EFFICIENT OWNERSHIP PATTERNS: THREE EXAMPLES

A Thesis
Submitted to the Department of Economics
and the Institute of Economics and Social Sciences of
Bilkent University
In Partial Fulfilment of the Requirements
for the Degree of

MASTER OF ARTS IN ECONOMICS

by
Murat Sever
August, 1994

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tarafından bağışlanmıştır.

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I certify that I have read this thesis and in my opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Economics.

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I certify that I have read this thesis and in my opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Economics.

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Approved by the Institute of Social and Economic Sciences

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ABSTRACT

EFFICIENT OWNERSHIP PATTERNS

THREE EXAMPLES

MURAT SEVER

MA in ECONOMICS

SUPERVISOR : ASSIST.PROF.DR.MEHMET BAÇ

AUGUST 1994

This study provides three examples in which the ownership structure of productive assets affects efficiency of the economic outcome. We show how the incompleteness of contracts and the specificity of investments cause inefficient behaviours and reductions in the efficient level of relation-specific investment because of the individuals' opportunistic behaviour. We show the importance of ownership on behaviours of agents and their investment decisions by affecting the distribution of residual rights over assets and so the distribution of the surplus from investments. We observe the effects of monitoring on the behaviour of individuals in different types of ownership patterns.

Key Words : Efficiency, incomplete contracts, relation-specific investment, integration, non-integration, partnership, hierarchy, monitoring, asymmetric information, principal-agent relationship, indispensability.

ÖZET

OPTİMUM MÜLKİYET ŞEKİLLERİ
ÜÇ ÖRNEK

MURAT SEVER
YÜKSEK LİSANS TEZİ, İKTİSAT BÖLÜMÜ
TEZ YÖNETİCİSİ : YARD.DOÇ.DR.MEHMET BAÇ
AĞUSTOS 1994

Bu çalışmada üretken mülklerin mülkiyet haklarının ekonomik sonuçların etkinliğine tesir eden üç örnek veriyoruz. Kontratların tam olmamasının ve yatırımların spesifik olmasının bireylerin etkin davranış biçimlerini ve yatırımlarını nasıl etkilediğini gözledik. Mülkiyet haklarının mallar üzerindeki kullanım hakkı ve dolayısıyla da gelirin paylaşılmasını etkiliyerek, insanların davranişları ve etkin yatırım kararlarını nasıl etkilediğini gördük. Değişik mülkiyet şekillerinde monitör etmenin bireylerin davranışlarını nasıl etkilediğini gördük.

Anahtar Kelimeler : Etkinlik, eksik kontratlar, ilişkiye özel yatırım, birleşim, ayrılık, ortaklık, hiyerarşi, monitör etmek, asimetrik bilgi, patron-işçi ilişkişi, vazgeçilmezlik.

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Contents

1 Introduction

What structure of an organization is best in terms of the economic performance of assets or services, that is productivity and profitability? The market economy versus centrally planned economy debate, and privatization, i.e. the transfer of assets or service functions from public to private ownership or control, as an alternative to public ownership are just some manifestations of the problem posed above.

Dealing with the issue of privatization, Adam Smith (1776, p.77) thought that public administration was negligent and wasteful because public employees do not have a direct interest in the commercial outcome of their actions and private owners have a greater incentive to enhance the value of their lands through monitoring activities, eliminating waste and innovating.

The topic has many branches. We will mainly deal with the incentives created by different types of ownership structures: how can people be motivated to act in consistence with economic efficiency? Should ownerhip be concentrated, or should it be diffused? The first gives rise to a hierarchical structure; the second, to a partnership. Optimal ownership structure should also take into account potential inefficencies due to improper maintenance of assets. For example, giving the ownership of a truck to its driver may increase efficiency since the driver will take better care of the truck. Whether the driver can afford to buy the truck is another issue, related to the functioning of capital markets.

2 Literature Survey

Given that the topic of the thesis is "Efficient ownership patterns-Three examples", it is convenient to begin by giving the definition of *efficiency*. Under no wealth effects, an arrangement is efficient for the parties involved if it maximizes their total equivalent wealth, regardless of how that total is distributed.

There are three main implications of ruling out the wealth effects: The individuals must be able to evaluate all of the benefits and costs as being equivalent to some cash transfer, these evaluations must not depend on the wealth that the parties hold, the individuals must be able to make timely payments in whatever amounts may be required to divide up the benefits of the transaction without effecting the cost or feasibility of any other aspect of the transaction.

The definition of efficiency implies that the outcomes of economic activities tend to be efficient under costless bargaining and an environment where the agents can effectively implement and enforce their decisions.

Why do we put the emphasis on efficiency as a criterion? How is efficiency related to the value creation in the economy? Can private individuals achieve efficient outcomes on their own? The well-known theorem of Coase gives some insights about the answers. Coase showed that if the parties bargain to an efficient agreement and if their preferences display no wealth effects, then the value-creating activities that they will agree upon do not depend on the bargaining power of the parties or who owns what assets.

Therefore, in an economy where the Coase theorem holds, efficiency alone determines the activity choice. The other factors can affect only the decision about how the costs and benefits are to be shared.

The necessary conditions of the Coase theorem are quite restrictive. Because of the bargaining costs and transaction costs that arise from bounded rationality, private information and unobservability of the actions, value maximizing agreements may not be reachable. The best we can hope for in such situations will be a constrained efficiency. In the example that is given at the end of the introduction, the driver may not have sufficient funds to buy the truck. Hence, the ownership patterns may necessarily lead to an inefficient outcome.

At our second example we present a problem where the existence of private information will lead to a constrained-efficient outcome in some, but not in all cases. In the two other examples, we will focus on other impediments to reach an efficient outcome. Hence, our examples are concerned with situations where the Coase theorem fails; it is these circumstances that ownership matters, in terms efficiency.

Even if none of the stated problems exist, efficiency may not be reachable if there are no clear, enforceable, easily transferable property rights. If the owner of an asset is not explicit and precise, then it will be overused (Hardin's (1968) "tragedy of the commons" has made this point quite clear). On the other hand, if the property rights are not tradable, there is little hope that the assets will be in the hands of the individuals who can use them most efficiently. Finally, if property rights are not protected, individuals will have little incentive to invest in these assets not to lose their money (See Skaperdas (1993) for a model of conflict in the absence of property rights).

Therefore, ownership becomes a crucial issue when people fail to reach agreements that support efficient outcomes. What may be the main impediment for such ex-ante agreements? It is the incompleteness of contracts, i.e. the fact that parties are not be able to specify every detail that may arise in the future. We dicuss the reasons of this incompleteness in detail in the next section.

2.1 Impediments to Efficient Outcomes

2.1.1 Incompleteness of Contracts

Throughout this study, we make the fundamental behavioral assumption that individuals act opportunistically which means that they do what they perceive to be in their own individual interest. Note that this is the plain old rationality assumption. Opportunistic individuals must be motivated to fulfill their obligations in their relationships with others; for efficiency of the outcome, they must be induced to be "honest" and report information accurately.

Agreements must specify what action each agent should take, the rules and procedures that will used in settling potential conflicts, thereby regulating the behaviours that each might expect from the others. We refer to such agreements as *contracts* regardless of whether they have the legal status of contracts. In fact, contracts may be completely implicit with no power of law behind them.

The motivation issue becomes a problem only when contacts can not be made complete and enforceable for some reason. In fact, a complete contract will completely solve the motivation problem. A complete contract specifies what each party is expected to do in every possible circumstance, and arranges the distribution of realized costs and benefits in each contigency. If the original plan is an efficient one, then a complete contract can implement the plan leading to an efficient outcome.

In real life, it is nearly impossible to think of an environment where a complete contracts are be implemented. We can state three main requirements for contracts to be complete:

1-) Each party must be able to foresee the potential and relevant contingencies. The parties must also be able to describe these contingencies accurately and know which particular circumstances they considered beforehand has actually occured.

2-) The contract must clearly specify the appropriate actions to be taken at each state of nature.

3-The terms of the contract must be verifiable to a third party in order to be enforceable.

Because of bounded rationality, i.e. limited foresight, imprecise language (statements describing any resonably complex situation must be somewhat ambigious), the costs of calculating solutions and writing down a plan, not all of the contingincies can be fully accounted for. Even if all of the three requirements above were satisfied, the resulting complete document would be a very long one. Due to high costs (in terms of time and other resources) of writing almost complete contracts, real life contracts are necessarily incomplete.

2.1.2 Information Problems

Even if every contingency could be foreseen and planned for, and even if contractual commitments could be enforced, we still have the problem that one of the bargainers may have relevant private information before the contract is signed. This may prevent to reach a value maximizing, efficient agreement. This source of ineffiency is called *adverse selection*and it is precontractual opportunism.

We will investigate an adverse selection problem in our second example which is a principal-agent framework where the agent who has different interests than the principal is asked to act on behalf of the principal. In that example, because of the agent's quality is his private information, the principal may not be sure whether the agent is acting in a way that is most profitable for the principal. Furthermore, there may be inadequate information as to whether the terms of the agreement have been honored or acquiring information may be very costly. This brings in the possibility of self-interested behaviour, the celebrated problem of *moral hazard*, a post-contractual opportunism. There are three preconditions for a moral hazard problem: first; there must be some potential divergence of interest between the parties, second; there must be a basis for gainful exchange or another type of coordination between the individual that activates the divergent interests, and finally there must be difficulties in determining whether the terms of the contract have been followed.

In our first example, we will deal with a way of reducing the moral hazard problem, monitoring. Monitoring will reduce the information problem at a cost. If the cost exceeds it benefit, obviously monitoring can not be a solution to the moral hazard problem.

To summarize the discussion above, the self interested behaviour of the agents may prevent the realization of an efficient plan. This is so because individual interests under actual contracts will not necessarily be properly aligned.

2.1.3 Relation-specific Investments

An *investment* is an expenditure of money or other resources that creates a potential continuing flow of future benefits and services. When significant investments are required, even relatively simple contracts can be subject to various problems. The most problematic investments are the investments in *specific assets*- that is, assets that are most valuable in one specific setting or relationship.

An important special case of specific assets are *cospecialized assets*. Two assets are cospecialized if they are most productive when used together and lose much of their value if used seperately to produce independent products or services. Our second example is a case where a machine and another asset, information, are cospecialized and efficiency will be reached only when they are used together.

The specificity of assets together with imperfect contracting causes the *hold-up* problem. The hold-up problem impedes investment ex ante: worries about being forced to accept some disadvantageous terms later, once a sunk investment is made, or about that the investment may be damaged by the actions of the others, reduces the incentives to invest in a specific asset.

In the next section, we will try to find a way to solve the problems described in this section. We will mainly focus on assigning ownership in the most efficient way and see how useful it is in eliminating the obstacles preventing efficiency.

2.2 Ownership as a Determinant of Efficiency

2.2.1 What is Ownership ?

Ownership is the residual rights of control over an asset, that is, the rights to make any decisions about the usage of the asset that are not explicitly given away by a contract or restricted by law.

If contracts were complete, residual returns would have no meaning for the simple reason that there would be no unspecified rights, hence nothing would be residual. But since most contracts are incomplete, residual rights of control are important. How they should be assigned is the main subject of the thesis.

Residual returns of an asset is defined to be the returns accrued after the eventualities. Like residual control, this concept is relevant only in a world of incomplete contracts. If contracts were complete. the distribution of the returns could be specified in detail, hence no return would be left residual.

There is certainly a close link between residual rights of control and residual returns of an asset. If the person who has the residual control rights also has the rights over residual returns, an efficient solution can be reached by maximizing his own return. We will show this in our second example. In that example, the residual control will automatically be in the hands of the party who has a private information and making this same person also the residual claimant will lead to an efficient outcome. But making the person who has no private information (so no residual control rights), the residual claimant, will have some probability of leading to an inefficient outcome.

Our conclusions will enforce the common belief that an efficient way to motivate people to create. maintain and improve assets is the assignment of residual control rights, i.e. ownership.

2.2.2 Unified Ownership; A Solution for Reaching Efficiency?

The solution to the stated problems of not reaching an efficient outcome in economic activities may be a unified structure, where one party to the transaction takes command of the assets of the second, internalizing the transaction. It will reduce the need to have contracts which is the origin of most of the problems. From now onwards, a "firm" refers to a unified structure commanding an array of assets.

According to an argument, when the market transactions work well, the firm may replicate the same style and when there are efficiency gains from deviating from the market type transactions, the central management may selectively intervene to the operations of the relevant unit. But then there will be no limit on the efficient size of an organization. This argument is not acceptable for the following reasons:

1-) As the size of a firm increases, the uncertainty in that organization increases. This increase in uncertainty will make the problems of the organization more complex, leading to decreasing returns to scale. An increase in uncertainty is clearly not favorable to the firms that rely on long term contracts.

2-) In a hierarchical organization, there will be what Williamson (1985) calls a *control loss* problem. As the firm gets larger, more levels of organization will be added implying that the control loss problem becomes more severe. Hence, a point may come where the costs of control loss exceed the gains from scale. Thus, selective intervention is not possible because it relies on control.

3-) High powered market incentives generally fail to exist in firms because of the moral hazard issue; the firm is organized as a nexus of vague contracts. Therefore, incentives in firms do not match those in the market.

In general, many individuals can work on the same set of assets. If the actions of each individual includes an investment specific to those assets, the way ownership is vested matter as far as it determines the returns of these investments. If the investment of the owner of the unified structure is more "important" than the others', the unified structure will be an efficient way of organization since it will provide higher incentives to the owner. If the investments of the others are more important, which is generally the case [1],

[1] It is so because the owner is just one person and the others, e.g. the workers form the majority. This argument has most of its power when most of the investments are on

the unified structure will give less incentives to them and so it is not efficient.

4-) Since incentives in a unified structure are weak, the owner may prefer to monitor, and monitoring is costly. We study this case in one of our examples.

5-) When a decision affects the distribution of the benefits among members, the individuals may attempt to influence the decisions to their own benefit. Thus, efficiency might suffer from these self interested activities. The costs of such activities are called as influence costs. The magnitude of influence costs increases when two seperate organizations are brought together under a central management with the power to intervene selectively. For example, the units may try to transfer more resources to their unit even if it is not value maximizing, but just a transfer increasing the benefits of the receiving unit.

Hence, besides their achievement of activities which the seperate units can not do, the unified structure itself generated problems that were not present in the market, before the transaction is brought in a unified structure. The comparison of a market and a unified structure depends on the nature of the transaction. This issue is discussed in the next section.

2.3 The Optimal Governance Structures for Various Types of Transactions

What is the most efficient ownership pattern or the governance structure for different types of transactions? The principal dimensions for describing a contract are asset specificity, uncertainty and frequency. By holding uncertainty constant, we can investigate the efficient type of organization in terms of asset specificity and frequency. We will have three broad levels of asset specificity -nonspecific, mixed and highly specific -and two levels of frequency- occasional and recurrent (See Williamson (1985)). Table 1 summarizes the most efficient organization type for each of these cases.

human capital. But if the model is extended through time, this kind of an argument may suffer because the workers may be able to use their human capital investment in some other place later

		INVESTMENT CHARAC.		
		NONSPEC.	MIXED	HIGHLY SPEC.
TRANS. FREQ.	OCCASIONAL	*MARKET*	*TRILATERAL GOVERNANCE*	
	RECURRENT		*SPECIALIZED GOVERNANCE*	

Table 1

We have two main deductions from Table 1: first, special governance structures are not needed for highly standardized transactions, second, only recurrent transactions may require a highly specialized governance structure.

Market transactions are especially efficient when there are recurrent non-specific transactions. Hence, standard transactions must be performed under a market structure. The market provides efficient protection from opportunism.

Trilateral governance includes the assistance of a third party in resolving disputes and evaluating performance. The third party takes the adjudicary role. It is an ideal way of governance for occasional transactions of both mixed and highly specific kinds. In such transactions, the continuation of the relation is important since specialized investments are taken. Relying on a market transaction is not sensible because these specialized investments need better protection. But it is also not wise to use a transaction specific governance structure since set up costs can not be recovered for occasional transactions. Trilateral governace is somewhat between these two ways.

Transaction-specific governance is good for mixed and highly specific transactions of a recurrent type since the continuation of the relationship is very important due to the nonstandardized nature of the transaction. Under recurrent transactions, costs of specialized governance can be recovered. There are two types of transaction-specific governance: bilateral structures and unified structures. The autonomy of the parties is maintained under a bilateral structure whereas the transaction is removed from the market and organized within the firm under unified governance. If one of the parties engages in transactions frequently and the other less frequently, a hierarchical form may be appropriate where the first party is the owner. In fact, in our first example, we will investigate a bilateral stucture (the partnership) and a unified structure (the hierarchy). We will derive conditions about the relative efficiency of organizing the transaction under a unified structure; or a bilateral structure. Our conclusions will have potential implications about the limit for the size of a firm.

3 First Example: A Monitoring Game

3.1 The Model

Consider an economy consisting of two assets and two individuals, A and B, with the following set of opportunities. Each can choose to work individually on a project or they can decide to undertake the project together either in a form of partnership or in a form of hierarchy where one individual is the principal, the other the agent. Individual production requires at least one of the assets. In accordance with the incomplete contracts approach, we assume that contracts are incomplete as to the expost division of the output; the share one gets from joint production depends rather on one's bargaining power, which in turn depends on how ownership is vested. In the partnership structure, one of the assets is owned by A and the other by B, so that the surplus is equally distributed. In the hierarchy, both assets will be owned by one party, whom we will call, the principal. The other party is the worker. We therefore have a standard principal-agent setting where the principal takes all of the surplus and gives a reservation wage to the worker. Now, we will investigate the two structures one by one and then compare the results in terms of efficiency.

In both partnership and hierarchy, each individual faces a decision to supply working effort. This is a binary choice, $x = 1$ for working, and $x = 0$ otherwise. The cost of working is c. The project carried by two individuals yields $S(2)$ if both work, whereas the yield to a one-person enterprise is $S(1)$.

Assumption 1: If no individual works, there is no yield, i.e. $S(0) = 0$. The yield from a two-person enterprise is more than the sum of the yields from two seperate one-person enterprises, i.e. $S(2) > 2S(1)$.

Though the output is observable, an individual's working decision is not observable to the other. This may lead to opportunistic behaviour in the organizational form, be it the partnership or hierarchy: in the partnership each individual has an incentive to free ride, and in the hierarchy the agent has an incentive to shirk. In order to prevent free riding, each partner disposes of an identical monitoring technology which identifies the free rider in a way that can be proved to a third party with probability $p(m)$ if m is the monitoring effort. Similary, in the hierarchy the principal exerting a monitoring effort m can prove that the agent shirks with probability $p(m)$ if the agent actually shirks. We will denote the disutility of monitoring effort by $d(m)$. Both $p(m)$

and $d(m)$ are common information, i.e. they are functions that are known by both A and B.

Assumption 2: p:$\mathcal{R}^+ \to [0,1]$ has the following properties: $p(0) = 0$, $p'(m) > 0$, $p''(m) \leq 0$ for all $m \in \mathcal{R}^+$ and $lim_{m\to\infty} p(m) = 1$.

Assumption 3: d:$\mathcal{R}^+ \to \mathcal{R}^+$ has the following properties: $d(0) = 0$, $d'(m) \geq 0$, and $d''(m) \geq 0$ for all $m \in \mathcal{R}^+$.

Let x_i denote the probability that individual i works where $i \in \{A, B\}$. So, $x_i \in [0,1]$.

We start with the analysis of the partnership in the first section and then we will look at the hierarchy in the second section. Finally, we will compare the two structures in terms of efficiency in the third section.

3.2 The Partnership

As mentioned, the partners share the total surplus equally. We can write the objective function of i, where $i, j \in \{A, B\}$, as:

$$\begin{aligned} V_i &= x_i[x_j \tfrac{S(2)}{2} + (1-x_j)(1-p(m_i))\tfrac{S(1)}{2} + (1-x_j)p(m_i)S(1) - d(m_i) - c] \\ &\quad + (1-x_i)x_j(1-p(m_j))\tfrac{S(1)}{2} \\ &= x_i[x_j \tfrac{S(2)}{2} + (1-x_j)(1+p(m_i))\tfrac{S(1)}{2} - d(m_i) - c] \\ &\quad + (1-x_i)x_j(1-p(m_j))\frac{S(1)}{2} \end{aligned} \tag{1}$$

The best reply of individual i, denoted by r_i, can be defined in the obvious way: it is a pair of (possibly mixed) working strategy and a monitoring effort $\{x_i, m_i\}$ maximizing (1) given $\{x_j, m_j\}$. More precisely, $r_i : [0,1] \times \mathcal{R}^+ \to [0,1] \times \mathcal{R}^+$ where the first component represents the probability of working x_i and the second represents the monitoring effort m_i. We shall consider the Nash equilibrium of this partnership game. The components of the best reply mapping can be determined from (1) as follows: $x_i^* = 1$ if

$$x_j \frac{S(2)}{2} + (1-x_j)(1+p(m_i)\frac{S(1)}{2} - d(m_i) - c > x_j(1-p(m_j))\frac{S(1)}{2} \tag{2}$$

$x_i^* = 0$ if

$$x_j\frac{S(2)}{2} + (1 - x_j)(1 + p(m_i)\frac{S(1)}{2} - d(m_i) - c < x_j(1 - p(m_j))\frac{S(1)}{2} \quad (3)$$

and $x_i \in [0, 1]$ if

$$x_j\frac{S(2)}{2} + (1 - x_j)(1 + p(m_i)\frac{S(1)}{2} - d(m_i) - c = x_j(1 - p(m_j))\frac{S(1)}{2} \quad (4)$$

On the other hand, assuming an interior solution, the optimal monitoring effort of agent i is implicitly defined by $x_i(1 - x_j)(S(1)/2)(\partial p(m_i)/\partial m_i) = x_i(\partial d(m_i)/\partial m_i)$. If $x_i \neq 0$, it reduces to:

$$(1 - x_j)\frac{S(1)}{2}\frac{\partial p(m_i)}{\partial m_i} = \frac{\partial d(m_i)}{\partial m_i} \quad (5)$$

If $x_i = 0$, agent i will not monitor because he has no output to lose to a possibly free riding agent j. Agent i will obtain $S(1)/2$ if agent j works and zero,otherwise. Thus, when $x_i = 0$, there is no monitoring by agent i, i.e. $m_i = 0$. We also see from eqn. (5) that the monitoring effort is positive only when the partner puts positive probability on shirking. Therefore, when $x_j = 1$, m_i is again zero.

The only reason why equation (5) may not admit a solution is that the left hand side may be smaller than the right hand side for all $m \in \mathcal{R}^+$, from assumptions (2) and (3). The interpretation is straightforward: the cost of monitoring, $d(m)$, is always relatively higher than the benefit of monitoring, p(m), and so it is optimal to choose $m_i = 0$ in such a situation.

Proposition 1 : There are four possible Nash Equilibrium outcomes among which the first two are in pure strategies, the last two are in completely mixed strategies at least for one of the partners. The outcomes presented below are exhaustive.

1-) If $c < \frac{S(2)}{2} - \frac{S(1)}{2}$,

$\{(x_A^*, m_A^*) = (1, 0)$ and $(x_B^*, m_B^*) = (1, 0)\}$ is a Nash equilibrium.

2-) If $c > S(1)/2$,

$\{(x_A^*, m_A^*) = (0, 0)$ and $(x_B^*, m_B^*) = (0, 0)\}$ is a Nash equilibrium.

3-) If $S(1)/2 < c < S(1)$,

there may exist Nash equilibria in which one agent free rides while the other is "mixed" : both

$\{(x_A^* = 0, m_A^* = 0)$ and $(x_B^* \in [0,1], m_B^* \geq 0)\}$ or alternatively, $\{\ (x_A^* \in [0,1], m_A^* \geq 0)$ and $(x_B^* = 0, m_B^* = 0)\}$ may be Nash equlibria.

4-) If $c < S(2)/2$,

$\{(x_A^* \in [0,1], m_A^* \geq 0)$ and $(x_B^* \in [0,1], m_B^* \geq 0)\ \}$

may be a Nash equilibrium.

Proof :

The proof follows from inspection of the best-reply mappings.

1-) Given that B works (and does not monitor), A will optimally choose $m_A = 0$. Moreover, A will decide to work if $c < (S(2) - S(1))/2$, by substituting $m_A^* = m_B^* = 0$ to (2). So, if the additional surplus, $(S(2) - S(1))/2$ is greater than the cost of working, c, A will prefer to work. The arguments are the same from B's point of view.

2-) Given that B does not work and hence does not monitor A, A prefers not to work if, from (3), $(S(1)/2)(1 + p(m_A)) - d(m_A) - c < 0$. But since m_A when $x_A = 0$, using $m_A = 0$ in this condition reduces it to $c > S(1)/2$. The arguments are again the same from B's point of view.

3-) We consider the case in which B is indifferent between working and free riding and A does not work and $m_A^* = 0$. Given these strategies, A prefers not to work if

$$x_B^* \frac{S(2)}{2} + (1 - x_B^*)\frac{S(1)}{2} - c < x_B^*(1 - p(m_B^*))\frac{S(1)}{2}$$

and B will be indifferent between working and free riding if

$$\frac{S(1)}{2}(1 + p(m_B^*)) - c = d(m_B^*)$$

where m_B^* is found from (5) by substituting $x_A^* = 0$ and m_A^* is zero since A prefers not to work.

Notice that there may be no combination of m_B and x_B which satisfy the three conditions mentioned above. Then, the specified Nash equilibrium will not exist. Therefore, we can not give a sufficient condition in terms of the parameters of the model, $c, S(1)$ and $S(2)$ for the existence of the specified Nash equilibrium.

However, we can determine necessary conditions. If we solve for $p(m_B^*)$ from the second condition above;

$$p(m_B^*) = \frac{d(m_B^*) + c - \frac{S(1)}{2}}{\frac{S(1)}{2}}$$

Since $p(m_B^*) \leq 1$, $c < S(1) - d(m_B^*)$ and $-d(m_B^*) < 0$, we can find that $c < S(1)$.

If we solve the first condition for x_B^*, we get

$$x_B^* < \frac{\frac{S(1)}{2} - c}{S(1) - \frac{S(2)}{2} + \frac{S(1)}{2} - d(m_B^*) - c}.$$

Using Assumption 1, i.e. $S(1) - S(2)/2 < 0$ and the deduction that $S(1)/2 - d(m_B^*) - c < 0$, yields the condition $S(1) - S(2)/2 + S(1)/2 - d(m_B^*) - c < 0$. From the fact that $x_2 \geq 0$, we can find $S(1)/2 - c < 0$.Therefore $c > S(1)/2$.

Hence, a necessary condition for the specified outcomes to be Nash equilibria is $S(1)/2 < c < S(1)$.

4-) B's monitoring effort and that his is indifference between working and free riding implies that, A will be indifferent between working and free riding as well if the corresponding two first order conditions for m_A^* and m_B^* are satisfied. From these conditions, x_A^* and x_B^* are obtained as follows:

$$x_A^* = \frac{d(m_B^*) + c - (1 + p(m_B^*))\frac{S(1)}{2}}{\frac{S(2)}{2} - \frac{S(1)}{2}(2 + p(m_B^*) - p(m_A^*))}$$

$$x_B^* = \frac{d(m_A) + c - (1 + p(m_A^*))\frac{S(1)}{2}}{\frac{S(2)}{2} - \frac{S(1)}{2}(2 + p(m_A^*) - p(m_B^*))}$$

It is quite possible that these conditions can not be all satisfied by x_A, x_B, m_A, m_B. As in case (3), we are not able to give a sufficient condition in terms of the parameters of the model, $S(1), S(2)$ and c. We can, however, give a necessary condition. From the equality for x_A^* above,

$$d(m_B^*) + c - (1 + p(m_B^*))\frac{S(1)}{2} \leq \frac{S(2)}{2} - S(1)$$

since $x_B^* \leq 1$. But then $c \leq S(2)/2 - S(1)/2 - d(m_B^*) + p(m_B^*)S(1)/2$. Using Assumptions 2 and 3, i.e. $p(m_B^*) \leq 1$ and $-d(m_B^*) < 0$, we obtain $c < S(2)/2$.

The four types of equilbria above are exhaustive, i.e. no other Nash equilibrium exists. The proof of this statement is given in the Appendix.

Q.E.D.

3.3 The Hierarchy

Here, ownership is confined to, say, A, who becomes the principal while B is the agent. Hierarchy has two distinctive features that contrast with the partnership. First, ownership of the assets is concentrated in the hands of A. Ownership entitles him how to use these assets. Second, monitoring follows the pattern of the hierarchy: A disposes of a technology to monitor B but B does not. In fact, as can be easily shown, the assumption of incomplete contracts as to the ex-post division of the surplus and the definition of ownership rights imply that B would never monitor A.

The sequence of events is as follows: first, A offers a wage contract to B who may either accept or reject. If B rejects the contract, B obtains his reservation wage (which is normalized to zero) and A is left with just two alternatives: to work or not to work. If $c \leq S(1)$, he will work and produce a positive surplus of $S(1) - c$ and if $c > S(1)$, he will not work. If B accepts the contract, the outcome is described by the Nash equilibrium.

A will foresee the post-contract Nash equilibrium of the inspection game, (depending on the parameters of the model) and offer $w = 0$ if B will not work and $w = c$ if B works in the equilibrium. However, we will show later that $w > c$ may be offered if in the post-contract Nash equilibrium, B's strategy is completely mixed (indifferent between working and shirking).

The returns of A and B depend on their decision of working or not working. If both works, A's net returns is $S(2) - c$ and B's is $w - c$. If A works, but not B, A will obtain $S(1) - c$ and B nothing. If B works, But not A, A gets $S(1)$ and B $w - c$. Given a specified wage contract $\{w\}$, the objective function of A is:

$$V_A = x_A(x_B(S(2)-w)+(1-x_B)(1-p(m_A)(S(1)-w)-(1-x_B)p(m_A)S(1)$$
$$-d(m_A) - c) + (1 - x_A)x_B(S(1) - w)$$
$$= x_A(x_j(S(2) - w) + (1 - x_B)(S(1) - w + p(m_A)w) - d(m_A) - c)$$
$$+(1 - x_A)x_B(S(1) - w). \tag{6}$$

The objective function of B is:

$$V_B = x_B(w - c) + (1 - x_B)x_A(1 - p(m_A))w \tag{7}$$

On the other hand, assuming an interior solution, the optimal monitoring effort of agent i is implicitly defined by $x_A(1 - x_B)wp'(m_A) = x_A d'(m_A)$. If $x_A \neq 0$, it reduces to;

$$(1 - x_B)wp'(m_A) = d'(m_A). \tag{8}$$

As in the case of partnership, A will not monitor B if he himself does not work. The deduction that $m_A = 0$ if the first order condition has no solution remains.

A post-contract Nash equilibrium is defined as follows: x_A^*, m_A^* maximizes (6) given x_B^* and x_B^* maximizes (7) given x_A^* and m_A^*. The Nash equilibrium of the whole game includes, in addition to the strategies described above, the optimum wage contract $\{w^*\}$ which maximizes (6) given x_A^*, x_B^* and m_A^*.

As in the partnership case, there are also four possible Nash Equilibrium outcomes here, characterized by Proposition 2 below. Among these, the first two are in pure strategies, the last two are in completely mixed strategies, at least for one of the partners.

Proposition 2 : Depending on the parameters of our model, there are four possible Nash equilibria which can be specified as follows:

1-) If $c > S(1)$,

$\{(w^* = 0, x_A^* = 0, m_A^* = 0)$ and $x_B^* = 0\}$ is a Nash equilibrium.

2-) If $c < S(1)$,

$\{(w^* = 0, x_A^* = 1, m_A^* = 0)$ and $x_B^* = 0\}$ is a Nash equilibrium.

3-) If $S(1) = c$,

$\{(w^* = 0, x_A^* \in [0,1], m_A^* = 0)$ and $x_B^* = 0\}$ is a Nash equilibrium.

4-) If $c < S(2) - S(1)$,

$\{(w^* = c/p(m_A^*), x_A^* = 1, m_A^* \geq 0)$ and $x_B^* \in [0,1]\}$ may be Nash equilibrium.

The four cases presented above are exhaustive, i.e. no other Nash equilibrium exists.

Proof :

1-) Given that B shirks, A will not monitor B and will offer $w = 0$. If $c > S(1)$, he will also prefer not to work.

Given that A does not monitor B, the latter will not work. Hence, the specified strategies form a Nash equilibrium.

2-) The only difference from the proof of part (1) is that now $c < S(1)$. But then A will prefer to work; so that $x_A = 1$. Given A does not monitor B, B does not work.

3-) Given that B does not work and if $S(1) = c$, then the principal will be indifferent between working and not working. We have $m_A^* = 0$ and $x_B^* = 0$ and $w = 0$ by the same arguments as in part (1) and (2).

4-) From (7), given A's decision to work and his positive monitoring effort, B will be indifferent between working and shirking if

$w - c = (1 - p(m_A^*))w$, implying that $w^* > c$ since $p(m_A^*) > 0$.

From (6), given $x_B^* \in [0,1]$, the following inequality must be satisfied for A to decide to work:

$$x_2(S(2) - w) + (1 - x_2)(S(1) - w + p(m_A)w) - d(m_A) - c > x_2(S(1) - w)$$

where m_A^* satisfies (8). If such an m_A does not exist, the specified strategy can not be a Nash equilibrium strategy.

By simplifying and solving for x_B^* yields,

$$x_B^* > \frac{-S(1) + w + d(m_B^*)}{S(2) - 2S(1)}$$

Because $S(2) > 2S(1)$ from Assumption 1 and $x_B^* < 1$, we have $-S(1) + w + d(m_B^*) < S(2) - 2S(1)$. Also since $w > c$ and $d(m_B^*) > 0$, it must be that $c < S(2) - S(1)$. Therefore, $c < S(2) - S(1)$ is a necessary condition (not a sufficient condition since m_A^* may be found to be zero from (8)).

That other strategies can not be realized as Nash outcomes proved in the Appendix.

Q.E.D.

3.4 The Two Structures Compared

We will now compare the two structures, the partnership and the hierarchy, in terms of efficiency, i.e. the total surplus generated. Note that we are not concerned with the distribution of the total surplus. The structure which generates a higher surplus will be said to dominate the other.

Proposition 3 : If $c < (S(2) - S(1))/2$, the partnership dominates the hierarchy. If $S(2)/2 < c < S(2) - S(1)$ the hierarchy may dominate the partnership. If $c > S(2) - S(1)$, both structures are equivalently efficient. If $(S(2) - S(1))/2 < c < S(2)/2$, the domination depends on the two functions, p and d.

Remark : We saw in Proposition 1 and Proposition 2 that there may be more than one Nash equilibria for some values of $S(1), S(2)$ and c. In such cases, we will assume that the parties will choose the structure whose outcome corresponds to the highest total surplus.

Proof : If $c < (S(2) - S(1))/2$, the maximum total surplus is $S(2) - 2c$. This is obtained in a partnership structure (see Proposition 1) whereas it is never obtained in a hierarchy (see Proposition 2). Therefore the partnership structure definitely dominates the hierarchy for this range of parameters values.

If $c > (S(2) - S(1))/2$, the results depend on whether $S(1)$ is greater or smaller than $(S(2) - S(1))/2$. We first will consider the case where $S(1) < (S(2) - S(1))/2$ and later the case where $S(1) > (S(2) - S(1))/2$.

Now, assume that $c > (S(2) - S(1))/2$ and $S(1) < (S(2) - S(1))/2$. If we further assume that $c < S(2) - S(1)$, the hierarchy may dominate the partnership if the Nash equilibrium in the hierarchy structure is described by case 4 of Proposition 2. This is so because both individuals don't work in the partnership from Proposition 1. But if $c > S(2) - S(1)$, the two structures are equivalently efficient since both A and B will not work.

Now, assume that $c > (S(2) - S(1))/2$ and $S(1) > (S(2) - S(1))/2$. Moreover, if $S(1) < c < S(2)/2$, the Nash equilibrium outcome in both the partnership and the hierarchy be given by the case of Proposition 1 and 2. Respectively, the comparison depends on the values of x_A and x_B. If $S(2)/2 < c < S(2) - S(1)$, the hierarchy may dominate the partnership provided that we are in case 4 of Proposition 2 since both A and B will not work in the partnership. If $c > S(2) - S(1)$, the structures are equivalently efficient since both A and B will not work. If $c < S(1)$, the partnership has its outcome described by case 2,3 or 4 of Proposition 1 whereas the outcome of the hierarchy may be described by cases 2 or 4 of Proposition 2. Therefore, the comparison depends on the functions $p(m)$ and $d(m)$.

Q.E.D.

In this example, we give a model which puts a limit on the efficient size of an organization. We observed that the parnership, where the ownership of assets are not concentrated, may be better than the hierarchy in terms of efficiency. Therefore, the claim that efficiency increases as the firms get larger and larger is not correct.

4 Second Example: Information and Efficiency of Ownerhip

We consider two individuals, A and B. A is a potential buyer of a product manufactured by B. The value of the product to A is v. The cost of production to B is $\beta C(Q)$. where $Q \in \mathcal{R}^+$ is the total quantity produced and β is an efficiency parameter that can take only two values: $\bar{\beta}$ and $\underline{\beta}$. We identify these values with the types of individual B: high quality workers ($\bar{\beta}$), and low quality workers ($\underline{\beta}$) where $\bar{\beta}, \underline{\beta} \in \mathcal{R}^+$, $\bar{\beta} < \underline{\beta}$). The probability that B is of high quality and low quality is $\bar{\pi}$ and $\underline{\pi}$, respectively. A makes a transfer $\bar{T}$ to high quality types and $\underline{T}$ to low quality types.

In this example, information about the type of B can be interpreted as a relation-specific asset because it has no value outside the relationship. Two cases will be investigated: the case where there is symmetric information and the case where there is asymmetric information. The former case will refer to integration since both A and B will be informed and the second case will refer to nonintegration since only B will have the information.

The crucial assumption is the completeness of contracts, i.e. every possible outcome and the corresponding payoffs can be specified in unlimited detail if necessary. We will try to find whether the efficiency is affected or not if the party who offers the contract changes.

Assumption 1: The cost function $C(Q, \beta)$ is defined as $C : \mathcal{Q} \times \mathcal{B} \rightarrow \mathcal{Q}$ where $\mathcal{Q} = (0, \infty)$ and $\mathcal{B} = \{\underline{\beta}, \bar{\beta}\}$ and $C(0, .) = 0, C'(Q, .) > 0, C''(Q, .) > 0$ for all Q.

According to Assumption 1, both types of B dispose of a strictly convex cost-of-effort function (recall that effort is identically to output).

4.1 Case 1 : Symmetric Information

4.1.1 Contract is Offered by A

If the A knows B's type (β), he offers: ($\underline{T}, \underline{Q}$) to type $\underline{\beta}$ where

$$\underline{Q} = arg \max_{Q}(vQ - \underline{\beta} C(Q))$$

and

$$\underline{T} = \underline{\beta} C(\underline{Q})$$

$(\bar{T}, \bar{Q})$ to type $\bar{\beta}$ where

$$\bar{Q} = arg\max_{Q}(vQ - \bar{\beta}C(Q))$$

and $\bar{T} = \bar{\beta}C(\bar{Q})$

Solving by differentiating with respect to Q and equating to zero yields the following values for $\underline{Q}, \underline{T}, \bar{Q}, \bar{T}$:

$$\underline{Q} = C'^{-1}(v/\underline{\beta})$$

$$\underline{T} = \underline{\beta}C(\underline{Q}) = \underline{\beta}C(C'^{-1}(v/\underline{\beta}))$$

$$\bar{Q} = C'^{-1}(v/\bar{\beta})$$

$$\bar{T} = \bar{\beta}C(\bar{Q}) = \bar{\beta}C(C'^{-1}(v/\bar{\beta}))$$

Note that A captures the whole surplus generated by the relation no matter B's type. Assuming that the reservation utility of the agent is zero, A gives B just his cost since he knows the type of B. Therefore, maximizing the surplus of A is equivalent to maximizing the total surplus. Hence, maximum possible total surplus is obtained in this case and the resulting outcome is efficient.

4.1.2 Contract is offered by B

If B is a $\underline{\beta}$ type, he will offer $(\underline{T}, \underline{Q})$ where

$$\underline{Q} = arg\max_{Q}(vQ - \underline{\beta}C(Q))$$

and $\underline{T} = v\underline{Q}$

If B is a $\bar{\beta}$ type, he will offer $(\bar{T}, \bar{Q})$ where

$$\bar{Q} = arg\max_{Q}(vQ - \bar{\beta}C(Q))$$

and $\bar{T} = v\bar{Q}$

It is easy to verify that the solution of $\bar{Q}$ and $\underline{Q}$ are exactly the same as the case where the contract is offered by A. The difference lies in that B is getting all of the surplus since he demands a transfer equal to the value of the product to A. Therefore, as far as efficiency is concerned, it does not matter who offers the contract in the case of symmetric information. In each case, maximum total surplus is obtained and both outcomes are efficient. We proceed below with the case of asymmetric information.

4.2 Case 2 : Asymmetric Information

4.2.1 Contract is Offered by A

Now, let us assume that A does not know the type of B; but instead the probability of being of each type. The probabilities that B is a high quality or a low quality one, are $\bar{\pi}$ and $\underline{\pi}$, respectively. Now, A must consider the possibility that B can choose a contract which is designed for another type. In fact, we can show that B who will want to deviate is the $\bar{\beta}$ type. If the same contract is offered as in the symmetric information case, $\bar{\beta}$ will prefer to produce $\underline{Q}$ and take $\underline{T}$ since $\underline{T} - \bar{\beta}C(\underline{Q}) > 0$ while $\underline{T} - \underline{\beta}C(\underline{Q}) = 0$ and $\bar{\beta} < \underline{\beta}$. Therefore, A must give $\bar{\beta}$ sufficient incentives to enforce him to choose the contract designed for him, a course of action which requires A to sacrifice some of the total surplus. The problem of A is as follows:

$$\max_{\underline{Q},\underline{T},\bar{Q},\bar{T}} \bar{\pi}(v\bar{Q} - \bar{T}) + (1 - \bar{\pi})(v\underline{Q} - \underline{T})$$

subject to

$$P_{\underline{\beta}} \quad : \underline{T} - \underline{\beta}C(\underline{Q}) \geq 0$$

$$P_{\bar{\beta}} \quad : \bar{T} - \bar{\beta}C(\bar{Q}) \geq 0$$

$$IC_{\underline{\beta}} \quad : \underline{T} - \underline{\beta}C(\underline{Q}) \geq \bar{T} - \underline{\beta}C(\bar{Q})$$

$$IC_{\bar{\beta}} \quad : \bar{T} - \bar{\beta}C(\bar{Q}) \geq \underline{T} - \bar{\beta}C(\underline{Q}),$$

where P and IC refer to the participation and incentive compatibility constraints, respectively.

A would obviously prefer all of the four constraints to be satisfied with equality. But, as argued above, $\bar{\beta}$ type will prefer to shift to the contract offered to a $\underline{\beta}$ type. Hence, $IC_{\bar{\beta}}$ will not hold if other three hold with equality. Therefore, A has to sacrifice something. We'll assume that $IC_{\bar{\beta}}$ and $P_{\underline{\beta}}$ are satisfied with an equality. We can establish the following well-known result.

Lemma 1: If $IC_{\bar{\beta}}$ and $P_{\underline{\beta}}$ are satisfied with an equality, then $IC_{\underline{\beta}}$ and $P_{\bar{\beta}}$ are satisfied.

If $IC_{\bar{\beta}}$ holds with equality,

$$\bar{T} - \bar{\beta}C(\bar{Q}) = \underline{T} - \bar{\beta}C(\underline{Q})$$

which can be arranged to yield

$$(\bar{T} - \underline{T}) - \bar{\beta}(C(\bar{Q}) - C(\underline{Q})) = 0 \qquad (*)$$

Since $\underline{\beta} > \bar{\beta}$, we have

$$(\bar{T} - \underline{T}) - \underline{\beta}(C(\bar{Q}) - C(\underline{Q}) < 0$$

Then, $IC_{\underline{\beta}}$ holds with a strict inequality.

Then, $\bar{T} - \underline{\beta}C(\bar{Q}) < 0$ because we have $\underline{T} - \underline{\beta}C(\underline{Q}) = 0$ from $P_{\underline{\beta}}$. On the other hand, since $P_{\underline{\beta}}$ is satisfied with an equality, $\underline{T} - \underline{\beta}C(\underline{Q}) = 0$ must hold.

But since $\underline{\beta} > \bar{\beta}$, $\underline{T} - \bar{\beta}C(\underline{Q}) > 0$

Using this inequality in $IC_{\bar{\beta}}$, we get $\bar{T} - \bar{\beta}C(\bar{Q}) > 0$. So, $P_{\bar{\beta}}$ holds with a strict inequality.

Therefore, A's problem is simplified to :

$$\max_{\underline{Q},\underline{T},\bar{Q},\bar{T}} \bar{\pi}(v\bar{Q} - \bar{T}) + (1 - \bar{\pi})(v\underline{Q} - \underline{T})$$

subject to

$$P_{\underline{\beta}} \quad : \underline{T} - \underline{\beta}C(\underline{Q}) = 0$$

$$IC_{\bar{\beta}} \quad : \bar{T} - \bar{\beta}C(\bar{Q}) = \underline{T} - \bar{\beta}C(\underline{Q}).$$

The constraints can be eliminated through substitution. From $P_{\bar{\beta}}, \underline{T} = \underline{\beta}C(\underline{Q})$. Substituting this in $IC_{\bar{\beta}}$,

$$\bar{T} = \underline{\beta}C(\underline{Q}) - \bar{\beta}(C(\underline{Q} - C(\bar{Q})).$$

Substituting $\underline{T}$ and $\bar{T}$ in the objective function, we have:

$$\max_{\underline{Q},\bar{Q}} \bar{\pi}(v\bar{Q} - \underline{\beta}C(\underline{Q}) + \bar{\beta}(C(\underline{Q}) - C(\bar{Q})) + (1 - \bar{\pi})(v\underline{Q} - \underline{\beta}C(\underline{Q}))$$

By Assumption 1, the second order conditions hold, so the solution is unique. The first order conditions are respectively

$$\bar{Q}: \quad \bar{\pi}(v - \bar{\beta}C'(\bar{q})) = 0 \text{ and}$$

$$\underline{Q}: \quad \bar{\pi}(-\underline{\beta}C'(\underline{Q}) + \bar{\beta}C'(\underline{Q})) + (1 - \bar{\pi})(v - \underline{\beta}C'(\underline{Q})) = 0.$$

Solving for $\bar{Q}$ and $\underline{Q}$, yields

$$\bar{Q} = C'^{-1}(\tfrac{v}{\bar{\beta}})$$

$$\underline{Q} = C'^{-1}(\tfrac{v}{\underline{\beta}} \tfrac{(1-\bar{\pi})}{(1-\bar{\pi}\frac{\bar{\beta}}{\underline{\beta}})}),$$

which substituted in the expressions above yield $\bar{T}$ and $\underline{T}$ as

$$\bar{T} = \underline{\beta}C(C'^{-1}(\tfrac{v}{\underline{\beta}} \tfrac{(1-\bar{\pi})}{(\bar{\pi}\frac{\bar{\beta}}{\underline{\beta}})}) - \bar{\beta}(C(C'^{-1}(\tfrac{v}{\underline{\beta}} \tfrac{(\bar{\pi}-1)}{(\bar{\pi}\frac{\bar{\beta}}{\underline{\beta}}-1)})$$

$- CC'^{-1}(\frac{v}{\bar{\beta}}))$

and

$$\underline{T} = \underline{\beta}C(C'^{-1}(\tfrac{(1-\bar{\pi})}{(1-\bar{\pi}\frac{\bar{\beta}}{\underline{\beta}}}))$$

Note that, $1 - \bar{\pi}(\bar{\beta}/\underline{\beta}) < 1 - \bar{\pi}$ because $\underline{\beta} > \bar{\beta}$. Therefore, $\underline{Q}$ and $\underline{T}$ are smaller, $\bar{Q}$ is the same and $\bar{T}$ is higher than their values in the case of symmetric information. A further observation is that $\underline{T} = \underline{\beta}C(\underline{Q})$ and $\bar{T} \geq \bar{\beta}C(\bar{Q})$. From these observations, we reach the following conclusions:

1)Although the β type produces the efficient quantity, he obtains a tranfer greater than his total cost of effort. But this does not cause a loss of efficiency, it is just a transfer. Whatever the tranfer from A to B, the important question is whether or not the production quantity is efficient.

2)The quantity produced by the $\underline{\beta}$ type agent is less than the efficient quantity. Although his cost of effort is covered by the tranfer, he does not produce the efficient quantity. Therefore with probability $\bar{\pi}$, there will an inefficiency in the case of asymmetric information.

4.2.2 Contract is Offered by B

Consider now the case where B offers the contract. Clearly, both types of B will offer their symmetric information contract since there is no change in the position of B; they still have the information about their own types. Then, maximum total surplus can be obtained and the resulting outcome is efficient.

4.3 Conclusion

From this example, I conclude that efficiency requires the individual who has the relation-specific asset (information) to have the right to offer the take-it-or-leave-it contract. In the absence of information problems, it does not matter who offers the contract as far as efficiency is concerned, the maximum total surplus can be obtained whoever offers the contract. In the case of asymmetric information, efficiency can be reached if B offers the contract, but not A. Therefore, the symmetric information case is more efficient than the asymmetric information case if B is a $\underline{\beta}$ type and the contract is offered by A.

As an example, the right to offer the contract may be determined by the ownership of another asset, a machine, that is used in the production. Then, according to my conclusion, B should own the machine if he possesses output-relevant private information [2]. This is to provide high powered incentives to B to produce the efficient quantity.

Another possible interpretation is that the information and the machine can be considered as complementary assets in the sense that they are more efficient if owned together. We conclude that such complementary assets should be owned together,which is parallel to Hart and Moore (1990) theory of ownership.

[2]It may be the case that the product is no value to him. For example, the value v may come from the marketing of the product and B may not have the ability to market the product. So, production is no value to him without another person who can market it.

5 Third Example: Integration or Nonintegration

5.1 The Model

In this section we present an example based on the model of Hart and Moore (1990). Let S denote the set of agents and A the set of assets. There are two time periods in our model, time 0 and time 1. At time 0, the agents make some investments which are unobservable by the other agents. For simplicity, we will assume that the agents make investment only on human capital which will be denoted by x_i, $i \in S$. Therefore, the investment increases the productivity of the individuals; but not the asset's. Let x denote the investment vector of the individuals in a coalition. We will also assume that x_i's are so complex to specify and so it is very costly to write a complete contract at time 0. At time 1, all of the investments are observable to everyone and some value is generated whose value depends on the investments of time 0. Thus, the contract is negotiated under symmetric information at time 1.

We will denote the value generated by a coalition $S' \subset S$ having the control of the assets $A' \subset A$ and making the investments x_i, where $i \in A$, by $v(S', A', x)$. The derivative of this function with respect to x_k, i.e. the marginal product of investment of k, where $k \in S$, will be denoted by $v^k(S', A', x)$. We will denote the investment cost of x_i by $C_i(x_i)$. We make the following assumptions:

Assumption 1: $v(S, A|x) \geq 0$ and $v(\emptyset, A|x) = 0$, where $\emptyset$ is the empty set. $v(S, A|x)$ is twice differentiable and concave in x.

Assumption 2: $v^i(S, A|x) = 0$ if $i \notin S$.

Assumption 3: $(\partial/\partial x_j)v^i(S, A|x) \geq 0$ for all $j \neq i$.

Assumption 4: For all subset $S' \subseteq S$, $A' \subseteq A$, $v(S, A|x) \geq v(S', A'|x) + v(S \backslash S', A \backslash A'|x)$.

Assumption 5: For all subset $S' \subseteq S$, $A' \subseteq A$, $v^i(S, A|x) \geq v^i(S', A'|x)$.

Assumption 6: $C_i(x_i) \geq 0$ and $C_i(0) = 0$. C_i is twice differentiable where $C_i'(x_i) > 0$ and $C_i''(x_i) > 0$.

Now, suppose for simplicity that there are two assets and each asset a_i,

$i = 1, 2$ has one main worker. Besides these, there are many "small" workers, w_i, $i = 1, 2$, in the sense that they are dispensible.

As stated before, Hart and Moore (1990) used a cooperative approach where the grand coalition forms and distributes the total according to the Shapley value which will not be discussed here. We will rather use a non-cooperative approach. We will assume that coalition are partnerships that they distribute the total value equally among the members.

5.2 Definition of Some Concepts

Definition: An agent k is *dispensable* if the other agents' marginal product of investment is unaffected by whether or not he is a member of their coalition(assuming the coalition controls a given set of assets). That is, for all coalitions S containing agent k and for all sets A of assets,

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

The opposite of dispensability is indispensability.

Definition: An agent i is *indispensable* to an asset a_n if, without agent i in a coalition, asset a_n has no affect on the marginal product of investment for the members of that coalition. That is, for all agents j in any coalition S and for all sets A of assets containing a_n,

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

Hart and Moore present the following proposition emphasizing the importance of indispensibility.

Proposition: If an agent is indispensable to an asset, then he should own it.

It's obvious that giving the ownership of any asset to a person who is dispensable can not be optimal. Hence, neither w1 nor w2 should own any asset.

We will suppose further that a_1 is essential to 1 and w1 and a_2 is essential to 2 and w2.

Definition: An asset a_n is *essential* to an agent i if the marginal product of investment for the agents in a coalition will not be enhanced by agent i unless the coalition controls a_n. That is, for all agents j in any coaltion S and for all sets A of assets,

$v^j(S, A) = v^j(S\backslash\{i\}, A)\ a_n \notin A.$

There are four ownership alternatives: (i) 1 owns a_1 and 2 owns a_2 (which can be interpreted as nonintegration), (ii) 1 owns both of the assets (integration with 1 as the boss of the integrated firm), (iii) 2 owns both of the assets (integration with 2 as the boss of the integrated firm), (iv) 1 owns a_2 and 2 owns a_1.

Actually, the last alternative can be eliminated since it is dominated by both the second and the third alternatives. Consider giving the ownership of both assets to 1. Incentives of 1 and w1 will increase; but incentives of 2 and w2 will not change since they have to reach an agreement with 1 again because a_2 is essential to 2 and w2.

Now, we will consider the first and the second alternatives in detail. We will omit $w1$ and $w2$ in the v function since they are dispensable. Note also that small workers can obtain no surplus by themselves. They have to be in a coalition which has the control of the asset that is essential to them.

5.3 Investment Incentives in Nonintegration and Integration

5.3.1 Nonintegration

In this case 1 owns a_1 and 2 owns a_2. We will consider two alternatives: 1 and 2 may work seperately or they may form a partnership and share the surplus equally. Let's first state the first order conditions for investments if they act seperately:

$$1 \ : C_1' = v^1(1, a_1)$$

$$2 \ : C_2' = v^2(2, a_2)$$

$$\text{w1} : C_{w1}' = v^{w1}(1, a_1)/2 \text{ (w1 has to reach an agreement with 1)}$$

$$\text{w2} : C_{w2}' = v^{w2}(2, a_2)/2 \text{ (w2 has to reach an agreement with 2).}$$

If A and B form a partnership, their investments can be found from:

$$1 \ : C_1' = v^1(12, a_1 a_2)/2$$

$$2 \ : C_2' = v^2(12, a_1 a_2)/2$$

w1 : $C'_{w1} = v^{w1}(12, a_1a_2)/3$ (w1 has to be in agreement with 1 and 2)

w2 : $C'_{w2} = v^{w2}(12, a_1a_2)/3$.(w1 ")

5.3.2 Integration

Without loss of generality, we will only consider the case where 1 owns both of the assets. The case where 2 owns both of the assets is similiar. We will consider two alternatives: 1 and 2 may work seperately or they may form a hierarchy, i.e. 2 may work for 1 who owns both of the assets. Then, 1 will take all of the surplus and just gives a wage to 2. Let's first state the first order conditions for the investments if they act seperately:

1 : $C'_1 = v^1(1, a_1a_2)$

2 : No investment since a_2 is essential to him.

w1 : $C'_{w1} = v^{w1}(1, a_1a_2)/2$

w2 : No investment since $a_2$is essential to him.

Since there are just two periods in our example, 2 and w2 will make no investments. Although the investments are on human capital, they will not be able to use it in somewhere else later since there are just two periods in our example.
If they form a hierarchy, their investments can be found from:

1 : $C'_1 = v^1(12, a_1a_2)$

2 : No investment since he is just obtaining wage. All the surplus which will come from his investment will go to 1.

w1 : $C'_{w1} = v^{w1}(12, a_1a_2)/2$

w2 : No investment by the same reasoning for 2.

5.4 Comparison of Integration and Nonintegration

Comparison of two structures in terms of efficiency depends on whether 1 and 2 are dispensable or indispensable to any one or both assets. If 1 is indispensable only to a_1 and 2 is indispensable only to a_2, 1 must own a_1 and 2 must own a_2. If either 1 or 2 is indispensable to both assets, the indispensable one must be the owner of both assets. If both 1 and 2 are indispensable to both a_1 and a_2, they must form a partnership or a hierarchy.

If no agent is indispensable to any asset, the most efficient structure becomes a function of the form of v. In general, if the incentives of 1 and w1 increase more than the decrease in the incentives of 2 and w2 by transfering a_2 from 2 to 1, integration will dominate; otherwise nonintegration will dominate. We will now give some general examples to possible funtional forms of v and compare integration with nonintegration.

If we suppose that $v(1, a_1a_2)$ depends primarily on a_1, in the sense that $v(1, a_1a_2) = \alpha_1(1, a_1) + \epsilon_1\beta_1(1, a_2)$ and $v(2, a_1a_2)$ depends primarily on a_2, in the sense that $v(2, a_1a_2) = \alpha_2(2, a_2) + \epsilon_2\beta_2(2, a_1)$ where ϵ_1, $\epsilon_2 > 0$ are small, nonintegration dominates integration. Both 1 and 2 own the assets which are essential to them and neither 1 nor 2 will not make a contribution to the total value as much as the other does by also having the ownership of the other asset.

Now, suppose that $v(1, a_1a_2)$ hardly depends on a_1 and a_2, in the sense that $v(1, a_1a_2) = k_1 + \epsilon_3\beta_3(1, a_1a_2)$ where $\epsilon_3 > 0$ is very small and $k_1 \in \mathcal{R}^+$. Then, 2 should own both of the assets. 1 will not make a contribution to the total value as much as 2 by owning any one of the assets.

Similarily, if we suppose that $v(2, a_1a_2)$ hardly depends on a_1 and a_2, in the sense that $v(2, a_1a_2) = k_2 + \epsilon_4\beta_4(1, a_1a_2)$ where $\epsilon_4 > 0$ is very small and $k_2 \in \mathcal{R}^+$. Then, 1 should own both of the assets. 2 will not make a contribution to the total value as much as 1 by owning any one of the assets.

Many other comparisons are possible depending on the function v and the type of the integration (seperate or partnership) and the nonintegration (seperate or hierarchy).

6 Conclusion

The literature suggests a number of reasons for why transaction costs in a firm may be lower than in a decentralized market. If transaction costs are always lower in the firm. They could be reduced without limit by merging firms to remove any market transactions. But this is not the case. In our first example we present one disadvantage of firms, i.e. unified structures, and that is monitoring. Monitoring is an additional cost which does not exist when the units are operating seperately. In that example we interpret the hierarchy as a more unified structure than the partnership in the sense that ownership of assets are more concentrated in the hierarchy. From that example, we have the following conclusions: if the cost of working is small relative to the benefit of working, the partnership structure is more efficient than the hierarchy structure, imposing a limit on the size of an organization, if the cost of working is high relative to the benefit of working, two structures are equivalently efficient since noone will prefer to work. For some interval of cost of working within these two extremes, the hierarchy may be more efficient than the partnership depending on the cost and effectiveness of monitoring.

In our second example, we introduce the possibility of private information by one party. The most important conclusion from that example in terms of ownership is that two cospecialized assets-that is assets that are most productive when used together- should be owned together. In that example, one of the assets was a "machine" and the other was "information".

In the third example, we see that the integration of the production units is associated with a shift in decision making authority and a change in the relative bargaining power of the individual production units. Assuming that the contracts are incomplete and the investments are relation-specific, integration yields a more efficient outcome than nonintegration if the investment decisions of one production unit has a significantly greater impact on the joint surplus from investment than the other unit's investment decision.

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8 Appendix

Here, we complete the proofs of Proposition 1 and 2. We shall examine the corresponding strategy space to show that no other Nash equilibrium exists besides those listed in the Propositions.

The remaining proof of Proposition 1

Claim 1 : $\{(x_A^* = 1, m_A^* \geq 0)$ and $(x_B^* = 0, m_B^* = 0)\ \}$ or $\{(x_A^* = 0, m_A^* = 0)$ and $(x_B^* = 1, m_B^* \geq 0)\ \}$ can not be Nash equilibria.

Proof : Without loss of generality, we provide a proof of the first strategy configuration. Given B does not work and so will not monitor, A prefers to work if

$(S(1)/2)(1 + p(m_A^*)) - d(m_A^*) - c > 0.$

Given A works and monitors, B prefers to work if

$(S(2)/2) - c < (1 - p(m_A^*))(S(1)/2).$

From the first condition, we get

$c < (S(1)/2)(1 + p(m_A^*)) - d(m_A^*).$

Combining the last inequality with the second condition, we have:

$S(2)/2 - (1 - p(m_A^*)) < (S(1)/2)(1 + p(m_A^*)) - d(m_A^*).$

Arranging the terms gives us

$\frac{S(2)}{2} - S(1) < -d(m_A^*).$

From Assumption 1, the left hand side is positive. From Assuption 3, the right hand side is negative. Therefore, the required two conditions can never be satisfied for any values of the parameters, hence the strategies in claim 1 do not form a Nash equilibria.

Claim 2 : $\{(x_A^* = 1, m_A^* \geq 0)$ and $(x_B^* \in [0,1], m_B^* = 0)\ \}$ or $\{(x_A^* \in [0,1], m_A^* = 0)$ and $(x_B^* = 1, m_B^* \geq 0)\ \}$ can not be Nash equilibria.

Proof : We consider the first case. Given B is indifferent between working and not working and that he does not monitor, A prefers to work and monitor B if

$x_B^* \frac{S(2)}{2} + (1 - x_B^*)(1 + p(m_A^*)\frac{S(1)}{2} - d(m_A^*) - c > x_B^* \frac{S(1)}{2}.$

Given A works and monitors B, B does not monitor A since he is sure that A works. He is indifferent between working and not working if

$\frac{S(2)}{2} - c = (1 - p(m_A^*))\frac{S(1)}{2}$.

Solving for $p(m_A^*)\frac{S(1)}{2}$ from the second condition and substituting into the first condition gives the following inequality:

$x_B^* \frac{S(2)}{2} + S(1) - \frac{S(2)}{2} + c - x_B^* \frac{S(1)}{2} - x_B^* p(m_A^*)\frac{S(1)}{2} - d(m_A^*) - c > x_B^* \frac{S(1)}{2}$.

By arranging this last inequality, we have

$x_B^* p(m_A^*)\frac{S(1)}{2} + d(m_A^*) - (1 - x_B^*)(S(1) - \frac{S(2)}{2}) < 0$.

But it is impossible for the above inequality to hold since $x_B^* p(m_A^*)\frac{S(1)}{2} > 0$, $d(m_A^*) > 0$ and from Assumption 1, $-(1 - x_B^*)(S(1) - \frac{S(2)}{2}) > 0$. So, the specified strategies can not be a Nash equilibrium.

The remaining proof of Proposition 2

First note that there can not be any Nash equilibria in the hierarchy where B works, i.e. $x_B = 1$. This is so because if B works, A does not monitor him; but if B is not monitored, he does not work. Hence, $x_B = 1$ can not be a Nash equilibrium strategy. We are left just one strategy for A and B which is not included in Proposition 1. This strategy configuration is: $\{(w^*, x_A^* \in [0,1], m_A^* \geq 0)$ and $x_B^* \in [0,1]\}$.

Let us show that this is not a Nash equilibrium. Given that B is indifferent between working and not working, A is also indifferent between working and not working if

$x_B^*(S(2)-w^*)+(1-x_B^*)(S(1)-w^*+p(m_A^*)w^*)-d(m_A^*)-c = x_B^*(S(1)-w^*)$.

On the other hand, from B's point of view, we must have:

$w^* - c = x_A^*(1 - p(m_A^*)w^*$.

After simplyfing the first condition above, Assumption 1, Assumption 2 and the fact that $x_B \leq 1$ imply

$S(2) - S(1) < c - w$.

Since $S(2) - S(1) > 0$ from Assumption 1, c must be strictly greater than w. But it is straightforward to see from the second condition that $w \geq 0$, contradicting the implication from the other condition. Therefore, there can not be a Nash outcome where both A and B are indifferent between working and not working.