Why Use Requirement Contracts?
The Tradeoff between Hold Up and Breach

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Abstract

A requirements contract is a form of exclusive dealing in which the buyer promises to buy only from one seller if he buys at all. This paper models a most common-sense motivation for such contracts: that the buyer wants to ensure a reliable supply at a pre-arranged price without any need for renegotiation or efficient breach. This requires that the buyer be unsure of his future demand, that a seller invest in capacity specific to the buyer, and that the transaction costs of revising or enforcing contracts be high. Transaction costs are key, because without them a better outcome can be obtained with a fixed-quantity contract. The fixed-quantity contract, however, requires breach and damages. If transaction costs make this too costly, an option contract does better. A requirements contract has the further advantage that it evens out the profits of the seller across states of the world and thus allows for an average price closer to marginal cost.

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This draft isn’t really finished. The second model—of capacity choice—is rather a mess, and I might even drop it from the final version. If you skip that model, though, you will find the last part of the paper, on the Teethcleaner’s Case, interesting.
1. Introduction

In a requirements contract, the buyer agrees to purchase all of his requirements for a particular product from a given supplier for a specified length of time. This is one of the forms of exclusive dealing contracts, which have been much studied because they have a number of motivations, some efficiency-enhancing and some strategic (see Ramseyer & Rasmusen (2015) for a summary). One of the classes of efficiency-enhancing motivations is ways that exclusive dealing can help induce relationship-specific investments, a line of thought going back to Klein, Crawford & Alchian (1978, pp. 308-310 especially), Klein (1988), and Frasco (1991).

The well-known hold-up problem is based on the difficulty of determining whether a contract was breached. Suppose the seller must make a specific investment. He will be reluctant to do so if the buyer can speciously claim the quality is low and refuse delivery except after the price is bargained down. If the seller has the exclusive right to supply the buyer, the buyer’s outside option is closed off and he cannot bargain the seller down to as low a price. Exclusivity helps because courts cannot tell whether the correct product has been delivered but can tell which supplier delivers it. This is the theme of a literature based on the model of Hart & Moore (1990). Segal & Whinston (2000) model this with one seller and two buyers, one of whom can make a relationship-specific investment. In the three-person bargaining specification employed, a contract binding the seller and that buyer does not change the level of investment. De Meza & Selvaggi (2007) revisit the situation with a different bargaining specification and find that exclusivity does promote investment. Other papers in this literature are Bolton & Whinston (1993) on vertical integration for supply assurance and Noldeke and Schmidt (1995) on the use of option contracts. This is distinct from another class of efficiency-enhancing reasons for exclusive-dealing based on providing incentives, e.g. Bernheim & Whinston (1998), Klein & Lerner (2007), and Marvel (1982). A typical incentive explanation is that if a retailer binds himself to sell only one manufacturer’s product, then when the manufacturer advertises and brings customers to the retailer, the retailer cannot substitute another, higher-margin product for the manufacturer’s.

In the present paper, neither hold-up because of unenforceability of delivery nor incentives for promotion will play a role. We will address the question of how the buyer chooses between an option contract (the buyer has the option to buy a specified amount at a specified price), a requirements contract (which adds exclusivity to the option contract) and a fixed-quantity contract (in which an exact price and quantity are specified). This question is appropriate for the most common kind of contractual situation, where a court can tell whether delivery took place or not. Like the Hart-Moore literature, we will be looking at contracts that are incomplete in the
sense of failing to pin down quantity exactly, but in our context complete contracts will be feasible. Our goal will be to explain the absence of quantity terms in the contract. After the identity of the product, quantity is the most important term in a contract, the hardest for a court to fill in. A contract lacking price terms will be binding if courts think that a market price can serve as a default. Courts will fill in the price, and almost any other contract term, but not quantity.\(^1\) The need to specify quantity does not exclude requirement contracts, however, which are specifically allowed. The Uniform Commercial Code’s section UCC 2-306, “Output, Requirements and Exclusive Dealings,” says

(1) A term which measures the quantity by the output of the seller or the requirements of the buyer means such actual output or requirements as may occur in good faith, except that no quantity unreasonably disproportionate to any stated estimate or in the absence of a stated estimate to any normal or otherwise comparable prior output or requirements may be tendered or demanded.

In the standard model, the motivation for long-term contracts is the seller’s apprehension of hold-up, of being bargained down to a low price after he has sunk the cost of relationship-specific investment. A hotel chain builds a hotel next to an auto plant, and the auto company forces the price of a hotel room down to below average cost. Here, the motivation will also be hold-up, but on the opposite side: the buyer will fear being held up because of the seller’s relationship-specific investment. If the buyer needs a product with a specific investment and the seller is the only firm that makes the investment, the seller has monopoly power. Once one hotel chain builds a hotel next to the factory, no other hotel will enter and create head-to-head competition.

To avoid this kind of natural monopoly, if the buyer knows the exact quantity he wants he can contract for that quantity in advance, making various potential sellers compete to be the one to make the specific investment. If the buyer is less certain, but litigation and renegotiation are costless, we will see that a fixed-quantity contract is still a good choice for the buyer. A fixed-quantity contract does not constrain the parties to produce the quantity specified; it only provides a starting point for bargaining.

\(^1\)This is a basic principle of contract law. Price can be filled in by the court (Uniform Commercial Code 2-305), as can place of delivery (UCC 3-308), time of delivery (UCC 3-309) and time of payment (UCC 3-310). For an introduction to the law, see Martin Carrara “The Basics of U.C.C. Article 2 - Sales,” http://news.acca.com/acnj/issues/2013-06-07/3.html.
We will compare that with what happens when transaction costs are positive to get something close to the common-sense explanation for requirements contracts: the buyer isn’t sure how much he’ll want to buy, and the seller wants exclusivity in exchange for letting the buyer keep his quantity option open. Careful modelling is necessary, however, to compare requirements contracts, option contracts, fixed-quantity contracts, and spot sale.

Since the explanation will appeal to transaction costs, it is useful to start with a true story that illustrates the kind of situation in which a requirements contract is used. *Jullie G. Horn v. United States*, United States Court of Federal Claims No. 07-655C (May 3, 2011), was a lawsuit over a 2005 contract between Jullie Horn and the Federal Bureau of Prisons. Horn was awarded a contract to provide professional dental hygiene services under the direction of the Dentist to the inmate population at the United States Penitentiary and Federal Prison Camp, Marion, Illinois. The contract specified that she was to provide a maximum of 1,560 one-hour dental hygiene sessions at a price of $32 per session. The contract was labelled a “REQUIREMENTS” contract in capital letters. It said,

(a) This is a requirements contract for the supplies or services specified, and effective for the period stated, in the Schedule. The quantities of supplies or services specified in the Schedule are estimates only and are not purchased by this contract. Except as this contract may otherwise provide, if the Government’s requirements do not result in orders in the quantities described as “estimated or “maximum in the Schedule, that fact shall not constitute the basis for an equitable price adjustment.

and

(c) The estimated quantities are not the total requirements of the Government activity specified in the Schedule, but are estimates of requirements in excess of the quantities that the activity itself furnish within its own capabilities. Except as this contract otherwise provides, the Government shall order from the Contractor all of that activity’s requirements for supplies and services specified in the schedule that exceed the quantities that the activity may itself furnish within its own capabilities.

One month later, after Horn had completed and been paid for 130 tooth-cleaning sessions, the dentist told her that he had hired an in-house hygienist and her services were no longer needed. She sued for breach of contract on the grounds that she had been awarded all of the prison’s tooth-cleaning requirements.

The prison contract is the kind of requirements contract we are trying to explain. Why was there a contract at all, rather than hiring the hygienist session by session? Why wasn’t the
quantity pinned down precisely in the contract? Why was the contract exclusive rather than at the government’s option? Note, too, that there was no attempt to use nonlinear pricing, that is, to set different per-hour prices for different quantities of hours. And there were no lump-sum transfers. The government could have used a contract in which Horn paid a lump sum to obtain the contract and then received a very large hourly fee so she would have ample incentive to make herself available for the marginal hours. We know nonlinear-price and two-part tariff contracts are unrealistic in a context like this, but knowing why they aren’t used is more difficult than known they aren’t.

I think a requirements contract was used for a relatively simple reason. The government wanted some kind of contract so it could be assured of supply at a low price rather than be faced later with no seller or with just one seller who could charge a monopoly price. A fixed-quantity contract would have required renegotiation later, since the government did not know its own future demand precisely. Renegotiation would take up management time and be subject to corruption. An option contract would not need renegotiation but it would need high prices to compensate for the hygienist’s risk that the government would switch to buying from someone else. A requirements contract did not have these disadvantages. It does not require renegotiation, and the price that yields zero economic profit to the hygienist could be lower because with outside supply ruled out, she could expect a higher quantity of her services to be demanded. Of course it went wrong in the end, which is why there was a lawsuit, but I will return to that at the end of the paper and describe what happened to Jullie Horn.

I will build two models, to model two aspects of relationship-specific investment: product development, and capacity. Product development would here be the problem that the hygienist might or might not succeed in providing satisfactory dental services at low enough personal cost and she did not know in advance whether this would happen. She might not be competent, or might dislike the town, or might dislike treating prisoners. Capacity would here be the problem that Mrs. Horn might not budget enough time to treat all the prisoners if the number with dental problems turned out to be higher than expected.²

²Note that this illustrates a separate and distinct reason for exclusivity in the opposite direction—that the buyer wants the seller’s full attention and loyalty. This is why many employers forbid moonlighting. Another reason is illustrated by code of conduct of the Dutch central bank which which forbids indecent behaviour and says no employee should act in a way which could lead to negative publicity. One of its managers, 46-year-old Conchita van der Waal was fired for advertising herself for “kinky sex” dressed as an SS Commandant. See Peter Cluskey, “Woman fired for being a prostitute by Dutch central bank: Employee said to have charged €450 an hour as prostitute specialising in sadomasochism,” Irish Times, April 15, 2015.
In the model, the buyer desires the seller to make a specific investment in dedicated capacity that will be useful if other firms in the marketplace happen to be unavailable. An easy way to get the first-best would be a contract in which the buyer agrees to a very high price, equivalent to its marginal consumer surplus when the social optimization problem is solved, combined with a large advanced fixed payment from the seller to the buyer to remove seller profit. We do not observe such contracts, perhaps because of seller illiquidity, perhaps because for agency reasons—it is dangerous for a seller firm to allow its manager to make contracts in which he pays out large lump sums in transfers for uncertain future cash flows. So we will rule out side payments in bargaining. We will also rule out nonlinear option contracts, in which the buyer pays more per unit if he buys more units, but has the option to choose whichever amount he wants once he knows the state of the world. They would allow for a very high price for units unlikely to be demanded, to induce the seller to choose a high capacity, combined with a price below marginal cost for a low number of units so as to reduce seller expected profits to zero. This may require too much cleverness to be practical; again, it is hard for the buyer’s top manager to monitor and is complex to set up.

I. A Unit Demand Model with a Specialized Product

The buyer’s value for the single unit he might buy of the good is \( v \), unknown at the time of contracting and distributed by \( F(v) \) on the support \([0, \bar{v}]\), with density \( F'(v) \equiv f(v) \), where \( f > 0 \) and \(-2f(v) - (v - c)f'(v) < 0\) so that a higher price is always more profitable up to the reservation price of \( \bar{v} \).

With probability \( \theta \), the buyer needs a specialized version of the product and the normal product is worth 0 to him. He will then be in a “thin” market with few or no sellers. With probability \((1 - \theta)\), the buyer, like other potential buyers, is indifferent between the specialized and the normal product.

The good’s marginal cost is \( c \) and many firms can produce the normal version of it. A firm may try to design the specialized product by investing \( I \), and will succeed with probability \( g(I) \), where \( g(0) = 0, g'(0) = \infty, g' > 0, g'' < 0 \) for \( I < \overline{I} \) and \( g(\overline{I}) = 1 \). Under these assumptions, a firm must invest a positive amount to have a positive chance of success, the marginal product of

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This is a standard assumption of convenience. It says that the demand curve cannot be too convex. Otherwise, we would have to deal with subcases where the buyer cannot increase a seller’s profits from negative to zero by increasing the contract price.
investment starts equal to infinity, and success is certain if enough is invested. Assume too that if
firms 1 and 2 spend $I_1$ and $I_2$ with $I_1 < I_2$, firm 2 is successful whenever firm 1 is successful.\footnote{Thus, success depends on the product, not the individual attributes of the firm, and it is not independent across firms. “Design” here does not mean innovation, just the setting up of a specialized version of the standard product, which can always be done with enough time and trouble.}

We will assume that $I^* < I$ and that $I = 1$ produces more social surplus than $I = 0$, where $I^*$
is the decentralized optimum investment as explained below. Both players are risk neutral. Each
side captures half the surplus if bargaining takes place.

First, we will analyze the model as thus far described. Later, however, we will analyze it under
the assumption that both buyer and seller feel that the reputational and transaction costs of
breaching contracts are higher than any possible benefits. When we assume that breach costs are
zero, that does not mean that breach prices are zero. If a player breaches, he will have to meet his
legal obligations. Those legal obligations can be met at zero cost, however, by both parties. They
do not need to hire lawyers, the managers do not need to discuss the breach with each other or
their subordinates, they do not need to estimate their own and the other party’s costs from breach
(either at the time of making the contract or after breach), and they do not need to haggle over
out-of-court settlement.\footnote{Note that this is different from the assumption in Hart & Moore (2008) and Halonen-Akatwijuka & Hart (2015) that contactors feel cheated if their expectations are not met and so start shading on performance.}

We will rule out nonlinear contracts by assumption—that is, rule a lump sum payment as
part of the contract. This corresponds with reality, where we do not see contracts that provide the
seller with a lump sum and a price equal to marginal cost, perhaps because of the risk that he
would take the lump sum and then breach the loss-generating part of the contract.

This first model does not allow for the possibility of overcapacity by the seller. It is a bit odd
to try to model requirement contracts when the buyer needs at most 1 unit, so later we will look
at a second model, in which the quantity demanded rises continuously as the price falls but
demand can be high or low, depending on chance.

**The First Best: Vertical Integration ($P = MC$).** The first best maximizes the sum of the
negative investment costs, the surplus over marginal cost when the specialized product is needed
and successfully produced, and the surplus when the specialized product is not needed. This is the
surplus that would be achieved by vertical integration, if the buyer could make the investment and
produce the product himself. We will denote this first-best investment as $I^{**}$.

$$ Surplus(I) = \theta g(I) \int_c^\pi (v - c) f(v) dv + (1 - \theta) \int_c^\pi (v - c) f(v) dv - I $$

(1)

Maximizing the surplus has the first order condition

$$ Surplus'(I) = -1 + g'(I^{**}) \theta \int_c^\pi (v - c) f(v) dv = 0. $$

(2)

The Decentralized Optimum (P=AC). Since we do not allow lump-sum payments, the seller makes losses and not participate if the price equalled marginal cost. In the “decentralized optimum”, the seller’s profit must be raised to zero by raising the price high enough to cover the fixed cost of investment, and the buyer cannot be forced to buy at that price. This is the “price equals average cost” equilibrium of rate-of-return regulation. Surplus will not be as high as in the first-best, since the buyer will buy less if the price is above marginal cost.

Let the price be $p_1$ for the normal product and $p_2$ for the specialized product. The maximization problem becomes to maximize by choice of $I, p_1,$ and $p_2$,

$$ Surplus(I, p_1, p_2) = \theta g(I) \int_{p_2}^\pi (v - c) f(v) dv + (1 - \theta) \int_{p_1}^\pi (v - c) f(v) dv - I $$

(3)

such that the prices lies in $[0, \pi]$ and

$$ \pi = \theta g(I) \int_{p_2}^\pi (p_2 - c) f(v) dv + (1 - \theta) \int_{p_1}^\pi (p_1 - c) f(v) dv - I \geq 0. $$

The decentralized optimum’s first order condition for choice of $p_1$ is (using unconventional but obvious notation, and denoting the Lagrange multiplier by $\mu$):

$$ Surplus'_{p_1} = (1 - \theta)[- (p_1 - c) f(p_1)] - \mu (1 - \theta) \left[ \int_{p_1}^\pi f(v) dv - (p_1 - c) f(p_1) \right] = 0 $$

$$ -(p_1 - c) f(p_1) - \mu [- \int_{p_1}^\pi f(v) dv + (p_1 - c) f(p_1)] = 0 $$

(4)

$$ \mu = \frac{(p_1 - c) f(p_1)}{(p_1 - c) f(p_1) - \int_{p_1}^\pi f(v) dv} $$
For \( p_2 \) the first order condition is

\[
\text{Surplus}'_{p_2} = \theta g(I)[-(p_2 - c)f(p_2)] - \mu \theta g(I) \left[ \int_{p_2}^{\bar{v}} f(v)dv - (p_2 - c)f(p_2) \right] = 0
\]  

(5)

\[
\mu = \frac{(p_2 - c)f(p_2)}{(p_2 - c)f(p_2) - \int_{p_2}^{\bar{v}} f(v)dv}
\]

The first order condition for \( p_2 \) in equation (4) is the same as for \( p_1 \) in (5), which means \( p_2^* = p_1^* \). Let us call this optimal price \( p^* \). This is the same idea as in Ramsey pricing, that two medium price distortions are preferable to one big and one small because surplus loss rises with the square of the distortion. Note that the shadow price of the seller’s zero-profit constraint, \( \mu \), is in \((0,1)\). The constraint is binding and hence costly, but less than an entire unit of the buyer’s surplus has to be sacrificed to the seller at the margin.

The first order condition for choice of \( I \) is (denoting the decentralized optimum by \( I^* \))

\[
\text{Surplus}'_I = -1 + \theta g'(I^*) \int_{p^*}^{\bar{v}} (v - c)f(v)dv - \mu \left( -1 - \theta g'(I^*) \int_{p^*}^{\bar{v}} (p^* - c)f(v)dv \right) = 0
\]

\[
(1 - \mu) \left( -1 + \theta g'(I^*) \int_{p^*}^{\bar{v}} (v - c)f(v)dv \right) = 0
\]

(6)

\[-1 + \theta g'(I^*) \int_{p^*}^{\bar{v}} (v - c)f(v)dv = 0 \]

Equation (6) yields a smaller \( I \) than in the first-best of (2) because the integral is from \( p^* \) to \( \bar{v} \), not \( c \) to \( \bar{v} \). The buyer will not purchase if his value is between \( c \) and \( p \), even though that would be efficient, so it is not worth investing as much in trying to obtain the specialized product.

**Spot Sale.** With no contract, and thus no pre-set price, only one seller will invest, since if two do they would compete the price of the specialized good down to marginal cost, \( c \).\(^6\) The seller will have profit

\[
\pi_{spot}(I) = \theta g(I) \int_{\frac{v+c}{2}}^{\bar{v}} \left( \frac{v+c}{2} - c \right) f(v)dv - I
\]

(7)

\(^6\)We will ignore the mixed-strategy equilibrium where two or more sellers invest with positive probability, with resulting waste and with the price either \( c \) or \( \frac{v+c}{2} \).
with first order condition

\[ \pi_{\text{spot}}' = \theta g'(I_{\text{spot}}) \int_{v+c}^{v} \left( \frac{v+c}{2} - c \right) f(v) dv - 1 = 0 \]  

(8)

If \( p^* < \frac{(v+c)}{2} \), the seller’s profit will be positive and there will be moderate underinvestment compared to the decentralized optimum. If \( p^* > \frac{(v+c)}{2} \), the seller’s profit will be negative, so the problem has a corner solution and the first order condition is not relevant: the seller will choose \( I = 0 \) and there is severe underinvestment. This is the hold-up problem that provides a standard explanation for long-term contracts: if investment costs are sunk at the time of bargaining over price, then investment will be inefficiently low. Thus, we will assume that \( p^* < \frac{(v+c)}{2} \) in this paper, to focus on the opposite problem: monopoly power of the seller that results from lack of a long-term contract.

**Zero Transaction Costs**

We will assume transaction costs are zero in this section. This does not mean that a player can breach without consequence; he must meet his legal obligations. Those legal obligations can be met at zero real economic cost to either party. Managers do not need to hire lawyers, discuss the breach with each other or their subordinates, estimate their own and the other party’s costs from breach (either at the time of making the contract or after breach) or haggle over out-of-court settlement.

Note that the buyer will always want the price to yield zero profits to the seller who wins the contract in competition with the other sellers. The only possible benefit from a higher price would be to induce the seller to choose higher investment, but higher investment does not help the buyer because he can collect expectation damages from the seller if the seller fails in designing the specialized product.

**A Fixed-Quantity Contract, Zero Transaction Costs.** Consider a fixed-quantity contract with 1 unit and price \( p_{fq} \) (a contract for 0 units would be just like having no contract). There may be efficient breach by either side. If the buyer’s value \( v \) turns out to be less than \( c \) he will breach; if the seller fails in designing the specialized product he will breach. If the seller had succeeded in designing the specialized product, the buyer would pay damages of \( (p_{fq} - c) \) to the seller. If the
seller had failed, the buyer would not have to pay damages, since under standard contract law
delivery is necessary to trigger the buyer’s requirement to pay.\(^7\)

If the seller fails in designing the specialized product, he will pay compensatory damages of
\(v - \bar{p}_{fq}\) if the buyer values it at more than \(\bar{p}_{fq}\), which has probability \((1 - g(I))(1 - \theta)\int_{\bar{p}_{fq}}^{\bar{v}} f(v) dv\).\(^8\)

Note that when the buyer does not need the specialized product, if the seller breaches by
supplying the unspecialized product the buyer’s damages are zero. The seller will thus have
expected profit consisting of the cost of investment, the profit from selling if a normal product is
satisfactory, the profit from selling the specialized product if the investment is successful, and the
loss from breach damages if the investment is unsuccessful:

\[
\pi_{fq}(I) = \theta g(I) \int_{0}^{\bar{v}} (\bar{p}_{fq} - c) f(v) dv - \theta (1 - g(I)) \int_{\bar{p}_{fq}}^{\bar{v}} (v - \bar{p}_{fq}) f(v) dv
\]

\[\]  

\[
\pi'_{fq}(I) = \theta g'(I) \int_{0}^{\bar{v}} (\bar{p}_{fq} - c) f(v) dv - \theta g'(I) \int_{\bar{p}_{fq}}^{\bar{v}} (v - \bar{p}_{fq}) f(v) dv - 1
\]

\[\]  

\[
= \theta g'(I) \int_{\bar{p}_{fq}}^{\bar{v}} (\bar{p}_{fq} - c) f(v) dv + \theta g'(I) \int_{\bar{p}_{fq}}^{\bar{v}} (v - \bar{p}_{fq}) f(v) dv
\]

\[\]  

\[
+ \theta g'(I) \int_{0}^{\bar{p}_{fq}} (v - \bar{p}_{fq}) f(v) dv - 1
\]

\[\]  

\[
= \theta g'(I) \int_{0}^{\bar{p}_{fq}} (\bar{p}_{fq} - c) f(v) dv + \theta g'(I) \int_{\bar{p}_{fq}}^{\bar{v}} (v - c) f(v) dv - 1 = 0
\]

Recall that the decentralized optimum’s first-best condition is \(\theta g'(I^*) \int_{p^*}^{\bar{v}} (v - c) f(v) dv - 1 = 0\).

The seller now has two incentives to make investment high. First, if the buyer needs the
specialized product, the seller both gets his profit margin and avoids paying damages. Second, if

\(^7\)UCC 2-507(1): “Tender of delivery is a condition to the buyer’s duty to accept the goods and, unless otherwise
agreed, to his duty to pay for them. Tender entitles the seller to acceptance of the goods and to payment according
to the contract,” https://www.law.cornell.edu/ucc/2/2-507.

\(^8\)UCC 2-p511(1): “Unless otherwise agreed tender of payment is a condition to the seller’s duty to tender and
complete any delivery.” https://www.law.cornell.edu/ucc/2/2-511. There is the possibility of buyer bluff: the buyer
shows up with payment, the seller does not perform, and the buyer claims damages. Expectation damages would be
zero, however, because the buyer would actually lose by having the contract fulfilled.
the buyer doesn’t need the specialized product, the seller gets the margin anyway. It is this second effect which both helps and hurts efficiency. It hurts as far as capacity is concerned, because it makes it excessive. It helps as far as the price is concerned, because it allows for a lower price.

An Option Contract, Zero Transaction Costs. We could have an option contract at price \( p_{oc} \). Then only the seller breaches with positive probability in equilibrium. The seller will have expected profit composed of the profit from the specialized product minus the damages he pays the buyer if he fails in designing it and it would have been useful to the buyer minus the investment cost:

\[
\pi_{oc}(I) = \theta g(I) \int_{p_{oc}}^{\bar{v}} (\bar{p}_{oc} - c) f(v) dv - \theta (1 - g(I)) \int_{p_{oc}}^{\bar{v}} (v - \bar{p}_{oc}) f(v) dv - I_{oc}
\]

with first order condition

\[
\pi'_{oc}(I_{oc}) = \theta g'(I_{oc}) \int_{p_{oc}}^{\bar{v}} (\bar{p}_{oc} - c) f(v) dv + \theta g'(I_{oc}) \int_{p_{oc}}^{\bar{v}} (v - \bar{p}_{oc}) f(v) dv - 1 = 0
\]

This is the same first order condition as for the decentralized optimum except that the price must be higher: \( \bar{p}_{oc} > p^* \). That is because the seller makes a sale with lower probability— with probability \( \theta g(I) \) instead of \( 1 - \theta + \theta g(I) \), and so to recover his investment cost he must charge a higher price. As a result, the amount of investment will also be smaller than in the decentralized optimum.

A Requirements Contract, Zero Transaction Costs. We could have a requirements contract at price \( p_{rc} \). Again, only the seller has a positive probability of breaching in equilibrium. The seller will have expected profit composed of the profit when the buyer does not need the specialized product plus the profit from the specialized product minus the damages he pays when he fails in designing the specialized product and the buyer needs it minus the investment cost:

\[
\pi_{rc}(I) = \theta g(I) \int_{p_{rc}}^{\bar{v}} (\bar{p}_{rc} - c) f(v) dv - \theta (1 - g(I)) \int_{p_{rc}}^{\bar{v}} (v - \bar{p}_{rc}) f(v) dv \\
+ (1 - \theta) \int_{p_{rc}}^{\bar{v}} (\bar{p}_{rc} - c) f(v) dv - I
\]
with first order condition

\[ \pi_{rc}'(I) = \theta g'(I) \int_{p_{rc}}^{v} (\bar{p}_{rc} - c)f(v)dv + \theta g'(I) \int_{p_{rc}}^{v} (v - \bar{p}_{rc})f(v)dv - 1 \]

\[ = \theta g'(I) \int_{\bar{p}_{rc}}^{v} (v - c)f(v)dv - 1 = 0 \] (14)

This is the same first order condition as for the fixed-quantity contract except that the values of the prices will be different.

**Proposition 1:** In the specialized-product model with zero breach costs, the fixed-quantity contract is superior to the requirements or option contract in terms of total and buyer surplus.

**Proof:**

**Lemma 1.** The option and requirements contract prices will be higher than under the fixed-quantity contract’s.

Denote the optimal investment under the option contract by \( I_{oc}^* \). Suppose we fix \( I = I_{oc}^* \), we impose the fixed-quantity-contract, and we let the players choose the fixed-quantity price in response. Competition among the sellers will, as usual, result in zero profits for the seller who wins the contract. From equation (9), profits are

\[ \pi_{fq} = \theta g(I_{oc}) \int_{c}^{v} (\bar{p}_{fq} - c)f(v)dv - \theta \left( 1 - g(I_{oc}) \right) \int_{\bar{p}_{fq}}^{v} (v - \bar{p}_{fq})f(v)dv \]

\[ + (1 - \theta) \int_{c}^{v} (\bar{p}_{fq} - c)f(v)dv - I_{oc} \]

Under the option contract, profits are, from equation (11),

\[ \pi_{oc} = \theta g(I) \int_{\bar{p}_{oc}}^{v} (\bar{p}_{oc} - c)f(v)dv - \theta \left( 1 - g(I) \right) \int_{\bar{p}_{oc}}^{v} (v - \bar{p}_{oc})f(v)dv - I_{oc} = 0 \]

The difference between the profits if the two prices were both equal to \( \bar{p}_{oc} \) would be

\[ \pi_{fq} - \pi_{oc} = \theta g(I_{oc}) \int_{c}^{\bar{p}_{oc}} (\bar{p}_{oc} - c)f(v)dv + (1 - \theta) \int_{c}^{\bar{p}_{oc}} (\bar{p}_{oc} - c)f(v)dv > 0 \] (15)
Since $\pi_{oc} = 0$ with $p = \bar{p}_{oc}$ and $I = I_{oc}$, it must be that $\pi_{fq} > 0$ with those two variable values. If we still impose $p = \bar{p}_{oc}$ but allow the seller to choose $I$ freely under the requirements contract, his profits will rise even further above zero. To reduce them to zero, it must be that $\pi_{fq} < \pi_{oc}$.

Now do the same for the requirements contract. From equation (35) its profit is

$$
\pi_{rc}(I) = \theta g(I_{rc}) \int_{\bar{p}_{rc}}^{\bar{v}} (\bar{p}_{rc} - c) f(v) dv - \theta \left(1 - g(I_{rc})\right) \int_{\bar{p}_{rc}}^{\bar{v}} (v - \bar{p}_{rc}) f(v) dv
$$

$$
+ (1 - \theta) \int_{\bar{p}_{rc}}^{\bar{v}} (\bar{p}_{rc} - c) f(v) dv - I_{rc} = 0
$$

Impose $I = I_{rc}$ and $p = \bar{p}_{rc}$ for the fixed-quantity contract. The difference in profits between the two contracts is then

$$
\pi_{fq} - \pi_{rc} = \theta g(I_{rc}) \int_{\bar{p}_{rc}}^{\bar{v}} (\bar{p}_{rc} - c) f(v) dv + (1 - \theta) \int_{\bar{p}_{rc}}^{\bar{v}} (\bar{p}_{rc} - c) f(v) dv
$$

$$
- \theta g(I_{rc}) \int_{\bar{p}_{rc}}^{\bar{v}} (\bar{p}_{rc} - c) f(v) dv - (1 - \theta) \int_{\bar{p}_{rc}}^{\bar{v}} (\bar{p}_{rc} - c) f(v) dv - 1 = 0
$$

Equating the contract prices, the three contracts’ first order conditions for choice of $I$ are, from equations (10), (12) and (14),

$$
\pi'_{fq}(I) = \theta g'(I) \int_{0}^{\bar{v}} (\bar{p} - c) f(v) dv + \theta g'(I) \int_{\bar{p}}^{\bar{v}} (v - c) f(v) dv - 1 = 0,
$$

$$
\pi'_{oc}(I) = \theta g'(I) \int_{\bar{p}}^{\bar{v}} (v - c) f(v) dv - 1 = 0
$$

and

$$
\pi'_{rc}(I) = \theta g'(I) \int_{\bar{p}}^{\bar{v}} (v - c) f(v) dv - 1 = 0
$$
Since \( g'(I) > 0, g''(I) < 0 \), and the option and requirements contracts’ first order conditions lack the first term of the fixed-quantity contract’s, they are solved by a smaller \( I \) when the prices in all three contracts are equal.

In fact, the price is lower under the fixed-quantity contract by Lemma 1, so even its second term is greater than the second term of the marginal profit of the option and requirements contracts if the investments are equal, so a fortiori the fixed-quantity contract’s investment must be bigger.

(3) Consider the total surplus in real terms, which can ignore payments between the parties since they cancel out. Total surplus under any contract consists of the the buyer surplus when the specialized product is needed and and the seller has successfully produced it plus the buyer surplus when the specialized product is not needed, minus the investment cost. The seller surplus is zero. Under the fixed-quantity contract, the buyer buys whenever his value \( v \) exceeds \( c \), whether the market is thin or thick, so

\[
\text{Total surplus}_{fq} = \theta g(I_{fq}) \int_c^\pi (v - c)f(v)dv + (1 - \theta) \int_c^\pi (v - c)f(v)dv - I_{fq}
\]

Under the option contract, the buyer buys in the thin market only if his value is at least \( p_{oc} \), so total surplus is

\[
\text{Total Surplus}_{oc} = \theta g(I_{oc}) \int_{p_{oc}}^\pi (v - c)f(v)dv + (1 - \theta) \int_c^\pi (v - c)f(v)dv - I_{oc}
\]

From Lemma 2 we know that \( I_{fq} \) is bigger and thus closer to the first-best level and preferable to \( I_{oc} \). Moreover, the lower bound of the first integral is \( c \) for the fixed-quantity contract but \( p_{oc} > c \) for the option contract, so that portion of the surplus is lower. Hence, the fixed-quantity contract has higher surplus than the option contract.

Under the requirements contract, whether the market is thick or thin the buyer will only buy if his value is at least \( p_{rc} \), so

\[
\text{Total surplus}_{rc} = \theta g(I_{rc}) \int_{p_{rc}}^\pi (v - c)f(v)dv + (1 - \theta) \int_{p_{rc}}^\pi (v - c)f(v)dv - I_{rc}
\]

From Lemma 2 we know that \( I_{fq} \) is bigger and thus closer to the first-best level and preferable to \( I_{rc} \). Moreover, the lower bound of both integrals is \( c \) for the fixed-quantity contract but \( p_{rc} > c \) for the requirements contract, so that portion of the surplus is lower. Hence, the fixed-quantity contract
contract has higher surplus than the requirements contract. Hence the fixed-quantity contract is superior to both alternatives. Q. E. D.

No Breaching

Let us now assume that neither party will breach the contract. This might be because breaching creates a bad reputation and hinders future contracting. Or, it could be that the other party will sue to enforce the contract, not because it is directly profitable but in order to preserve a reputation for enforcing contracts, and the resulting litigation costs in terms of legal fees and managerial time would make the breach unprofitable even if it would be efficient in the absence of transaction costs. Charny (1990) surveys informal reasons why firms do not breach contracts. It is well known that although businesses devote great care to writing legally enforceable contracts with each other, they rarely go to court to enforce them except in end-games—bankruptcy, or the collection of bad debts. Macaulay (1963) is the standard cite for that point. In a later article, Macaulay (1977) says (citing Llewellyn (1931) and Kurczewski & Frieske (1977)),

The contract litigation process may also maintain a vague sense of threat that keeps everyone reasonably reliable (see Llewellyn, 1931:725 n.47). For this process to operate, it is not necessary that business managers understand contract norms and the realities of the litigation process. Perhaps all that is needed is a sense that breach may entail disagreeable legal problems. The Polish managers described by Kurczewski and Frieske reflect this when they tell us that “one needs to threaten [to use contract penalties] intelligently.” The authors go on to remark, somewhat paradoxically, that the “system works well so long as the penalties [for breach of contract] are not actually applied. They work well as a threat, but their application will injure the relationship with the cooperating enterprise so that in the future it will seek contacts with other directors who have a more conciliatory approach” (1977:497).

How this works out is worthy of careful modelling and investigation, with emphasis more on why firms do not breach than on why they do not litigate if the other party breaches. We will take it as given here, however.

A Fixed-Quantity Contract, No Breaching. We could have a fixed-quantity contract with 1 unit and price $p$. The seller does not wish to breach, so he will choose $I = \bar{T}$, which is enough to guarantee success in producing the specialized product. Nor will the buyer breach. Thus, the seller’s expected profit is

$$\pi_{fq}(I) = (pq - c) - \bar{T} = 0,$$  (23)
\[
\bar{p}_{fq} = c + \bar{I}. \tag{24}
\]

Recall that the first-best condition for \( I \) is \( \theta g'(I) \int_p^\infty (\bar{p} - c) f(v) dv - 1 = 0 \). This makes \( I^* \) less than \( \bar{I} \), so we now have overinvestment.

There is another source of loss, however. The surplus is

\[
\text{Total surplus}_{fq} = \int_0^\infty (v - p_{fq}) f(v) dv \tag{25}
\]

\[
= \int_{p_{faq}}^\infty (v - \bar{p}_{fq}) f(v) dv - \int_0^{p_{eq}} (\bar{p}_{fq} - v) f(v) dv.
\]

The buyer will be buying sometimes when the product is useless. The buyer, as in the case where there are no breach costs, will set \( p \) so that seller profits are zero.

**An Option Contract, No Breaching.** We could have an option contract at price \( \bar{p}_{oc} \). As with the fixed-quantity contract, the seller will choose \( I = \bar{I} \) to avoid the possibility of breach. The seller will have expected profit

\[
\pi_{oc}(I) = \theta (\bar{p}_{oc} - c) - \bar{I} \tag{26}
\]

\[
= \theta (\bar{p}_{oc} - c) - \bar{I},
\]

and the buyer will choose \( p_{oc} \) to make seller profit equal to zero, yielding

\[
p_{oc} = c + \frac{\bar{I}}{\theta} \tag{27}
\]

Since \( \theta < 1 \), it follows that the price is higher under the option contract than under the fixed-quantity contract.

The buyer never has to buy an unwanted specialized product, so that source of welfare loss is absent. He will, however, have to pay indirectly for the excess investment, so this contract will not achieve the decentralized optimum. The surplus is

\[
\text{Total surplus}_{oc} = \theta \int_{p_{oc}}^\infty (v - \bar{p}_{oc}) f(v) dv + (1 - \theta) \int_c^\infty (v - c) f(v) dv \tag{28}
\]

**A Requirements Contract, No Breaching.** We could have a requirements contract at price \( \bar{p} \). As with the other two contracts, the seller will choose \( I = \bar{I} \) to avoid the possibility of breach.
The seller will have expected profit
\[ \pi_{rc}(I) = (\overline{p}_{rc} - c) - I \]  
and the buyer will set this equal to zero in the contract, yielding
\[ p_{rc} = c + I \]  

Note that this price is identical to the price in the fixed-quantity contract.

Surplus is
\[ \text{Total surplus}_{rc} = \int_{\overline{p}_{rc}}^{\overline{v}} (v - p_{rc}) f(v) dv \]  

Since the price is the same as in the fixed-quantity contract and the surplus there is expression (31) minus a positive term, the surplus is higher with the requirements contract.

How about the option contract? Jensen’s inequality tells us that if a function \( h(\cdot) \) is strictly concave then
\[ \theta h(x) + (1 - \theta) h(y) < h(\theta x + (1 - \theta)y) \]  

Let \( h(x) \equiv \int_{x}^{\overline{v}} (v - x) f(v) dv \). This is concave because \( h'(x) = (x - x) f(x) + \int_{x}^{\overline{v}} f(v) dv \) and \( h''(x) = -f(x) < 0 \).

Expression (28) is \( \theta h(\overline{p}_{oc}) + (1 - \theta) h(c) \) and expression (31) is
\[ h(\overline{p}_{oc}) = h(c + I) = h(\theta (c + \frac{I}{\theta}) + (1 - \theta)c) = h(\theta \overline{p}_{oc} + (1 - \theta)c) \]

Thus expression (31), the requirements surplus, is bigger.

**Proposition 2:** In the specialized-product model with high breach costs, the requirements contract is superior to both the fixed-quantity contract and the option contract.

**II. A Model with Capacity Choice**

The explanation for requirements contracts in this paper will rely on
(a) the buyer’s uncertainty of how much he needs,
(b) his uncertainty over whether the market can supply his needs, and
(c) his demand being at least slightly elastic.
Thus, let the buyer’s demand (or marginal benefit) curve be the low $b_{Lo}(p)$, $b'_{Lo} < 0$ with probability $\lambda$ and high $b_{Hi}(p), b'_{Hi} < 0$ otherwise, where $b_{Lo} > 0$ and $b_{Hi} > b_{Lo}$ for any $p$. The inverse demand curves will be $p_{Lo}(q)$ and $p_{Hi}(q)$. The marginal cost is $c$. With probability $\theta$, the outside market is thin: the only production is by “the seller”, who can sell up to $k$ units if he has invested $I(k)$ before the states of demand and supply are revealed. With probability $(1 - \theta)$, the market is “thick” and a competitive market will sell as many units as needed at a price of $c$. Neither player knows the state of demand or supply at the time of contracting, and contracts cannot be conditioned on the seller’s capacity. Later we will introduce the assumption that negotiations over prices or damages incur a prohibitive cost on both players, but we will not for the first part of the analysis.

**The First-Best: Vertical Integration (P=MC).** We know that the first-best price will be $c$, the marginal cost. Consumer surplus at a price of $c$ is

\[ \int_0^{q_{Lo}(c)} (b_{Lo}(q) - c) dq \]

or

\[ \int_0^{q_{Hi}(c)} (b_{Hi}(q) - c) dq \]

if the market is thick (integrating now over $q$, not $p$). Let us assume that it is efficient to choose a capacity big enough to serve low demand at first-best prices— that is, the derivative with respect to $k$ of social surplus is positive if $k = q_{Lo}(c)$:

\[ Surplus'(k) = \theta(1 - \lambda)(b_{Hi}(q_{Lo}(c)) - c) - I'(q_{Lo}(c)) > 0 \]  

(33)

Expected consumer surplus at a price of $c$ will be as just specified if the market is thick or demand is weak, but $\int_0^k (p_2(q) - c) dq$ if the market is thin and demand is strong. Subtracting the cost of capacity yields the social surplus:

\[ Surplus(k) = \theta \left( \lambda \int_0^{q_{Lo}(c)} (p_1(q) - c) dq + (1 - \lambda) \int_0^k (b_{Hi}(q) - c) dq \right) \]

\[ + (1 - \theta) \left( \lambda \int_0^{q_{Lo}(c)} (p_1(q) - c) dq + (1 - \lambda) \int_0^{q_{Hi}(c)} (b_{Hi}(q) - c) dq \right) - I(k) \]

(34)

The first order condition for maximizing social surplus by choice of $k$ is

\[ Surplus'(k) = \theta(1 - \lambda)(b_{Hi}(k) - c) - I'(k) = 0 \]  

(35)

Let $k^{**}$ be defined as the first best level of $k$, which solves equation (35).

We do not need to assume $k^{**} \leq q_{Hi}(c)$. The optimal capacity would not be able to satisfy the demand if demand is strong and price equals marginal cost, so $k^{**} < q_{Hi}(c)$. That is because
otherwise the first order condition would become
\[
\theta(1 - \lambda)(b_{Hi}(q_{Hi}(c)) - c) - I'(q_{Hi}(c)) = \theta(1 - \lambda)(c - c) - I'(q_{Hi}(c)) < 0.
\]

If capacity were contractible, the seller would agree to install \( k = k^{**} \) with a heavy penalty for breach, the buyer would have the option to choose any quantity up to \( k^* \), and the price would be set to yield zero expected profits to the seller. Note that we allow the contract to condition on the state of demand, but that will not make any difference, for the reason explained in the unit demand model.

**Contracts with Fixed Payments.** If fixed payments are allowed, it is easy to attain the first best. One way is with a contract specifying a price of \( c \), quantity at the option of the buyer, and a fixed payment of \( S = \theta(1 - \lambda)\int_{k}^{q_{Hi}(c)}(b_{Hi}(q) - c)dq - I(k^{**}) \). Under that contract, the seller's cash flows will be the payment of \( S \) with zero cash flow from sales of the product, and the loss of expectation damages paid to the buyer of \( \int_{k}^{q_{Hi}(c)}(b_{Hi}(q) - c)dq \) if the seller chooses \( k \leq q_{Hi}(c) \).

The side payment \( S \) is chosen to make seller profit equal zero in the following equation
\[
\pi_{sp}(k) = S - \theta(1 - \lambda)\int_{k}^{q_{Hi}(c)}\left(b_{Hi}(q) - c\right)dq - I(k) = 0. \tag{36}
\]

The seller’s first order condition is then the same as the first best condition:
\[
\pi'_{sp}(k) = \theta(1 - \lambda)(b_{Hi}(k) - c) - I'(k) = 0. \tag{37}
\]

**Contracts with Multiple Prices.** Nonlinear pricing could also attain the first best, with a price of \( p_a = c + \frac{I(k^{**}) - (1 - \lambda)(p_b - c)k^{**}}{\lambda q_{Lo}(c)} \) per unit for \( q_{Lo}(c) \) units and \( p_b \) per unit for \( k^{**} \) units, with the buyer being required to buy one or the other quantity from the seller and \( p_b = c + \theta b_{Hi}(k^{**}) \).

Seller profits are
\[
\pi_{mp}(k) = \lambda(p_a - c)q_{Lo}(c) + (1 - \lambda)(p_b - c)k - I(k), \tag{38}
\]
where the value of \( p_a \) is chosen so \( p(k^{**}) = 0 \). Note that this will require a \( p_a \) below marginal cost if \( I(k^{**}) < (1 - \lambda)(p_b - c)k^{**} \), and a negative price if \( \frac{I(k^{**}) - (1 - \lambda)(p_b - c)k^{**}}{\lambda q_{Lo}(c)} < -c \). This will yield the first-order condition
\[
\pi'_{mp}(k) = (1 - \lambda)(p_b - c) - I'(k) = 0
\]
\[
= (1 - \lambda)(c + \theta(b_{Hi}(k^{**}) - c) - I'(k) = 0 \tag{39}
\]
\[
= (1 - \lambda)\theta(b_{Hi}(k^{**}) - c) - I'(k) = 0,
\]
which is solved by \( k = k^{**} \) and is identical to the best first order condition.

We will henceforth rule out non-linear pricing—which just involves two prices, or a fixed payment, in our model, but could involve an entire continuous price schedule if we had continuous states of the world. We will allow only a single price in a contract.

**The Decentralized Optimum (\( P = AC \)).** Now we add the constraint that the seller must have zero profit and that the buyer must be charged a price, though we will still specify \( k \). The problem becomes to maximize

\[
Surplus(k, p) = \theta \left( \lambda \int_0^{q_{Lo}(c)} \left( b_{Lo}(q) - c \right) dq + (1 - \lambda) \int_0^k \left( b_{Hi}(q) - c \right) dq \right) + (1 - \theta) \left( \lambda \int_0^{q_{Lo}(p)} \left( p_1(q) - c \right) dq + (1 - \lambda) \int_0^{q_{Hi}(p)} \left( b_{Hi}(q) - c \right) dq \right) - I(k)
\]

such that

\[
\pi(k, p) = (1 - \theta) \left( \lambda(p - c)q_{Lo}(p) + (1 - \lambda)q_{Hi}(p)(p - c) \right) + \theta \left( \lambda(p - c)q_{Lo}(p) + (1 - \lambda)q_{Hi}(p)(p - c) \right) - I(k) \geq 0.
\]

The first order condition for maximizing social surplus by choice of \( k \) is (where we will denote the decentralized optimum level as \( k^* \)) is, since it is optimal to set \( k = q_{Hi}(p) \),

\[
\frac{dSurplus}{dk} = \theta (1 - \lambda) \left( b_{Hi}(k) - c \right) - I'(k) - \lambda \left( \theta (1 - \lambda)(p - c) - I'(k) \right) = 0
\]

\[
\frac{dSurplus}{dk} = (1 - \lambda) \left( \theta (1 - \lambda)(p - c) - I'(k) \right) = 0
\]

\[
\theta (1 - \lambda)(p - c) - I'(k) = 0
\]

\[
p = c + \frac{I'(k)}{\theta(1 - \lambda)}
\]

which says the fixed cost needs to be spread into the price to yield profits. It’s best just to make the price as low as possible subject to the constraint. The constraint will be binding. So just solve with the \( k \) first order condition, as in the unit-demand model. Since \( p > c \), comparison of equation (6) with the equation defining \( k^{**} \) shows that \( k^* < k^{**} \). Since we must reimburse the seller for his costs and cannot force the buyer to buy as much at \( p = p^* \) as at \( p = c \), trade diminishes and some surplus is lost.
**Spot Sale: No Contract At All.** How about a spot sale? If two sellers invest in capacity, they will both have negative profits. If just one does, his expected profits are zero if the market is thick. If the market is thin, however, buyer and seller are in a bilateral monopoly. If the seller’s optimal $k$ is less than $q_{Lo}(c)$, his profit is

$$\pi_{\text{spot}}(k) = \theta \lambda \int_{0}^{k} \left( \frac{b_{Lo}(q) - c}{2} \right) dq - I(k)$$

(43)

and his first order condition is

$$\pi'_{\text{spot}}(k) = \theta \lambda \left( \frac{b_{Lo}(k) - c}{2} \right) - I'(k) = 0.$$ 

(44)

If investment is expensive enough, this will occur even if $k^* > q_{Lo}(c)$, because the seller only gets half of the surplus. This is the conventional hold-up problem.

On the other hand, if the last equation is false then the seller will pick $k > q_{Lo}(c)$ and his profit is

$$\pi_{\text{spot}}(k) = \theta \lambda \int_{0}^{q_{Lo}(c)} \left( \frac{p_{1}(q) - c}{2} \right) dq + (1 - \lambda) \int_{0}^{k} \left( \frac{b_{Hi}(q) - c}{2} \right) dq - I(k)$$

(45)

with first order condition

$$\pi'_{\text{spot}}(k) = \theta (1 - \lambda) \left( \frac{b_{Hi}(k) - c}{2} \right) - I'(k) = 0.$$ 

(46)

This is less than the feasible first-best capacity too, unless we have a corner solution because $k^* = q_{Hi}(p^*)$ and $\pi'(k^*) > 0$.

Under our assumption of costless renegotiation, the buyer and seller will bargain to the efficient output level, $q_{Lo}(c)$ or $k$ and choose the price to split the surplus. (If the seller chooses a price, or they can just bargain over a price and not quantity, then the price will be greater than $c$, so quantity will be inefficiently low, and $k$ will be chosen lower too.)

**A Fixed-Quantity Contract.** How about a fixed-quantity contract with price $p_{fq}$ and quantity $\bar{q}$? Can we get the first-best? If $\bar{q}$ is set to $k^*$, then we can set $p_{fq}$ to do it. Note, first, that if $\bar{q} = k^*$ then if demand at price $p_{fq}$ is less than $k^*$, the buyer will breach the contract. He will purchase either $q_{Lo}(p_{fq})$ or $q_{Hi}(p_{fq})$ from the seller. If the market is thick and demand is high, he will buy an additional $q_{Hi}(c) - \bar{q}$ at price $c$ from the market.\(^9\)

\(^9\)Alternately, if the market is thick, the buyer could purchase anywhere from 0 to $\text{Max}(q_{Lo}(c), \bar{q})$ or $\text{Max}(q_{Hi}(c), \bar{q})$ units from the seller, and buy as much more to add up to $q_{Lo}(c)$ or $q_{Hi}(c)$ from the market. For the first $\bar{q}$ units, buying from the seller costs $p_{fq}$, while buying from the marketplace costs the price $c$ plus damages of $p_{fq} - c$, for a total cost which is also $p_{fq}$.
In any situation in which the spot sale does not achieve \( k = k^* \) (the corner solution mentioned above), \( k \) will be chosen so \( k \leq \bar{q} \), because \( k > k^* \) would only yield extra profit at a rate of 
\[
(1 - \theta)(1 - \lambda)(p_2(k^*) - c)/2,
\]
which is less than the extra cost of \( I'(k^*) \).

The seller’s profit from choosing \( k \) is, since \( k \leq \bar{q} = k^* \),
\[
\pi_{fq}(k) = (1 - \theta)[\lambda(\bar{p}_{fq} - c)\bar{q} + (1 - \lambda)(\bar{p}_{fq} - c)\bar{q}]
+ \theta\left[\lambda(\bar{p}_{fq} - c)\bar{q} + (1 - \lambda)[(\bar{p}_{fq} - c)k - \int_k^{\bar{q}(\bar{p}_{fq})}(b_{Hi}(q) - \bar{p}_{fq})dq]\right] - I(k)
\]
with derivative
\[
\pi'_{fq}(k) = (1 - \lambda)[(\bar{p}_{fq} - c) + (b_{Hi}(k) - \bar{p}_{fq})] - I'(k)
\]
which is the first-best condition. Thus, the seller will pick \( k = k^{**} \). The contract quantity is not in the seller’s capacity first order condition, and so can be set to the level that yields zero profit.

We can get the first-best, unlike in the specialized-product model, because the seller’s choice here is directly related to the quantity, which is specified in the contract. The buyer would, ex post, rather not buy \( q_{hi}(c) \) at a price of \( \bar{q} \), but he has to pay damages if he does not buy the full quantity. The contract has delinked the price from the quantity, so the price can be used solely to compensate the seller for the fixed cost of investment.

An Option Contract. How about an option contract? This would specify a price \( p_{oc} \) at which the seller is obligated to provide as much of the good as the buyer desires. The seller will choose \( k \) to be \( q_{Lo}(p_{oc}) \) or \( q_{Hi}(p_{oc}) \). With any quantity in between, the seller would have to pay damages or be able to sell more to the buyer if demand is high and markets are thin. The buyer chooses between the two quantities based on his surplus from the price necessary in each case to enable the seller to reach zero profits.

The profit from \( k = q_{Lo}(p_{oc}) \) is
\[
\pi_{oc}^L(k) = \theta((p_{oc} - c)k - p_{oc}) - \theta(1 - \lambda)\int_k^{q_{Hi}(p_{oc})}(b_{Hi}(q) - p_{oc})dq - I(k)
\]
Profit if \( k = q_{Hi}(p_{oc}) \) is
\[
\pi(k) = \theta(p_{oc} - c)k - I(k)
\]
A Requirements Contract. How about a requirements contract? The seller will then definitely choose \( k \geq q_{Lo}(\overline{p}_{rc}) \), since he is guaranteed that much in sales whether the market is thick or not. Suppose \( k < q_{Hi}(\overline{p}_{rc}) \). Then seller profit does not depend on whether the market is thick or not, and equals

\[
\pi_{rc}(k) = (1 - \theta)\left[ (\overline{p}_{rc} - c)q_{Lo}(\overline{p}_{rc}) \right] + \theta \left[ (\overline{p}_{rc} - c)q_{Lo}(\overline{p}_{rc}) - (1 - \lambda) \int_{k}^{q_{Hi}(\overline{p}_{rc})} \left( b_{Hi}(q) - \overline{p}_{rc} \right) dq \right] - I(k) \tag{51}
\]

which has first order condition

\[
\pi'_{rc}(k) = \theta(1 - \lambda)\left( b_{Hi}(k) - \overline{p}_{rc} \right) - I'(k) = 0 \tag{52}
\]

Thus, we have Proposition 3 below.

Proposition 3: In the capacity model with zero breach costs, the fixed-quantity contract achieves the first-best. The requirements contract achieves the decentralized optimum, and the options contract is the worst of the three.

The Model with High Breach Costs

The fixed-quantity contract above is informationally demanding and vulnerable to transaction costs. If the buyer wishes to breach because demand is low, the damages he pays depend on \( c \), the marginal cost of the seller. Realistically, they would also depend on whether the seller could sell at the contract price to some other buyer, thought that is not in the model. The seller’s choice of \( k \) is based on the incentive that if it breaches, it will have to pay damages that depend on \( v \), the marginal benefit of the buyer. Again, realistically, they would also depend on whether the buyer could have obtained the good at some price less than \( v \) even if the market were not thick. Not knowing these parameters is something of a problem for designing the contract, since it means that each side is vulnerable to the other side’s superior information. The buyer knows less accurately than the seller what damages the buyer would pay in case of breach. The seller knows less accurately than the buyer what damages the seller would pay in case of breach. Trying to
learn more or to deduce hidden information from the other side's behavior creates transaction costs. In addition, resorting to court to enforce contracts is costly, and so most cases settle—that is, the parties bargain, so again, bargaining is costly.

What a contract does, then, is to create a fixed price, a price which requires no future bargaining, and particular rights to buy and sell quantities, rights which again do not need future bargaining.

It's interesting that one's first thought is that it would be wonderful to have a world in which everyone keeps their contracts perfectly. Here, however, the outcome will turn out to be worse than in our case where transaction costs are low enough that efficient breach occurs.

**A Fixed-Quantity Contract.** The optimal fixed-quantity contract is now unlikely to be with \( q = k^* \). Now, the amount \( q \) is what will actually be produced and sold. Thus, \( k = q \). The amount \( q \) will be chosen to maximize the buyer's payoff while giving the seller a zero payoff. The buyer will always buy \( q \) from the seller, since the seller will not breach. The buyer will not buy less and pay damages, or buy more and bargain with the seller for a new price. If the market is thick, however, the buyer will buy more, at the market price of \( c \), which does not require any thought or negotiation by either side. The buyer's surplus is:

\[
\text{Buyer Surplus} = \lambda \int_0^q \left( b_{Lo}(q) - \bar{p}_{fq} \right) dq + (1 - \lambda) \int_0^q \left( b_{Hi}(q) - \bar{p}_{fq} \right) dq \tag{53}
\]

where \( \bar{p}_{fq} \) makes the seller's payoff zero:

\[
\pi_{fq} = (\bar{p}_{fq} - c)q - I(q) = 0. \tag{54}
\]

This is considerably inferior to the first best. Note that we can get the seller to choose the desired capacity easily enough now, since the seller does not want to breach. The differences between contracts will be in when trade occurs, and at what prices.

**An Option Contract.** An option contract will have the buyer paying \( c \) if the market is thick and \( \bar{p}_{oc} \) if it is not, as before. Unlike in the case without transactions costs, here we can be sure that the seller will choose \( k = q_{Hi}(\bar{p}_{oc}) \) because he will not want to breach. Buyer surplus will be:

\[
\text{Buyer Surplus} = \theta \left[ \lambda \int_0^{q_{Lo}(\bar{p}_{oc})} \left( b_{Lo}(q) - \bar{p}_{oc} \right) dq + (1 - \lambda) \int_0^{q_{Hi}(\bar{p}_{oc})} \left( b_{Hi}(q) - \bar{p}_{oc} \right) dq \right]
+ (1 - \theta) \left[ \lambda \int_0^{q_{Lo}(c)} \left( b_{Lo}(q) - c \right) dq + (1 - \lambda) \int_0^{q_{Hi}(c)} \left( b_{Hi}(q) - c \right) dq \right] \tag{55}
\]
where $\bar{p}$ makes the seller’s payoff zero:
\[ \pi_{oc} = \theta (\bar{p}_{oc} - c)(\lambda q_{Lo}(\bar{p}_{oc}) + (1 - \lambda)q_{Hi}(\bar{p}_{oc})) - I(q_{Hi}(\bar{p}_{oc})) = 0. \tag{56} \]

**A Requirements Contract.** A requirements contract will have the buyer paying $\bar{p}_{rc}$ whether the market is thick or not. Buyer surplus will be
\[
\text{Buyer Surplus} = \lambda \int_{0}^{q_{Lo}(\bar{p}_{rc})} (b_{Lo}(q) - c) dq + (1 - \lambda) \int_{0}^{q_{Hi}(\bar{p}_{rc})} (b_{Hi}(q) - c) dq, \tag{57}
\]
where $\bar{p}_{rc}$ makes the seller’s payoff zero:
\[ \pi_{rc} = (\bar{p}_{rc} - c)(\lambda q_{Lo}(\bar{p}_{rc}) + (1 - \lambda)q_{Hi}(\bar{p}_{rc})) - I(q_{Hi}(\bar{p}_{rc})) = 0. \tag{58} \]

The disadvantage of the requirements contract relative to the option contract is that the buyer must pay $\bar{p}_{rc}$ instead of $c$ when the market is thick. The advantage is that this allows $\bar{p}$ to be lower than in the option contract. Because triangle losses rise with the square of the overpricing, the requirements contract is better. Thus, we have Proposition 4:

**Proposition 4.** In the capacity model with high breach costs, the requirements contract is superior to both the fixed-quantity contract and the option contract.

**What Happened in Horn v. United States?**

We have seen that requirements contracts are useful when the buyer is unsure of his needs, wishes to avoid the possibility of being caught with no supplier or just one, and has a strong desire to avoid having to think about seller costs or buyer benefit again at a later time. If sellers know the range of possible demands as well as the buyer does, then the problem is not lack of investment, because a seller will provide for the buyer’s need speculatively, but the buyer will pay a high price if no price has been arranged in advance. Nor is the problem just that the buyer is unsure of his needs, because a fixed-quantity contract can pin down a price and efficient breach would allow the quantity to be adjusted up or down. The cost of such breach in terms of managerial attention, however, is high enough that the buyer may prefer to pay extra for the option of deciding later how much to buy. This, in turn, leaves the seller vulnerable to being undercut by other sellers, so it will result in a high price unless they go one step further and make it a requirements contract, so that the seller will always earn the contract profit margin and the quantity he sells will depend only on the buyer’s needs, not whether competitors are available.
Let us now return to *Horn v. United States*. It illustrates the peril of one party accepting the other party’s standard-form contract. As I explained in my 2001 “Explaining Incomplete Contracts as the Result of Contract-Reading Costs,” a party to a contract should be wary of complicated contract language, because it may contain concealed “booby trap” language and it is harder to carefully read a complex contract than to write one. Horn’s contract contained such a boobytrap. It may even have been unknown to the particular federal officials who awarded her the contract, though the federal government has long been aware of it. The judge reluctantly but without doubt ruled against Horn, saying,

> Although it appears that both parties entered into the contract with the intent to form a requirements contract, that fact cannot overcome the plain language of the contract. ...

The contract makes clear that the BOP only intended to utilize Ms. Horn for the services it could not fulfill in-house, stating, the Government shall order from the Contractor all of that activity’s requirements for . . . services specified in the schedule that exceed the quantities that the activity may itself furnish within its own capabilities.

The plain language of the contract was clear. It addressed the question of whether the government could satisfy its requirements internally, and said it could. Labelling the contract a “requirements contract” and both parties thinking of it as such could not overrule what was written. The crucial clause was not obscurely concealed, but reading a contract incurs a transactions cost, one lower than renegotiating but costly nonetheless. Horn’s skipping the cost of reading the contract meant she incurred the cost of abiding by it. Indeed, it may have been precisely because of her mistake that she won the contract award; this may be an example of the winner’s curse.

Horn’s fallback argument was that this was an “indefinite quantities contract”, an option contract giving the buyer the option of a range of quantities, so that even if the prison was justified in meeting some of its requirements internally it still was under an obligation to let her fulfill some too. Again, the plain language of the contract was decisive. The judge said,

> In order for an indefinite quantities contract to be enforceable, it must: (1) specify the period of the contract; (2) specify the total minimum and maximum quantity of supplies or services for the Government to purchase; and (3) include a statement of work. See FAR 16.504(a)(4)(i)-(iii); see also *Varilease Tech. Group, Inc.*, 289 F.3d at 799-800. Without an expressly stated minimum quantity purchased by the contract, however, an indefinite quantities contract fails for lack of mutuality and consideration because it does not specifically define the parties obligations under the contract. See, e.g., *Maxima Corp.*
v. United States, 847 F.2d 1549, 1557 (Fed. Cir. 1988) (noting a minimum quantity clause serves to ensure mutuality of obligations and to make the contract enforceable by both parties to it).”

The judge was, however, quite critical of the Government, despite ruling in its favor. Apparently, this misleading language has been deceiving unwary government contractors for over seventy years.

It is unfortunate that the Government has continued to use this standard form document that appears to the non-legal reader as a binding contract, but is in fact not. It is clear that this document misled Ms. Horn into believing she had an agreement with the Government when, in reality, the agreement was unenforceable. More to the point, even the Government officials with whom she dealt did not seem to understand the documents lack of enforceability. This point is particularly troublesome to the Court. While there are certainly instances where a contract contains a latent defect rendering it unenforceable, this is not the case here. As early as 1929, the Supreme Court put the Government on notice that this type of contractual language created an unenforceable instrument. See Willard, Sutherland & Co., 262 U.S. at 493. In 1984, the Court in Ralph Constr. Inc. similarly declared an indefinite quantities contract unenforceable that contained seemingly identical FAR language. See Ralph Constr. Inc., 4 Cl. Ct. at 731-32. Yet, more than a quarter of a century later, these FAR provisions are still rendering contracts unenforceable and unsuspecting contractors are being denied the opportunity to pursue what may be meritorious claims.

The Horn case illustrates transaction costs in a variety of ways. The government wanted to obtain teeth-cleaning services at a low price by awarding a contract in advance of knowing the quantity that would be demanded. It used a simple, one-price contract, with no signing fee for either side, keeping complexity down. And it used a form of requirements contract, to induce the provider to focus her attention on the prison’s needs first. But the bureaucrats in Washington had written a requirements contract with an out, allowing the prison to hire a provider internally. Perhaps this would have been efficient even if it had been clear to both sides, but presumably the price would have been higher. I hope that Horn did not turn down attractive alternative employers in reliance on the contract, but this shows that the longer the contract, the greater the danger to the side that did not write it.
References


