longrightarrow$ incentives to renegotiate $\Longrightarrow$ punishment no credible.

Solution: Change contract so that after deviation, agent who deviated is at his/her reservation utility and the other one gets $s^* - \bar{u}$ or $s^* - \bar{\pi}$. Same incentives not to deviate, no incentives to renegotiate.
Levin calls contracts that satisfies this property *strongly optimal*.

There are optimal contracts that are stationary, self enforcing and strongly optimal.

Implementability

The effort schedule $e(\theta)$ can be implemented iff

- *IC* constraint: e best static response to W;
- *DE* (Dynamic Enforcement) constraint:

$$\frac{\delta}{1-\delta}(s - \bar{s}) \geq \sup_{\phi} W(\phi) - \inf_{\phi} W(\phi).$$

Proof of DE. We must have

$$\frac{\delta}{1-\delta}(\pi - \bar{\pi}) \geq \sup_{\phi} b(\phi) \text{ and } \frac{\delta}{1-\delta}(u - \bar{u}) \geq -\inf_{\phi} b(\phi).$$

Add these two inequalities to get

$$\frac{\delta}{1-\delta}(s - \bar{s}) \geq \sup_{\phi} b(\phi) - \inf_{\phi} b(\phi) = \sup_{\phi}(w + b(\phi)) - \inf_{\phi}(w + b(\phi)),$$

which proves the result.

Adverse selection

- Principal observes e and not θ.
- Cost c increasing and convex in e, increasing in θ, with $c_{e\theta}$, $c_{\theta ee}$ and $c_{\theta e\theta}$ positive.
- And we add constraints on the distribution of costs — to make problem well behaved.

I will not prove the results just explain a little bit.

Adverse selection (2)

Theorem 4 states that $e(\theta)$ is implementable iff e non-increasing and

$$\frac{\delta}{1-\delta}(s-\bar{s}) \geq c(e(\underline{\theta}),\underline{\theta}) + \int_{\underline{\theta}}^{\overline{\theta}} c_\theta(e(\tau),\tau)\, d\tau.$$

Hint of proof. The standard incentive compatibility condition show $\dot{U} = -c_\theta$, and because $W = U + c$ we can express the variation in W as a function of c_θ.
Notice that DE puts limits on the power of incentives as the c_θ cannot be too large, which, because $c_{e\theta} > 0$, implies that e cannot be too large.

Adverse selection (3)

The optimal production schedule takes one of the following three forms

- **Pooling** $e(\theta)$ is constant;
- **Semi-pooling** e is constant on $[\underline{\theta},\hat{\theta}]$ and strictly decreasing on $(\hat{\theta},\overline{\theta}]$;
- **First-best** e is first best effort for all θ.

If the first best cannot be implemented, $e(\theta)$ is strictly smaller that the first best for all θ.

Subjective performance measure

Assume e is privately chosen, and principal privately observes y. Assuming that the contract gives the principal incentives to reveal y, Levin shows that optimal contract if of the following form: if y is “small” relationship terminates with payment w; if y “large” relationship continues with payment $w + b$.

Can you see relationship with Riordan’s theory of vertical integration?

Discussion

- ☞ What happens if investment changes stationarity of environment?
- ☞ There is lots of work on dynamic incentives contracts.
- ☞ Problems of adding two sided asymmetric information.
- ☞ More than two parties.

Arm's length relationships

Arm's Length relationship

In which I explain why you may want *not* to have information in order to provide better incentives.

In classical principal agent theory, there is never any loss, and there are in general benefits, in using all available information in the design of incentive schemes (see Holmström (1979)).
But

- ☞ Firms sometimes choose external procurement for products that could be done in house, "If we do this in house, and it is not well done we will spend endless hours trying to determine who is to blame. If an outsider does it for us, and we do not like the result, we can switch."
- ☞ Many professors "do not want to hear" the reasons why undergraduates do not complete their assignments, in part because they want to go back to their research, in part because they know that future students will work harder for somebody who has the reputation of not giving second chances.

Model

An agent affects output in two ways:

- First, by his suitability for the job (incentive compatibility);
- second, by his effort (moral hazard)

In each period, the agent can also be lucky or unlucky, and this luck will affect production.
The principal can examine output at no cost. He can also, at some cost, examine ex post the reasons for the performance of the agent, and in particular determine his ability.

- an efficient monitoring technology gives the reasons for the performance at the end of the first period.
- an inefficient technology does not

Why would the principal ever refuse an efficient monitoring technology?
It prevents him from threatening the agent by statements of the type "if output is low, you will be fired" which are not credible.
Indeed, upon seeing a low output he will want to check the reason.
If the agent has been unlucky, but adapted to the job, the principal would rather keep him than hire another one.
Intuition linked to theory of vertical integration and of influence costs.

Presentation of the model: one period, very simple

Agents can be of two types and before works begin neither principal nor agent know the type. The proportion of good agents is $p \in (0,1)$.

- A poor agent always has a productivity of zero;
- the productivity of a good agent depends on his effort:
  - A strong effort, for which he has a disutility of 1 franc: yields a profit of B with probability q_h and of 0 with probability $(1-q_h)$.
  - A weak effort, which brings no disutility, yields profits of B with probability q_ℓ and 0 with probability $(1-q_\ell)$.

$$q_\ell < q_h$$

- The principal is risk neutral. The reservation utility of an agent is 0 franc.

Let w be the wage when output is B (it is obviously optimal to give a wage of 0 for low output).
Effort will be high if

$$pq_h w - 1 \geq pq_\ell w \iff w \geq w^1 = \frac{1}{p\delta},$$

where $\delta = q_h - q_\ell$.
Principal's expected profit:

$$S = pq_h(B - w^1) = pq_h B - \frac{q_h}{\delta}.$$

The principal can also ask for no effort, with wage is 0, and profit $pq_\ell B$.
We assume

$$B > \bar{B} = \frac{q_h}{p\delta^2} \iff S \geq pq_\ell B,$$

the principal finds it worthwhile to induce high effort.

The two period model

1. The principal chooses the monitoring technology;
2. The principal offers a contract to the agent;
3. The agent chooses first period effort and nature chooses first period output;
4. The principal decides whether or not to propose a new contract to the agent, who decides whether or not to accept it;
5. If the contract in force requires it, monitoring takes place;
6. If the contract in force requires it the principal fires the agent, after paying him any salary that he owes him, and hires another agent;
7. The agent chooses second period effort and nature second period output;
8. The agent is rewarded according to the terms of the contract.

A second period contract is composed of the following elements:

- a statement that there will be or will not be monitoring.
- a statement that the the agent will be rehired or fired (if monitoring is to be used this decision can be a function of its result);
- if the contract calls for the agent to be fired a payment;
- if the contract calls for the agent to be rehired a payment contingent on second period output.

A first period contract is a function from $\{0, B\}$ to second period contracts.
A first period contract is renegotiation proof when there exists an equilibrium of the continuation game where the principal chooses not to offer a new contract at stage.
It is easy to see that the best renegotiation proof contract is not dominated by a contract in which renegotiation takes place (renegotiation principle).
Two points deserve to be stressed:

- the principal cannot commit not to renegotiate;
- the only renegotiation proofness constraint that binds is the constraint bearing on the decision to fire the agent. I assume that the principal can commit himself to second period wages, and show ex-post that there is no incentive to renegotiate second period wages.

The efficient monitoring technology

After choosing the efficient monitoring technology, the principal will not be able to commit himself to firing the agent if the output is equal to 0 in the first period:

- If he fires him, the sum of the utilities of the (old) agent and the principal in the second period will be S.
- This can be increased to S' (same as S when $p = 1$) by rehiring the agent when it is known that he is of high quality, and this can be determined at no cost. By sharing the increase in social welfare both parties can be made better off than in the original contract, and hence renegotiation would occur.
- Similarly, it would not be feasible to commit oneself to rehire an agent of low quality.

The only renegotiation proof contracts will therefore specify that monitoring will take place and that the agent will be fired if he is found to be of low quality.
More precisely, these contracts will be composed of two second period contracts:

- a second period contract applicable if first period output is B: the agent is rehired, he is paid $w(B0)$ if second period output is low and $w(BB)$ if second period output is B.
- a second period contract applicable if first period output is 0. This contract states that monitoring will take place, then
  - if the agent is of low quality, he is paid $w(0)$ and fired;
  - if the agent is of high quality, he is rehired, paid $w(00)$ or $w(0B)$.

When the contract has been signed, the payoff of the principal is (discount rate is 0)

$$p[q_h^2(2B - w(BB)) + q_h(1-q_h)(B - w(B0)) + (1-q_h)q_h(B - w(0B)) - (1-q_h)^2 w(00)] + (1-p)[S - w(0)]$$

The optimal contract is then solution of

$$\begin{aligned}
&\max_{w(\cdot)} - pq_h^2 w(BB) - pq_h(1-q_h)(w(0B) + w(B0)) \\
&\qquad - p(1-q_h)^2 w(00) - (1-p)w(0) \\
\text{s.t. } & q_h w(BB) + (1-q_h)w(B0) - 1 \geq q_\ell w(BB) + (1-q_\ell)w(B0) \\
&\iff w(BB) \geq w(B0) + 1/\delta, \\
&w(0B) \geq w(00) + 1/\delta, \\
&q_h w(BB) + (1-q_h)w(B0) \geq q_h w(0B) + (1-q_h)w(00) + 1/(p\delta) \\
&\qquad \text{(see next slide)}, \\
&w(BB), w(B0), w(0B), w(00), w(0) \geq 0.
\end{aligned}$$

Third constraint is equivalent to

$$\begin{aligned}
&pq_h[q_h w(BB) + (1-q_h)w(B0) - 1] \\
&+ p(1-q_h)[q_h w(0B) + (1-q_h)w(00) - 1] + (1-p)w(0) - 1 \\
&\geq pq_\ell[q_h w(BB) + (1-q_h)w(B0) - 1] \\
&+ p(1-q_\ell)[q_h w(0B) + (1-q_h)w(00) - 1] + (1-p)w(0).
\end{aligned}$$

- ☞ It is clear that the optimal solution will satisfy $w(0) = 0$.
- ☞ $w(00)$ appears only with a positive sign on the right hand side of the constraints and with a negative sign in the objective function, it is optimal to set it equal to 0.
- ☞ We must set $w(0B)$ as low as possible given that the second constraint is satisfied, that is equal to $1/\delta$.

The problem is therefore equivalent to

$$\max -q_h^2 w(BB) - q_h(1-q_h)(w(B0)+1/\delta)$$
$$\text{subject to } w(BB) \geq w(B0) + 1/\delta,$$
$$q_h w(BB) + (1-q_h)w(B0) \geq q_h/\delta + 1/(p\delta).$$

Any optimal solution must meet strictly the second constraint of this simplified problem.
One focal solution is

$$w(B0) = 0,$$
$$w(BB) = 1/\delta + 1/(p\delta q_h).$$

A more interesting solution is

$$\begin{aligned} w(B0) &= 1/(p\delta) \\ w(BB) &= 1/(p\delta) + 1/\delta \end{aligned} \qquad (1)$$

This solution shows clearly that, with efficient monitoring, for all practical purposes the principal faces two one period problems:

- ☞ The wage for production in the first period is equal to $w^1 = 1/(p\delta)$.
- ☞ The wage in the second period is equal to the wage in a one period model in which the agent would be known to be of high quality, $1/\delta$.
- ☞ The total payment for both periods is the sum of these wages.

Straightforward computations yield the payoff associated with this monitoring technology:

$$pq_h[(3-p)B - 2/(p\delta)]$$

This payoff is greater than $2S$. The principal does better than if he were selecting randomly two different agents.
Furthermore, if $B > \bar{B}$, the policy that we have just identified is better than asking for no effort.

The inefficient monitoring technology

The first period contract is composed of two second period contracts:

- ☞ if first period output is 0, the agent is fired and paid $w(0)$;
- ☞ if first period output is B, the agent is rehired and paid $w(BB)$ or $w(B0)$.

The problem of the principal can be written:

$$\max_{w(\cdot)} pq_h[q_h(2B - w(BB)) + (1-q_h)(B - w(B0))] + (1-pq_h)(S - w(0))$$

subject to $w(BB) \geq w(B0) + 1/\delta$,

$$q_h w(BB) + (1-q_h)w(B0) - 1 \geq \frac{1}{p\delta} + w(0),$$

$$w(0), w(B0), w(BB) \geq 0.$$

The second constraint states that the agent is induced to provide high effort in the first period:

$$pq_h[q_h w(BB) + (1-q_h)w(B0) - 1] + (1-pq_h)w(0) - 1 \geq pq_\ell[q_h w(BB) + (1-q_h)w(B0) - 1] + (1-pq_\ell)w(0).$$

$w(0)$, has a negative sign in the objective function, and from the second constraint we can set it equal to 0.
Therefore, the optimal $w(BB)$ and $w(B0)$ satisfy

$$q_h w(BB) + (1-q_h)w(B0) = 1 + 1/(p\delta),$$

as long as the first constraint is satisfied, which obtains if

$$w(B0) \leq 1 + (1-pq_h)/(p\delta).$$

A focal solution is

$$w(B0) = 0,$$
$$w(BB) = 1/q_h + 1/(p\delta q_h).$$

The wage in the case of two high outputs is higher with efficient technology. more generally that at equal $w(B0)$, the optimal $w(BB)$ will be higher.

This contract is renegotiation proof: any other contract would have to preserve the incentives of the agent to provide high effort, which implies that it would yield the same social surplus.
Because utility is essentially transferable, it is impossible for such a contract to increase the utility of the principal without decreasing the utility of the agent.

The value of the payoff function at the optimum is

$$pq_h[(B - 1/(p\delta))(2 - pq_h) + (Bq_h - 1)] = [2 + q_h(1-p)]S + \frac{q_h[(1-p)q_h + pq_\ell]}{\delta}.$$

This payoff is greater than $2S$, the principal is better off signing a long run contract than hiring two different agents in the two periods.

The optimal monitoring technology

$\Delta\Pi$ is the difference between the profits when monitoring is efficient and the profits when monitoring is inefficient.

$$\Delta\Pi/(pq_h) = (3-p)B - \frac{2}{p\delta} - [(B - \frac{1}{p\delta})(2 - pq_h) + (Bq_h - 1)]$$
$$= B(1-p)(1-q_h) - q_\ell/\delta$$

Depending on the values of the parameters, profits can be greater either with efficient or with inefficient monitoring technology:

- When p approaches the upper bound of this interval $\Delta\Pi$ is negative.
- when q_ℓ approach 0 with the other coefficients fixed so that $B > 1/(pq_h)$, $\Delta\Pi$ is positive.

Choose now any values of the parameters, $\hat{p}$, $\hat{q}_h$, and so on, such that $\Delta\Pi = 0$.

- **If $B < \hat{B}$, the inefficient monitoring technology is preferred;**
  if $B > \hat{B}$, the efficient monitoring technology is preferred.
- **If $p > \hat{p}$, the inefficient monitoring technology is preferred;**
  if $p < \hat{p}$, the efficient monitoring technology is preferred.
- **If $q_\ell > \hat{q}_\ell$, the inefficient monitoring technology is preferred;**
  if $q_\ell < \hat{q}_\ell$, the efficient monitoring technology is preferred.
- **The effect of a change in q_h is ambiguous.**

Proof:

- First two parts are obvious.
- $-q_\ell/\delta = 1/(1 - q_h/q_\ell)$, decreasing in q_ℓ.
- for q_h, compute derivative.

Monitoring technology and the level of effort

Assume that the agent generates a probability $q \in [0, 1)$ of high output by expanding an effort $e(q)$.
The first three derivatives of the function e exist and the first two are strictly positive on $(0, 1)$. Let

$$\eta(q) = qe'(q).$$

η is increasing, but also assume that it satisfies

$$\frac{d^2\eta(q)}{dq^2} = 2e''(q) + qe'''(q) > 0.$$

Add Inada conditions.
One can show that effort is lower with efficient monitoring technology.

Conclusion

- The contracts that have been identified are robust to renegotiation at any stage of the game.
- All results go through if we assume that the result of monitoring, or even the fact that monitoring takes place, if private information of the principal:
  with efficient monitoring, the optimal contract gives the principal the right to fire or rehire the agent at the end of the first period. The principal has incentives to fire the agent only when monitoring shows him to be of poor quality.
- In the first period, the principal only needs to be able to observe the quality of the agent, but not his effort or his luck.
- When output is high, it is known that the agent is of high quality, and the assumption that monitoring is only available when output is low does not play any role in the derivation of the results.