The economic organisation of specific assets

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1. Introduction[1]

A considerable amount of inputs are required to extract oil and gas offshore. One has to explore the petroleum deposits. One has to design and build equipment to extract the oil from the seabed. And, finally, one has to extract the oil. It is a great logistic challenge to organize all the involved activities in an effective way. In order to study the overall economic organization of these activities, it is useful to identify a few aggregate and strategic inputs. Two important inputs then emerge as natural choices within this framework: 1) the engineering of the oil platform and 2) the oil platform. With "oil platform" I mean "all types of installations that are built with the purpose of offshore oil extraction". The engineering includes "all activities involved in the planning and designing of the construction".

We then have three products in what we can call a vertical supply chain: engineering of the oil platform, oil platform, oil. How is the economic organization of these products? This question can be divided into the two following: a) under which ownership structure is the products organized? b) How are the contractual relations between and within the ownership entities?

The contractual relations between the elements in the supply chain vary, but they always contain implicit elements. Effective incentive schemes are necessary to reduce costs and promote quality. But it is difficult to formulate explicit verifiable contracts on quality. Relational contracts, built on implicit elements, and maintained through reputational motivations, are therefore required (see Klein and Leffler, 1981, among others).

We can identify six archetypes of ownership structures in the oil industry:

Alternative A: Total integration. The oil company (O) undertake the engineering (E) and construction (C) of the oil platform.

Alternative B: An independent engineering company designs the platform and delivers the service to an integrated oil company, which both builds the oil platform and extract the oil.

Alternative C: An integrated supplier both designs and builds the platform, and delivers it to the oil company.

Alternative D: An independent engineering company delivers project services to the main contractor that builds the platform and delivers it to the oil company.

Alternative E: The engineers work in the oil company. They design the platform, which is then built by the main contractor who delivers the platform to the oil company.

Alternative F: An independent engineering company delivers drawings to the oil company who contract with the main contractor to build the platform according to the design.
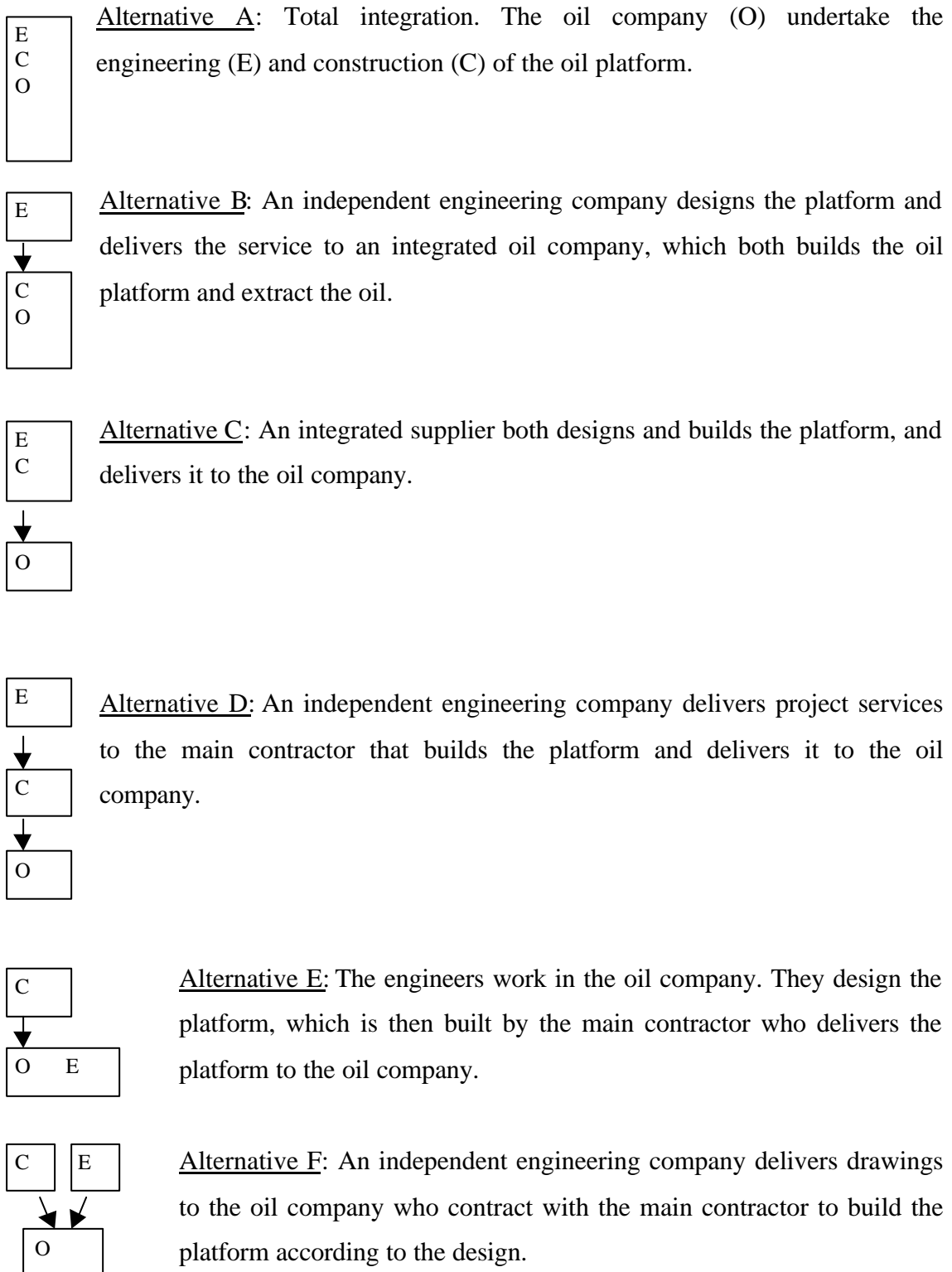
Figure 1: Six archetypes of ownership structures in the oil industry

Alternative A and B are not observed in this industry. The oil companies and the construction companies have always disintegrated ownership. The main engineering company does seldom operate as an independent company. Alternative D and F are therefore seldom seen. Today alternative C best illustrates the economic organization of the three activities. The oil company and the main contractor agree on a so-called EPCI-contract, in which the main contractor gets the responsibility of Engineering, Procurement, Construction and Installation. (For more details see Osmundsen 1999).

There may exist a number of explanations on why alternative C is a preferred way of organizing the oil industry. The oil companies want to focus on its core competence (defined as exploration, extraction, refining and distribution of oil and gas) and therefore find it optimal to let an outside supplier run the development projects. This focus may give them flexibility in adjusting the labor force, which again reduces costs. Strategic focus may also generate economies of scale in organization and production. The main contractors often find it optimal to integrate the engineers into their organization to better manage the requirements in the EPCI-contracts. Engineering has become a part of the main contractors core competence.

Within the traditional theory of the firm this organizational solution emerges as a puzzle. In short, the theory states that specific assets are best managed when organized under the same ownership. The main argument is that specific assets increase the possibility for opportunistic behavior (the supplier can "hold up" its product, the buyer can "hold up" its payments), and that this possibility is constrained through integration. The theory also advocates outsourcing of human capital. Human capital can always be managed strategically; independent of the ownership structure, and integration is therefore not perceived to reduce the problem of opportunistic behavior (Klein, Crawford and Alchian 1978, Williamson 1985).

The assets in the oil industry must be considered as specific: the supplier's capital stock and the inputs they produce and deliver to the oil companies do not enjoy a significant value in any alternative use. Specific inputs may still be valuable to a competing oil company, but the technology is often tailor-made for a specific field or a specific oil company. In addition to the recognition of asset specificity in the oil industry, it is reasonable to consider the building of the platform as intensive in physical capital and engineering as intensive in human capital. Thus, we should expect to see alternative B (outsource specific human capital, employ specific physical capital) in the oil industry. But alternative B is never observed.

In recent years, more sophisticated models on economic organization have emerged (Holmstrøm and Milgrom 1994; Halonen 1995; Baker, Gibbons and Murphy 1997; Rajan and Zingales 1998; Holmstrøm 1999 among others). Ownership has been considered as only one of many dimensions within the feasible organizational forms, and outsourcing of specific assets has been explained partly by developing of relational contracts.

Still, no model has, to my knowledge, explicitly shown how a high level of asset specificity actually can be an argument for separate ownership. In the following I will present a model that captures this. It is built on a model developed by George Baker, Robert Gibbons and Kevin J. Murphy 1997 (BGM). They develop a repeated game model where an upstream party in each period uses an asset to produce a good that could be used in a downstream party's production process. The parties agree on an implicit contract where bonuses are paid according to the quality of the good produced. If one of the parties reneges on the contract, they continue to trade with each other, but in a non-cooperative manner. They agree on a spot contract where outside alternatives and bargaining positions decide the price of the good. The main difference between BGM's model and my approach is in terms of the punishment strategies. In my model, the player's strategy is not one in which deviation results in an eternal non-cooperative mode. Instead the players use the more realistic carrot and stick strategy in which co-operation can exist also after deviation. But the deviation periods are tougher. The parties have to actually trade in an alternative market, and this makes it more costly to deviate. This difference gives us interesting implications on the nature of specific assets. I derive a result that goes against Williamson's claim that a high degree of asset specificity implies integration. Asset specificity makes it very costly to deviate from an implicit contract based on separate ownership. So a high degree of asset specificity is in a sense a blessing. These implications also help us understand the oil industry's preference for alternative C.

The rest of the paper is organized as follows: In section 2 I present an extension of the Baker, Gibbons and Murphy model. Section 3 discusses the theoretical and economic implications of the model. Section 4 applies these theoretical implications on the oil industry, while section 5 concludes.

2. The model

We study a game between a supplier (upstream) and a customer (downstream) where the supplier uses an asset to produce a good or a service for the downstream party. The upstream party can deliver its good to an alternative market, while the downstream party can buy the good in the alternative market.
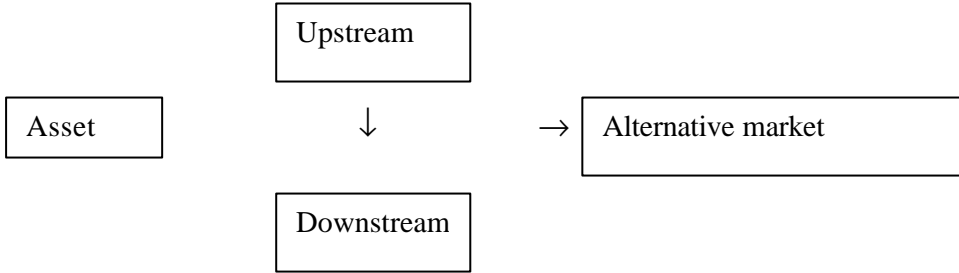
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                    ┌──────────────┐
                    │  Upstream    │
                    └──────────────┘
┌──────────┐              ↓              →  ┌──────────────────────┐
│  Asset   │                                │  Alternative market  │
└──────────┘        ┌──────────────┐        └──────────────────────┘
                    │  Downstream  │
                    └──────────────┘
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Figure 2: *The model*

Both parties are risk neutral and face the discount factor **d** per period. They play a so-called infinitely repeated game: both parties and the asset exist forever, or cease to exist at a random date. In each period the upstream party makes a choice of action (an investment choice) *a* at a cost *c(a)* which affects the value of the product both for the downstream party (*Q*) and for the alternative market (*P*). The downstream value is either high Q_H or low Q_L, where *q(a)* is the probability that a high value Q_H will be realized. The alternative-use value can also be either high, P_H, or low, P_L, where *p(a)* is the probability that a high value, P_H, will be realized. Given the upstream party's action, the downstream party and the alternative-use values are conditionally independent. We assume that $c(0) = q(0) = p(0) = 0$, so that when the upstream party decides not to invest, he bears no costs but also has no chance of realizing the high values.

We assume that $P_L < P_H < Q_L < Q_H$ so that the value to the downstream party always exceeds its value in the alternative use. In other words: the asset is relational specific. First best action, a^*, maximizes total surplus, S^*, which is given by:

$$Q_L + q(a^*)\Delta Q - c(a^*) = S^* \quad , \text{where} \ \Delta Q = Q_H - Q_L$$

The investment is unobservable to anyone but the upstream party, so contracts contingent on investment decisions cannot be enforced. We also assume that neither Q nor P is contractible in a way that a third party can enforce. This means that no court of law can prove whether the parties renege on or comply with the contract. But Q and P can be observed by the parties.

Even though the key elements are not contractible in an explicit manner, the parties can enter into a relational contract enforced through the parties' concerns about their reputations. We model an implicit contract $(b_L, b_H, \boldsymbol{b}_L, \boldsymbol{b}_H)$ where b_i is supposed to be paid when Q_i is realized *(i = H, L)* and $\boldsymbol{b}_j$ is supposed to be paid when P_j is realized *(j = H, L)*. For example: If the upstream party produces a good which holds a high value in the specific relation, Q_H, and a low value in the alternative market, P_L, the downstream party should, according to the contract, pay the bonuses $b_H + \boldsymbol{b}_L$ to the upstream party.

I assume that the parties use the following carrot and stick strategy:

1. Accept if both parties accepted in the last period.
2. Accept if the last period was a "punishment period".
3. Punish otherwise.

To accept means for the upstream party to accept the bonuses offered and for the downstream party to pay the promised bonuses. To punish means for the upstream party to trade in the alternative market or not to produce the good, while it for the downstream party means to trade in the alternative market. The act of punishment occurs when the other party reneged on the contract in the previous period. To renege means for the upstream party not to accept the bonuses offered, while it for the downstream party means not to pay the promised bonuses.

I assume that both parties incur a switching cost *s* by trading in the alternative market when the product already is produced with the purpose of trade in the specific relation. They avoid this cost if they know in advance, that is ex ante the production of the good, that no trade will occur between the parties.

We are now going to study this game with two different organizational forms as starting points: An integrated firm versus a disintegrated supplier-buyer relation. BGM use the terms relational employment (RE) and relational outsourcing (RO). Both these organizational forms are based on implicit relational contracts. The difference lies in the ownership structure. In the relational employment contract the downstream party owns the asset, and the upstream party is employed at, or integrated with, the downstream party. The two parties form one firm. In the relational outsourcing contract, the upstream party owns the asset. The parties are disintegrated, forming two independent firms. Ownership of the asset is important in the way that it conveys ownership to the good produced.

The game starts in period 1. In each period the upstream party first makes an investment and then sells the finished product to either the downstream party or the alternative market. When the players are to decide whether they will follow or renege on the contract, they know the quality realizations of period 1 but not of the remaining periods. The parties will honor the contract as long as the present value of honoring exceeds the present value of reneging.

2.1 Relational Employment

In the relational employment contract the downstream party owns the asset. Let us first look at the upstream party's payoffs under various decisions.

If the upstream party honors the contract, he will earn $b_i + \boldsymbol{b}_j - c\ (a\ )$ in the first period, $\boldsymbol{d}\big(b_i + \boldsymbol{b}_j - c\ (a\ )\big)$ in the second period, $\boldsymbol{d}^2\big(b_i + \boldsymbol{b}_j - c\ (a\ )\big)$ in the third period, and so on. When the upstream party is to decide whether he will honor or renege on the contract, he knows the quality realizations of the first period. In the second period he chooses an investment a^{RE} that solves:

$$\underset{a}{Max}\ (b_L + \Delta b q(a) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a) - c(a)) = U^{RE} \quad \text{where} \quad \Delta b = b_H - b_L, \quad \Delta \boldsymbol{b} = \boldsymbol{b}_H - \boldsymbol{b}_L \quad \text{and}$$

where the superscript (RE) stands for relational employment. The present value of earning D^{RE} in perpetuity is $\frac{1}{1-\boldsymbol{d}} D^{RE}$. To make the different payoffs easy to compare, I choose to distinguish between the first period, the second period and all the remaining periods. The present value of honoring the contract is therefore written:

$$b_i + \boldsymbol{b}_j - c\ (a^{RE}) + \boldsymbol{d}\left(b_L + \Delta bq(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b}p(a^{RE}) - c(a^{RE})\right) + \tfrac{\boldsymbol{d}^2}{1-\boldsymbol{d}}U^{RE}$$

If the upstream party reneges on the contract he will not receive bonuses in any of the first two periods, but in the second period he will bear no investment costs. The payoff after reneging is then:

$$- c\ (a^{RE}) + \tfrac{\boldsymbol{d}^2}{1-\boldsymbol{d}}U^{RE}$$

The upstream party will thus honor rather than renege on the contract when

(1) $b_i + \boldsymbol{b}_j - c\ (a^{RE}) + \boldsymbol{d}\left(b_L + \Delta bq(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b}p(a^{RE}) - c(a^{RE})\right) + \tfrac{\boldsymbol{d}^2}{1-\boldsymbol{d}}U^{RE}$

$\geq - c\ (a^{RE}) + \tfrac{\boldsymbol{d}^2}{1-\boldsymbol{d}}U^{RE}$

or: $b_i + \boldsymbol{b}_j + \boldsymbol{d}\left(b_L + \Delta bq(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b}p(a^{RE})\right) \geq \boldsymbol{d}c\ (a^{RE})$

Let us then look at the downstream party. If he honors the contract, he will earn $Q_i - b_i - \boldsymbol{b}_j$ in the first period, $\boldsymbol{d}(Q_i - b_i - \boldsymbol{b}_j)$ in the second period, $\boldsymbol{d}^2(Q_i - b_i - \boldsymbol{b}_j)$ in the third period, and so on. The expected payoff ex ante the quality realization is $E(Q_i - b_i - \boldsymbol{b}_j | a = a^{RE}) =$

$Q_L + \Delta Qq(a^{RE}) - b_L - \Delta bq(a^{RE}) - \boldsymbol{b}_L - \Delta \boldsymbol{b}p(a^{RE}) = D^{RE}$. If the downstream party honors the contract he will earn:

$$Q_i - b_i - \boldsymbol{b}_j + \boldsymbol{d}\left(Q_L + \Delta Qq(a^{RE}) - b_L - \Delta bq(a^{RE}) - \boldsymbol{b}_L - \Delta \boldsymbol{b}p(a^{RE})\right) + \tfrac{\boldsymbol{d}^2}{1-\boldsymbol{d}}D^{RE}$$

If the downstream party reneges on the contract, he will, in the first period, not pay the promised bonus and instead take the good and pay nothing. In the second period the upstream party will punish the downstream party by refusing to produce the good, so the downstream party has to buy the good in the alternative market. The good he buys in the alternative market is not specific to his needs. Both the value he sets and the price of the good is *P,* so he does not earn a specific surplus from this trade. Hence, the profits from trade is zero in the second period. In the third period the relational contract will again be established given that the strategies are followed[2]. The present value of reneging on the contract is thus simply:

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[2] I could assume that when a party reneges on the contract it decides to renege in each period, but this would have made a weaker restriction. I choose to formulate the restriction with the assumption that the strategies are followed forever after the first deviation. For further discussions of the different subgames, see appendix II.

$$Q_i + \tfrac{d^2}{1-d}D^{RE}$$

The downstream party will thus honor rather than renege on the relational contract when:

$$(2) \qquad Q_i - b_i - \boldsymbol{b}_j + \boldsymbol{d}\left(Q_L + \Delta Q q(a^{RE}) - b_L - \Delta b q(a^{RE}) - \boldsymbol{b}_L - \Delta \boldsymbol{b} p(a^{RE})\right) + \tfrac{d^2}{1-d}D^{RE}$$

$$\geq Q_i + \tfrac{d^2}{1-d}D^{RE}$$

or: $\quad b_i + \boldsymbol{b}_j + \boldsymbol{d}\left(b_L + \Delta b q(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RE})\right) \leq \boldsymbol{d}\left(Q_L + \Delta Q q(a^{RE})\right)$

(1) and (2) represent 8 constraints that have to hold if the relational contract shall be self-enforcing. Combining these restrictions yield: [3]

$$(3) \qquad |\Delta b| + |\Delta \boldsymbol{b}| \leq \boldsymbol{d}\left(Q_L + \Delta Q q(a^{RE}) - c(a^{RE})\right)$$

2.2 Relational outsourcing

In the relational outsourcing contract the upstream party owns the asset. If the upstream party honors the contract he will receive:

$$b_i + \boldsymbol{b}_j - c\ (a^{RO}) + \boldsymbol{d}\left(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RO}) - c(a^{RO})\right) + \tfrac{d^2}{1-d}U^{RO}$$

where the investment a^{RO} solves $\underset{a}{Max}\ \left(b_L + \Delta b q(a) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a) - c(a)\right) = U^{RO}$

The superscript RO stands for relational outsourcing.

If the upstream party reneges on the contract by refusing to accept the bonuses, we assume that the parties by 50:50 Nash negotiations agree on a price $\tfrac{1}{2}(Q_i + P_j - s)$ [4] in the first period.

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[3] See appendix I

[4] The downstream party will pay the upstream party the alternative value $P_j - s$ plus half the surplus from trade with the downstream party: $\tfrac{1}{2}\left(Q_i - (P_j - s)\right)$, that is $\tfrac{1}{2}\left(Q_i + P_j - s\right)$. It may seem a bit strange to only let the upstream party's quality realization decide the Nash-price and not take into account that the downstream party not necessarily faces the same alternative price as the upstream party. But I do follow Baker, Gibbons and Murphy in this. It is also reasonable to assume the prices are close to each other.

In the second period the downstream party will punish the upstream party by refusing to trade with him and instead buy the product in the alternative market at a price P. In the third period the parties reestablish their relational contract. The strategy, in which the downstream party waits to the second period by starting the punishment, coincides with subgame perfect equilibrium for s exceeding a critical level (see appendix II). In the second period, the parties know that no trade will occur between them, so they avoid the switching cost s. In the third period the parties reestablish the relational contract provided that they follow their initial strategies.

The upstream party's payoff after reneging is:

$$\tfrac{1}{2}(Q_i + P_j - s) - c\ (a^{RO}) + \boldsymbol{d}\!\left(P_L + \Delta Pp(a^{ROd}) - c\ (a^{ROd})\right) + \tfrac{\boldsymbol{d}^2}{1-\boldsymbol{d}}\ U^{RO}$$

where the upstream party in the punishment period chooses an investment a^{ROd} that solves
$$\underset{a}{Max}\!\left(P_L + \Delta Pp(a) - c(a\ )\right)$$

The upstream party will thus honor the contract if:

(4) $\quad b_i + \boldsymbol{b}_j - c\ (a^{RO}) + \boldsymbol{d}\!\left(b_L + \Delta bq(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b}p(a^{RO}) - c(a^{RO})\right) + \tfrac{\boldsymbol{d}^2}{1-\boldsymbol{d}}U^{RO}$

$\quad \geq \tfrac{1}{2}(Q_i + P_j - s) - c\ (a^{RO}) + \boldsymbol{d}\!\left(P_L + \Delta Pp(a^{ROd}) - c\ (a^{ROd})\right) + \tfrac{\boldsymbol{d}^2}{1-\boldsymbol{d}}\ U^{RO}$

or[5] $\quad b_i + \boldsymbol{b}_j + \boldsymbol{d}\!\left(b_L + \Delta bq(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b}p(a^{RO})\right) \geq \tfrac{1}{2}(Q_i + P_j - s) + \boldsymbol{d}\!\left(P_L + \Delta Pp(a^{ROd})\right)$

Let us then look at the downstream party. If he honors the contract he will earn:

$$Q_i - b_i - \boldsymbol{b}_j + \boldsymbol{d}\left(Q_L + \Delta Qq(a^{RO}) - b_L - \Delta bq(a^{RO}) - \boldsymbol{b}_L - \Delta \boldsymbol{b}p(a^{RO})\right) + \tfrac{\boldsymbol{d}^2}{1-\boldsymbol{d}}D^{RO}$$
$$\text{where } E(Q_i - b_i - \boldsymbol{b}_j | a = a^{RO}) = Q_L + \Delta Qq(a^{RO}) - b_L - \Delta bq(a^{RO}) - \boldsymbol{b}_L - \Delta \boldsymbol{b}p(a^{RO}) = D^{RO}$$

If the downstream party reneges by refusing to pay the bonuses, the upstream party can, as distinct from the relational employment contract, refuse to deliver the product. The parties will agree on the 50:50 Nash price so that the downstream party earns $Q_i - \tfrac{1}{2}(Q_i + P_j - s)$. In the second period the upstream party will punish the downstream party by refusing to trade

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[5] For simplicity I assume that $c(a^{RO}) = c(a^{ROd})$.

with him and instead sell the product in the alternative market at a price P_j. The downstream party then has to buy the product in the alternative market at a price P, earning nothing. The downstream parties' payoff after reneging is then:

$$Q_i - \tfrac{1}{2}(Q_i + P_j - s) + \tfrac{d^2}{1-d} D^{RO}$$

The downstream party will thus honor the contract if:

(5) $Q_i - b_i - \boldsymbol{b}_j + \boldsymbol{d}\left(Q_L + \Delta Q q(a^{RO}) - b_L - \Delta b q(a^{RO}) - \boldsymbol{b}_L - \Delta \boldsymbol{b} p(a^{RO})\right) + \tfrac{d^2}{1-d} D^{RO}$

$\geq Q_i - \tfrac{1}{2}(Q_i + P_j - s) + \tfrac{d^2}{1-d} D^{RO}$

or: $\tfrac{1}{2}(Q_i + P_j - s) + \boldsymbol{d}\left(Q_L + \Delta Q q(a^{RO})\right) \geq b_i + \boldsymbol{b}_j + \boldsymbol{d}\left(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_j + \Delta \boldsymbol{b} p(a^{RO})\right)$

Combining (4) and (5) yields the following condition for the relational outsourcing contract to be self-enforcing:

(6) $\left|\Delta b - \tfrac{1}{2}\Delta Q\right| + \left|\Delta \boldsymbol{b} - \tfrac{1}{2}\Delta P\right| \leq \boldsymbol{d}\left(Q_L + \Delta Q q(a^{RO}) - P_L - \Delta P p(a^{ROd})\right)$

Since $Q_L + \Delta Q q(a^{RO}) - P_L - \Delta P p(a^{ROd})$ can be interpreted as the level of asset specificity, we see that the relational contract is stronger the more specific the asset is.

4. Implications of the model

As opposed to Baker, Gibbons and Murphy's model, and also as opposed to most of the game theoretic models in this field, the stability of the contract depends on the level of asset specificity, not only on the specificity of the investments made by the parties. Technically this means that the organizational solution depends on the difference, $Q_i - P_j$, more than the difference $\Delta Q - \Delta P$. This happens because of the presence of a valid alternative market. In BGM the alternative market is merely a point of reference for the negotiating parties. In this model the carrot-stick strategy turns the alternative market into a valid alternative that actually is traded if the parties deviate. A high degree of specificity makes the alternative market less attractive compared to a stable relation with the specific trading partner.

If we now compare the right-hand side of the outsourcing restriction (6) with the right-hand side of the employment restriction (3), we see that the employment restriction does not depend on the level of asset specificity in the same way as the outsourcing restriction. We then have that the organizational structure may depend on the asset's specificity, and more importantly: if the asset contains a high level of specificity, separate ownership may prove a better alternative than integration. Why? In the outsourcing contract, both parties have to take into account what the alternative market actually offers. If the alternative market offers significantly lower values than the specific relation does, it can function as a buffer against opportunistic behavior. In the employment contract, on the other hand, the value of the alternative market does not make any difference for the upstream party. As long as the product he produces is not his property, he cannot carry through a hold-up strategy or sell the product on the alternative market.

In both the outsourcing restriction and the employment restriction, the strength of the incentives affects the stability of the contract. The incentives to exert effort are measured by Δb and $\Delta \boldsymbol{b}$. If there is a strong correlation between effort and quality realization, the downstream party may find it profitable to design strong incentive schemes. But the stronger the incentives, that is the larger the difference between high and low bonuses, the larger is the temptation to renege on the contract. Low bonuses may induce the upstream party to renege, while high bonuses may induce the downstream party to renege on the contract. In the outsourcing contract, a high degree of asset specificity can function as a buffer against this kind of opportunistic behavior. If high-powered incentives are desirable, asset specificity can thus ease the implementation of these incentives.
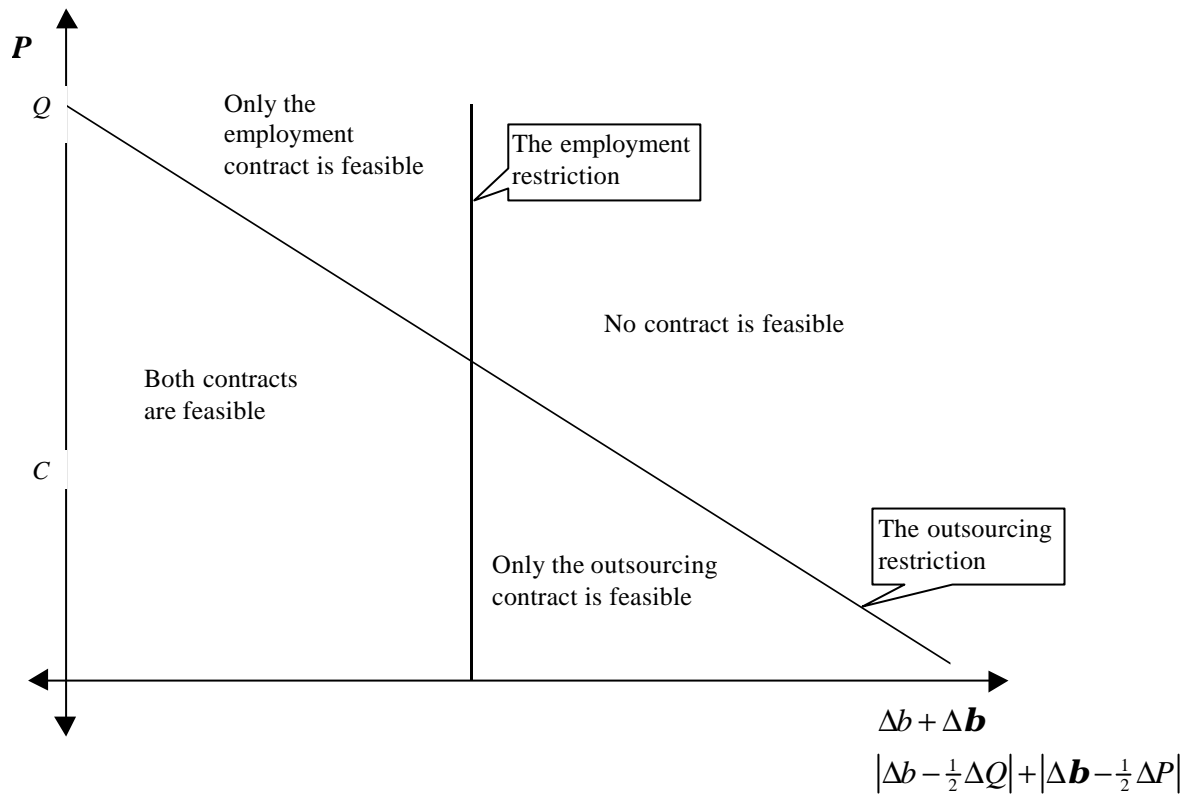
Figure 3: Feasible contracts as a function of asset specificity and incentives.

From figure 3 we see that if the asset specificity, measured by $Q - P$, is high, and strong incentives, measured by Δb and $\Delta \boldsymbol{b}$, are chosen, only the outsourcing contract is feasible. On the other hand, if the asset specificity is low, and weaker, but significant incentives are chosen, only the employment contract is feasible. The vertical axis represents different values of the price in the alternative market; P. The lower P, the higher specificity. The horizontal axis represents the left side of the two contract restrictions. While the employment restriction (integration restriction) is independent of the alternative market price and therefore is represented by a vertical graph, the outsourcing restriction is dependent on P. The lower P, the greater feasibility for the outsourcing contract. We also see that a higher value on Q increases this feasibility. Also the slope of the outsourcing-restriction-graph affects the outsourcing feasibility. It depends on the difference $(\Delta Q + \Delta P) - (\Delta b + \Delta \boldsymbol{b})$.

It is important to notice that the investments in the model are made in physical capital.[6] Once the investments are sunk, the specific surplus can be realized without the investor's

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[6] I apply Hart's (1995) definition of the distinction between physical and human capital investments. An investment is considered as "human" if its return depends on a specific human skill even after the investment is sunk.

participation. In the employment contract we saw that the downstream party had the opportunity to just take the good and realize the surplus without any further participation from the downstream party. If the situation was that the investments were made in human capital, in the sense that the downstream party was dependent on the upstream party even after the product- realization, the upstream party could still hold-up the product, even if he was employed by the downstream party. Thus, if there were a human-capital-binding between the parties, the employment analysis above would be identical to the relational outsourcing analyses. So the separate ownership arguments presented here is not relevant in the case of human capital. In the case of physical capital, the fear from trading in the alternative market disciplines both parties only if they are disintegrated. In the case of human capital the fear from trading in the alternative market disciplines both parties without regards to their choice of integration.

Can the theory of the firm then say anything meaningful about the position of human-capital-intensive activities in a vertical supply chain? Notice that we are not looking for obvious "business arguments" of the kind: "It is important for a firm to attract clever people, thus it is important for a firm to attract valuable human capital."   We are looking for arguments that say something about the strategic behavior of this capital. I will briefly present an argument for integration of human capital:

In an integrated solution where the investments are made in human capital, the upstream party knows that the surplus realization depends on his participation even after the product is made, and this motivates him to exert effort. If we assume that also the downstream party must make an investment ex ante the product realization (see Hart 1995), it would be reasonable to believe that he would not exert maximum effort since he has to share the surplus with the upstream party. If the investments were made in physical assets, the upstream party would not make any effort, while the downstream party would make maximum effort. In a disintegrated solution, the type of capital would not affect effort. It then follows that since the return from (specific) investments in general is assumed to be positive but decreasing, it is better to do two "medium size" investments than one small and one big. This implies that integration is a more valuable solution if the investments are made in human capital then if the investments are made in physical capital.

Conclusion: A high level of asset specificity can actually be an argument for outsourcing. The fact that this argument only applies in the case of physical assets, , and the assumption that the return from specific investments in general is positive but decreasing, imply that there may exist a reason to suggest: "Outsource specific physical capital. Employ specific human capital." This is exactly the opposite of what the Williamsonian transaction cost theory suggests, and interestingly: it is what we observe in the oil industry.

5. Application to the oil industry

The model presented above can easily be applied to the oil industry. The downstream party can be interpreted as the oil company, while the main contractor can be interpreted as the upstream party. If we look at the relation between the engineering activities and the main contractors, it is reasonable to interpret the engineers as the upstream party, and the main contractor as the downstream party.

If we look at the dynamics of the model, it has several similarities to the dynamics in the oil industry. First the parties agree on a relational contract that specifies quality and bonuses. These specifications are, both in the model and in the real world, difficult to verify. If mistrust arises, the parties agree on a spot contract where costs and benefits are renegotiated. This is also close to the real world. When mistrust arises, the parties renegotiate a contract that is more explicit and has fewer bonuses and other incentive instruments than the relational contract. The contract is more like a spot contract which specifies "who's going to pay how much for what went wrong". After the spot contract the model leads us to the punishment period where the parties trade in the alternative market. This can be interpreted as a period where new contracts are about to be made. In the mean time they have to seek alternative revenues. If the asset specificity is high, the alternative revenues are low. Finally comes the period where the parties reestablish their relational contract. "Reestablishing" does not have to be interpreted as "the parties have again found each other". "Reestablishing" can also mean that the parties have agreed on relational contracts with other partners.

Following the arguments in the previous section, one should expect that the oil company and the main contractor always enjoy separate ownership. The main contractor (the upstream party) manages a capital stock that is highly specific to the oil company (the downstream party). The oil platform (or any other kind of installations made by the purpose of oil

extraction) and its many components do not enjoy a significant value in any alternative use. The installation can, of course, have a certain value for another oil company. But the installations are often field specific: they are built with the purpose of oil extraction in a specific field and for a specific operator. Also, strong incentives are desirable as long as there is a lot to gain in promoting quality and reducing costs. Finally, the inputs produced by the contractor are physical. A contractor working as an employee would not own the platform. These factors make us expect disintegration, and disintegration is what we see.

The engineers do also manage a capital stock and produce inputs that are specific to the oil industry, and strong incentives are desirable to reduce costs and promote quality. But their assets and the inputs they produce are non-physical. Education and experience are their main assets and technical solutions are their products. Their assets and their input production exist in their minds. An oil company or a main contractor (which here represents the downstream party) would not attain a complete possession of the engineer's product even if he were employed by the downstream party. Following the arguments above, he can be given strong incentives even if he is employed, and low values in the alternative market would still discipline him as long as he controls what he produces and consequently can sell it. In other words: There does not exist a strong outsourcing argument. The engineer also produces physical write-downs of his thinking. These write-downs can be valuable in an alternative market. Concept evaluations or pre-engineering services may be valuable for some of the oil company's or the main contractor's rivals. This may be an argument for the downstream party to employ, rather than outsource the engineers.

In real life we see that the engineers usually are employed in the oil company or at the main contractor. In the EPCI contracts the main contractor is given, to a certain extent, the right to decide who shall produce the main engineering services. Contractors such as Kværner and Aker have their own engineering units that usually are awarded these engineering contracts.

From the archetypes introduced in the first section, alternative C seems to be the best description of the basic economic organization of the oil industry. And alternative C fits with the implications of the model presented.

6. Summary and conclusions

In this paper I have shown that a high degree of asset specificity can induce outsourcing of physical capital. Outsourcing may increase the feasibility for parties to behave opportunistically since a supplier then can hold up its product. But hold-up strategies are less profitable if the assets are specific. A high degree of specificity implies that the alternative market offers significantly lower values than the specific business relation does. If the alternative market offers significantly low values, it can function as a buffer against opportunistic behavior. But this buffer does not work if the parties are integrated. An integrated supplier does not care about the alternative market as long as what he produces isn't his property. If two parties wish to contract bonus-systems that induce incentives to exert effort, the possibility for the parties to behave opportunistically increases. We then have that if the assets are sufficiently specific, and high-powered incentive schemes are designed, the temptation to behave opportunistically is smaller if the parties are disintegrated.

I have argued that this reasoning only prevails in the case of physical capital. If a supplier delivers human-capital intensive services, he will care about the alternative market even if he is owned by the customer, because his human capital will always be his own property. Thus, the outsourcing argument presented above does not prevail in the case of human capital.

I have introduced six archetypes of ownership structures feasible in the oil industry. The archetype that best fits with the world is the one where an independent supplier both designs and builds the oil platform before it delivers it to the oil company. This archetype is consistent with the implications of the model.

Appendix I

The conditions for honoring the relational employment contract

The upstream party's condition is given by:

$$(\text{A.1}) \quad b_i + \boldsymbol{b}_j + \boldsymbol{d}\big(b_L + \Delta b q(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RE})\big) \geq \boldsymbol{d}c \; (a^{RE})$$

It contains the 4 following constraints:

$$(b_L + \Delta b + \boldsymbol{b}_L + \Delta \boldsymbol{b}) + \boldsymbol{d}\big(b_L + \Delta b q(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RE})\big) \geq \boldsymbol{d}c \; (a^{RE})$$

$$(b_L + \Delta b + \boldsymbol{b}_L) + \boldsymbol{d}\big(b_L + \Delta b q(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RE})\big) \geq \boldsymbol{d}c \; (a^{RE})$$

$$(b_L + \boldsymbol{b}_L + \Delta \boldsymbol{b}) + \boldsymbol{d}\big(b_L + \Delta b q(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RE})\big) \geq \boldsymbol{d}c \; (a^{RE})$$

$$(b_L + \boldsymbol{b}_L) + \boldsymbol{d}\big(b_L + \Delta b q(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RE})\big) \geq \boldsymbol{d}c \; (a^{RE})$$

The downstream party's condition is given by:

$$(\text{A.2}) \quad b_i + \boldsymbol{b}_j + \boldsymbol{d}\big(b_L + \Delta b q(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RE})\big) \leq \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RE})\big)$$

It contains the following 4 constraints:

$$(b_L + \Delta b + \boldsymbol{b}_L + \Delta \boldsymbol{b}) + \boldsymbol{d}\big(b_L + \Delta b q(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RE})\big) \leq \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RE})\big)$$

$$(b_L + \Delta b + \boldsymbol{b}_L) + \boldsymbol{d}\big(b_L + \Delta b q(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RE})\big) \leq \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RE})\big)$$

$$(b_L + \boldsymbol{b}_L + \Delta \boldsymbol{b}) + \boldsymbol{d}\big(b_L + \Delta b q(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RE})\big) \leq \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RE})\big)$$

$$(b_L + \boldsymbol{b}_L) + \boldsymbol{d}\big(b_L + \Delta b q(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RE})\big) \leq \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RE})\big)$$

We see that the high quality realization always gives the binding constraint for the downstream party, while low quality realization gives the relevant constraint for the upstream party. The relevant constraints are then:

$$(b_L + \boldsymbol{b}_L) + \boldsymbol{d}\big(b_L + \Delta b q(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RE})\big) \geq \boldsymbol{d}c \; (a^{RE})$$

$$(b_L + \Delta b + \boldsymbol{b}_L + \Delta \boldsymbol{b}) + \boldsymbol{d}\big(b_L + \Delta b q(a^{RE}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RE})\big) \le \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RE})\big)$$

Multiplying the upstream constraint by (-1) and adding the downstream constraint yields the following necessary condition for honoring the relational employment contract:

(A.3) $|\Delta b| + |\Delta \boldsymbol{b}| \le \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RE}) - c(a^{RE})\big)$

The conditions for honoring the relational outsourcing contract

The upstream party's condition is given by:

(A.4) $b_i + \boldsymbol{b}_j + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RO})\big) \ge \tfrac{1}{2}(Q_i + P_j - s) + \boldsymbol{d}\big(P_L + \Delta P p(a^{ROd})\big)$

It contains the following 4 constraints:

$$\tfrac{1}{2}(Q_L + \Delta Q + P_L + \Delta P - s) + \boldsymbol{d}\big(P_L + \Delta P p(a^{ROd})\big)$$
$$\le b_L + \Delta b + \boldsymbol{b}_L + \Delta \boldsymbol{b} + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RO})\big)$$
$$\tfrac{1}{2}(Q_L + \Delta Q + P_L - s) + \boldsymbol{d}\big(P_L + \Delta P p(a^{ROd})\big) \le b_L + \Delta b + \boldsymbol{b}_L + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RO})\big)$$
$$\tfrac{1}{2}(Q_L + P_L + \Delta P - s) + \boldsymbol{d}\big(P_L + \Delta P p(a^{ROd})\big) \le b_L + \boldsymbol{b}_L + \Delta \boldsymbol{b} + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RO})\big)$$
$$\tfrac{1}{2}(Q_L + P_L - s) + \boldsymbol{d}\big(P_L + \Delta P p(a^{ROd})\big) \le b_L + \boldsymbol{b}_L + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RO})\big)$$

The downstream party's condition is given by:

(A.5) $\tfrac{1}{2}(Q_i + P_j - s) + \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RO})\big) \ge b_i + \boldsymbol{b}_j + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_j + \Delta \boldsymbol{b} p(a^{RO})\big)$

It contains the 4 following constraints:

$$\tfrac{1}{2}(Q_L + \Delta Q + P_L + \Delta P - s) + \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RO})\big)$$
$$\ge (b_L + \Delta b + \boldsymbol{b}_L + \Delta \boldsymbol{b}) + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RO})\big)$$
$$\tfrac{1}{2}(Q_L + \Delta Q + P_L - s) + \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RO})\big) \ge b_L + \Delta b + \boldsymbol{b}_L + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RO})\big)$$
$$\tfrac{1}{2}(Q_L + P_L + \Delta P - s) + \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RO})\big) \ge b_L + \boldsymbol{b}_L + \Delta \boldsymbol{b} + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RO})\big)$$

$$\tfrac{1}{2}(Q_L + P_L - s) + \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RO})\big) \geq b_L + \boldsymbol{b}_L + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta\boldsymbol{b} p(a^{RO})\big)$$

It is now less obvious which constraints that bind. But it is always at most two constraints that will be binding. We see that it depends on the differences: $\tfrac{1}{2}\Delta Q - \Delta b$ and $\tfrac{1}{2}\Delta P - \Delta\boldsymbol{b}$.

When $\tfrac{1}{2}\Delta Q > \Delta b$ and $\tfrac{1}{2}\Delta P > \Delta\boldsymbol{b}$, the relevant constraints are:

$$\tfrac{1}{2}(Q_L + \Delta Q + P_L + \Delta P - s) + \boldsymbol{d}\big(P_L + \Delta P p(a^{ROd})\big)$$
$$\leq b_L + \Delta b + \boldsymbol{b}_L + \Delta\boldsymbol{b} + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta\boldsymbol{b} p(a^{RO})\big)$$
$$\tfrac{1}{2}(Q_L + P_L - s) + \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RO})\big) \geq b_L + \boldsymbol{b}_L + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta\boldsymbol{b} p(a^{RO})\big)$$

When $\tfrac{1}{2}\Delta Q > \Delta b$ and $\tfrac{1}{2}\Delta P < \Delta\boldsymbol{b}$, the relevant constraints are:

$$\tfrac{1}{2}(Q_L + \Delta Q + P_L - s) + \boldsymbol{d}\big(P_L + \Delta P p(a^{ROd})\big) \leq b_L + \Delta b + \boldsymbol{b}_L + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta\boldsymbol{b} p(a^{RO})\big)$$
$$\tfrac{1}{2}(Q_L + P_L + \Delta P - s) + \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RO})\big) \geq b_L + \boldsymbol{b}_L + \Delta\boldsymbol{b} + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta\boldsymbol{b} p(a^{RO})\big)$$

When $\tfrac{1}{2}\Delta Q < \Delta b$ and $\tfrac{1}{2}\Delta P > \Delta\boldsymbol{b}$, the relevant constraints are:

$$\tfrac{1}{2}(Q_L + P_L + \Delta P - s) + \boldsymbol{d}\big(P_L + \Delta P p(a^{ROd})\big) \leq b_L + \boldsymbol{b}_L + \Delta\boldsymbol{b} + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta\boldsymbol{b} p(a^{RO})\big)$$
$$\tfrac{1}{2}(Q_L + \Delta Q + P_L - s) + \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RO})\big) \geq b_L + \Delta b + \boldsymbol{b}_L + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta\boldsymbol{b} p(a^{RO})\big)$$

When $\tfrac{1}{2}\Delta Q < \Delta b$ and $\tfrac{1}{2}\Delta P < \Delta\boldsymbol{b}$, the relevant constraints are:

$$\tfrac{1}{2}(Q_L + P_L - s) + \boldsymbol{d}\big(P_L + \Delta P p(a^{ROd})\big) \leq b_L + \boldsymbol{b}_L + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta\boldsymbol{b} p(a^{RO})\big)$$
$$\tfrac{1}{2}(Q_L + \Delta Q + P_L + \Delta P - s) + \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RO})\big)$$
$$\geq (b_L + \Delta b + \boldsymbol{b}_L + \Delta\boldsymbol{b}) + \boldsymbol{d}\big(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta\boldsymbol{b} p(a^{RO})\big)$$

Multiplying the downstream party's constraints by (-1) and adding the upstream party's constraints yields an identical necessary condition for each pair of constraints:

(A.6) $\left|\Delta b - \tfrac{1}{2}\Delta Q\right| + \left|\Delta\boldsymbol{b} - \tfrac{1}{2}\Delta P\right| \leq \boldsymbol{d}\big(Q_L + \Delta Q q(a^{RO}) - P_L - \Delta P p(a^{ROd})\big)$

If the parties have the opportunity to agree on a fixed payment prior to the quality realizations, this payment can always be chosen in a way that (3) and (6) not only are necessary but also sufficient conditions.

Appendix II

The conditions for subgame perfect equilibria:

For the equilibria to be subgame perfect, they have to reach Nash-equilibrium in each subgame. This means that it should always be optimal to follow the strategy, independent of which subgame one finds oneself in. In this game we have an infinite number of subgames divided on three categories: The period where both parties honor the contract, the period where a spot contract is agreed upon and the punishment period. We have already explored and found the conditions for Nash-equilibrium in the subgame where both parties honor the contract. We now have to find the parties' conditions for honoring the contract in the deviation periods.

A general objection against trigger strategies in repeated games is the so-called renegotiation problem. Why can't both parties agree on co-operation when they are in a punishment period? The problem gets even more obvious in sequential games such as this one. In games were the parties move simultaneously it is more difficult to take the opponent's deviation from a deviation period into account since he cannot observe this deviation before his own move. But in sequential games where the players don't move simultaneously, a player can, before his own move, observe if the other deviates from the deviation period. He can then adjust his own move after this observation. The solution to this kind of renegotiation-problem can be to introduce different kinds of bonuses for carrying through the punishment. That is difficult in my model. It is easier to assume that the parties do a long-term consideration of their reputation. They take into account that an infinite punishment postponement weakens their general credibility in the market, so they cannot be tempted by an opponent who deviates from the punishment period. One can also assume that there exists some kind of costs in loss of honor if one puts off a punishment. When I here investigate the subgames, I will thus assume, in the same way as Baker, Gibbons and Murphy, that the parties always assume that the opponent follows his strategy.

The equilibrium conditions presented above are subgame perfect because both parties, in the case of deviation, find it optimal to carry out the punishment in the second period. The reason is: In the case of relational employment it is only the upstream party that has a valid punishment possibility, and that is not to produce the product. It is not possible to carry through this punishment in the first period since the product already is produced when the downstream party deviates. But from the second period the punishment of not producing becomes an opportunity. As we will see there is then no incentives to postpone this punishment. In the case of relational outsourcing there is an extra cost if one carries out the punishment in the first period. If this cost is sufficiently high the parties will postpone their punishment. In the second period there is no such cost-incentive to postpone the punishment further. It is therefore optimal to carry out the punishment in the second period.

Let us first take a closer look at the relational employment contract:

The upstream party: In a spot contract period, the upstream party does not have the possibility to carry through a punishment. The good is already produced and is thus in the hands of the downstream party. In the second period the upstream party can carry through a punishment by not producing the good. The question is now whether the upstream party has an incentive to postpone the punishment. If he postpones, he will produce without bonus payments yet another period. The condition for carrying through the punishment in the second period rather than in the third is:

$$d^2\left(b_L + \Delta bq(a^{RE}) + b_L + \Delta b p(a^{RE}) - c(a^{RE})\right) + d^3\left(b_L + \Delta bq(a^{RE}) + b_L + \Delta b p(a^{RE}) - c(a^{RE})\right)$$
$$\geq -dc(a^{RO}) + d^3\left(b_L + \Delta bq(a^{RE}) + b_L + \Delta b p(a^{RE}) - c(a^{RE})\right)$$

which holds as long as (1) holds. (It may seem unnecessary to discount the payments with period 1 as the starting point, but I do so to show where we are in the story).

The downstream party: In the case of relational employment, the downstream party has only one way to punish: To refuse paying the promised bonuses. As long as the downstream party owns the good, he cannot punish by buying the product in the alternative market. There is then only one kind of punishment in a relational employment contract: the one the upstream

party carries through by not producing the good. If the upstream party reneges in the first period by not taking the bonuses, the threat from the downstream party to refuse to pay the bonuses becomes meaningless. Thus, the downstream party cannot punish before the second period. Does the downstream party have an incentive to postpone the punishment? If he postpones, he will be able to cheat on the bonuses in the third period, but the upstream party will carry through a punishment in the fourth period as long as the downstream party's deviation in the third period cannot be identified as a punishment. The condition for carrying through the punishment in the second period is:

$$\boldsymbol{d}^2\left(Q_L + \Delta Qq(a^{RE}) - b_L - \Delta bq(a^{RE}) - \boldsymbol{b}_L - \Delta \boldsymbol{b}p(a^{RE})\right)$$
$$+ \boldsymbol{d}^3\left(Q_L + \Delta Qq(a^{RE}) - b_L - \Delta bq(a^{RE}) - \boldsymbol{b}_L - \Delta \boldsymbol{b}p(a^{RE})\right) \geq \boldsymbol{d}^2\left(Q_L + \Delta Qq(a^{RE})\right)$$

which holds as long as (2) holds.

Let us then take a look at the relational outsourcing contract:

The upstream party: If the downstream party reneges, the upstream party, instead of postponing the punishment to the second period, carries through the punishment immediately. But the upstream party then meets the cost s. He will choose to wait to the second period if:

$$\tfrac{1}{2}(Q_i + P_j - s) + \boldsymbol{d}\left(P_L + \Delta Pp(a^{ROd})\right) \geq P_j - s + \boldsymbol{d}\left(b_L + \Delta bq(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b}p(a^{RO})\right)$$

which holds as long as

$$s \geq 2\left(\boldsymbol{d}\left(b_L + \Delta bq(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b}p(a^{RO})\right) - \tfrac{1}{2}(Q_i + P_j) + P_j - \boldsymbol{d}\left(P_L + \Delta Pp(a^{ROd})\right)\right).$$

This is not a strong condition since the bonuses normally are close to the Nash price. What is the incentive to postpone the punishment further? The condition for carrying through the punishment in the second period rather than in the third period is given by:

(A.7) $\quad \boldsymbol{d}\left(P_L + \Delta Pp(a^{RO})\right) + \boldsymbol{d}^2\left(b_L - \Delta bq(a^{RE}) - \boldsymbol{b}_L - \Delta \boldsymbol{b}p(a^{RE})\right)$

$\quad\quad \geq \boldsymbol{d}\left(P_L + \Delta Pp(a^{RO})\right) + \boldsymbol{d}^2\left(P_L + \Delta Pp(a^{ROd})\right)$

As long as $Q_i > s$, (4) guarantees that (A.7) holds. But we do not have this guarantee, so (A.7) becomes a necessary condition for subgame perfect equilibrium.

The downstream party: If the upstream party reneges, the downstream party can, instead of postponing the punishment to the second period, carry through the punishment immediately. But he'll then meet the cost s. The condition for postponing the punishment to the second period is then:

$$Q_i - \tfrac{1}{2}(Q_i + P_j - s) \geq -s + \boldsymbol{d}\left(Q_L + \Delta Q q(a^{RO}) - b_L - \Delta b q(a^{RO}) - \boldsymbol{b}_L - \Delta \boldsymbol{b} p(a^{RO})\right)$$

which holds as long as

$$s \geq \tfrac{2}{3}\left(\tfrac{1}{2}(Q_i + P_j) - \boldsymbol{d}\left(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RO})\right) - Q_i + \boldsymbol{d}\left(Q_L + \Delta Q q(a^{RO})\right)\right)$$ which holds

as long as the upstream party's cost restriction holds, written as

$$(A.8) \quad s \geq \left|2\left(\boldsymbol{d}\left(b_L + \Delta b q(a^{RO}) + \boldsymbol{b}_L + \Delta \boldsymbol{b} p(a^{RO})\right) - \tfrac{1}{2}(Q_i + P_j) + P_j - \boldsymbol{d}\left(P_L + \Delta P p(a^{ROd})\right)\right)\right|$$

Does the downstream party have an incentive to postpone the punishment? The condition for carrying through the punishment in the second period is:

$$\boldsymbol{d}^2\left(Q_L + \Delta Q q(a^{RE}) - b_L - \Delta b q(a^{RE}) - \boldsymbol{b}_L - \Delta \boldsymbol{b} p(a^{RE})\right) \geq 0$$

which holds as long as (5) holds.

Conclusion: The strategies give subgame perfect equilibrium as long as (3), (6), (A.7) and (A.8) holds.

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Summary

In the international offshore industry we find that the oil companies and their main suppliers usually operate with separate ownership. But the main contractors manage a capital stock, and produce inputs, that are highly specific to the oil companies. Within the traditional theory of the firm this organizational solution emerges as a puzzle. Asset specificity is usually considered as an argument for vertical integration. The idea is that integration reduces the problem of opportunistic behavior. In this article I show that asset specificity actually can be an argument for separate ownership. While an integrated supplier considers the asset specificity as unimportant for his strategic behavior, disintegrated parties find that a high degree of specificity makes opportunistic behavior less profitable than if the assets enjoyed a low degree of specificity. Asset specificity can thus function as a buffer against opportunistic behaviour. This buffer can create room for strong incentive schemes.

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