Open Ownership—Not Common Carriage*

by

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Abstract

We consider regulating natural monopolies with open ownership and competitive rules as a substitute for common carriage regulation and illustrate it with an application for natural gas pipelines. A single set of production assets exhausts any economies of scale or scope, while owners compete with each other due to incentives from open ownership rules that promote efficient investment choices, primarily by breaking down barriers to entry, and competitive rules that promote an efficient secondary market. We argue that regulating a natural monopoly with these rules, in a market structure we call a competitive joint venture, significantly increases the efficiency of pricing, output, and capacity choices and may dramatically reduce regulatory costs when compared to regulating with common carriage.

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Common carriage often is used, proposed, or considered to regulate industries with natural monopoly characteristics, including pipelines, electric power transmission, telecommunications, railroads, and air and seaports. In general terms, common carriage requires the seller to offer its services to anyone at prices within specified constraints intended to limit above-competitive profits, allow revenues to cover all economic costs, and to limit discrimination between its customers. Typically, in implementing common carriage, a regulator directly sets rates for these services that are to remain constant over a variety of market conditions and that are based upon an allocation of historic costs, a process which yields mispriced and misallocated services almost surely. Such rates lack the flexibility needed for responding to rapidly changing market conditions, the process often leads to inefficient capacity choices, and the regulatory costs of the system are substantial.

We will consider a regulatory alternative that we call a competitive joint venture, first in a simplified "textbook" market, then incrementally complicating the environment and the regulatory alternative until it could apply to U.S. interstate natural gas pipeline transportation. In effect, the regulatory objectives are to be met by substituting for common carriage a mandated organizational structure with open ownership, where the regulator imposes common carrier pricing requirements to the purchase of capacity instead of its rental, plus competitive rules to promote an efficient secondary market. No further regulation concerning market power is to be imposed.

In a competitive joint venture each owner must satisfy open ownership and competitive rules. Stated somewhat loosely, each owner:

open ownership rules to promote efficient investment choices

(1.a) must allow open ownership, where anyone may purchase long-term rights to capacity at prices within specified regulatory constraints intended to just cover fixed costs and to limit discrimination;

(1.b) must have an undivided common interest in shared facilities;

(1.c) may establish a total owned capacity artificially below physical capacity;

competitive rules to promote the efficient use of existing capacity

(2.a) must independently market services produced from its capacity from this facility, paying regulated prices that just cover variable costs;

(2.b) must use its available capacity, or potentially lose its use to other owners or the operator; and

(2.c) must establish an operator independent of any individual user, or any sub-group of users, charged to act neutrally with respect to all owners.

While there were earlier hints to exploit competition between users of the same facilities, the first detailed work following this approach is in Lewis and Reynolds (1979). The Department of Justice then applied this approach in 1984 in an Alcan-Arco merger.[1] The modified form adopted here has had a tremendously long gestation period that started during my stay at the Federal Energy Regulatory Commission (1987-1991), and it more closely follows the institutions of natural gas pipelines. It has been developed by Smith and his colleagues (Smith (1987, 1988), McCabe, Rassenti, and Smith (1991), and Rassenti, Reynolds, and Smith (1993)), by Braman (1992), and later, independently by Gale (1994).

This paper, which builds upon this work published earlier, considers the application of this approach to natural gas pipelines in some detail. It builds particularly upon the detailed theoretical discussion in Gale (1994) of the short-term markets that result with a use-or-lose rule, and it stresses the effect of open entry into the competitive joint venture. With its policy focus, this paper considers more general market conditions that apply to natural gas pipelines but were not considered previously, it modifies rules, as necessary, to deal with these market conditions, and it compares the results to those obtained from the usual regulatory alternative, common carriage.

To set the stage for this paper, Section I describes the market environments that we consider and introduces the basic two-stage structure of our models. Sections II-IV describe and analyze the rules of a competitive joint venture. Sections II and III examine the open ownership rules of the first stage of our models. Section II examines the open ownership rule itself that promotes efficient, competitive long-run behavior by breaking down any barriers to entry. Our primary focus among the competitive joint venture rules is on the open ownership rule. This section also examines the common ownership requirement, a subsidiary rule designed to improve investment decisions by reducing the costs of enforcing open ownership. Section III examines the owner-determined capacity rule intended to both reduce any "options value" of an uncertain investment, as described in Dixit and Pindyck (1994), and (along with a modification to a competitive rule) to gain the efficiency benefits of acceptable price discrimination. A secondary focus among the competitive joint venture rules is on this rule, another subsidiary rule aimed at improving investment decisions, this time both by increasing profits acceptably in weak states of the world and by reducing the costs of enforcing open ownership. Section IV examines the competitive rules designed to promote efficient short-run behavior within the second stage of our model.

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[1] *U.S. v. Alcan Aluminum* (1985).

For comparison, Section V sketches a model of common carriage operating within our market environments. Section VI then compares the predicted performance of common carriage versus competitive joint ventures. To demonstrate the application of this approach for some actual markets, Section VII describes two types of pipeline networks as competitive joint ventures. Section VIII summarizes all the rules required of a competitive joint venture and provides some concluding comments. An Appendix provides more detailed arguments on some issues raised within the paper, allowing a more accessible policy paper than otherwise.

Ultimately, we argue that a regulator with common carriage regulatory objectives, and, in particular, the regulator of U.S. interstate natural gas pipelines, the Federal Energy Regulatory Commission, would reach its own objectives more successfully with a competitive joint venture than with common carriage. When compared to common carriage, a competitive joint venture improves investment decisions; adjusts prices automatically with market conditions, efficiently allocating the capacity available; and reduces the regulatory costs of the system significantly. We argue, not that a competitive joint venture achieves perfection, but that it performs better than common carriage.

I
The Market Environments

We consider production decisions to be made in two stages. Investment choices that determine fixed costs for constructing capacity are faced in the first stage. Production decisions on providing services from this capacity are faced in the second stage, a stage in which investment choices cannot be altered.

In Stage 1, the total quantity of capacity k of natural monopoly production assets is constructed. These natural monopoly assets will be available to produce services to use in Stage 2. The total fixed cost of capacity is denoted by the function $\mathbf{C}(k)$ for any nonnegative k. The average cost for constructing capacity $\mathbf{C}(k)/k$ is continuous and declines for all positive k, and $\mathbf{C}(0) = 0$.

In Stage 2, price-taking consumers determine the total quantity of services q that are produced from the available capacity k determined in Stage 1, that is, consumers choose some $q \le k$. Demand is given by the continuous downward-sloping demand function $\mathbf{D}(p)$, where p is the single market price. Equivalently, this demand could be described by the inverse demand $\mathbf{P}(q)$, which describes the market-clearing price if the quantity q were offered to the market. A variable cost $c{\cdot}q$ is paid to provide the output q. To eliminate uninteresting cases, assume that for some quantity, the market-clearing price exceeds the total average cost of providing this quantity.

These cost and demand conditions in our basic two-stage model are illustrated in Figures 1 and 2. Figure 1 illustrates investment choices made in the long run, and Figure 2 illustrates production and pricing choices made in the short run.

With the rules of a competitive joint venture and later the constraints of common carriage, we first consider their effect within the textbook case of the two-stage market described above. We then consider the market environments that result when we incrementally add each of the following:

- Short run demand may be uncertain.
- Production assets have long lives during which new investment could occur prior to the end of the economic life of the initial assets, so that production assets could have overlapping vintages.
- Demand may be uncertain in the long run, investment is irreversible with large sunk costs, and some flexibility is available for timing investments.
- Common costs may exist when producing multiple services from the production assets, costs that would be faced even if any of the services were to be discontinued while others remained.
- Firms in the industry know cost, market demand, and their uncertainties better than a regulator. This asymmetry is particularly acute for information not observed currently in the marketplace.

Within these market environments, a competitive joint venture consists of several firms that have or could have long-term rights to services from a single set of production facilities. These long-term rights include those rights necessary to make up the functional equivalent of ownership. As such, we call the long-term rights holder an owner.[2] The owners control the operational management of the facilities, and they must each follow two sets of rules designed to improve market performance. Open ownership rules are designed to improve the choice of capacity (Stage 1 of our model), and competitive rules are designed to improve the use of this capacity (Stage 2 of our model). A regulator must enforce these rules.[3]

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2 We are concerned only with the economic structure of this alternative and the economic incentives induced from it, not its legal structure. In particular, the incentives of "ownership" that come from the power to control the use of an asset's capacity for a price determined at the time of "purchase" may be created by long-term contracts as well as by legal ownership. This possibility is illustrated in the second pipeline application described in the penultimate section of this paper.

3 If the open ownership and competitive rules were established in a series of contracts, the "regulator" could conceivably be a court or some alternative institution for resolving disputes rather than a formal regulatory body. This alternative "regulator" may be preferable especially where industry-specific regulators do not now exist, such as in an antitrust application or in a country such as New Zealand that does not have them.

Our basic model of a competitive joint venture contains the following. In Stage 1, each potential owner $i = 1,2,3,...$ chooses the quantity of capacity k_i that it will be entitled to use in Stage 2. Any particular potential owner i that chooses $k_i > 0$ becomes an owner of the competitive joint venture. The total capacity $k \equiv \Sigma_i k_i$ determines the fixed costs $\mathbf{C}(k)$ necessary to construct this capacity. Open ownership rules determine the fixed costs that each owner is to pay in this stage.

Stage 2 must determine for each owner i the output q_i to offer and the price p_i to charge for each unit given the capacities determined in Stage 1. Each owner i knows the capacities of all owners at the beginning of Stage 2. Owner i pays a variable cost $c \cdot q_i$ to provide its chosen quantity. The demand for this market $\mathbf{D}(p)$, the competitive rules, and any voluntarily adopted market institutions consistent with them, determine the market outcome achieved in this stage.

In the resulting markets, we want to consider the equilibria of the relevant game, and then compare the equilibrium outcomes with outcomes from common carriage. The equilibria we wish to characterize are subgame perfect equilibria, where Nash equilibrium behavior occurs for the short-run decisions with known, fixed capacity in Stage 2 and, once this short-run behavior is assumed, Nash equilibrium behavior occurs for the long-run capacity decisions in Stage 1. Such an analysis requires a determination of Stage 2 behavior first, and then this behavior is incorporated into a Stage 1 analysis.

Even though this backwards induction would usually lead to a full analysis of Stage 2 first, since the primary focus of this paper is on long-run behavior, we will proceed to Stage 1 first. To do so, we make some assumptions about Stage 2 behavior, which we will then need to verify later when we return to analyze it.

II
Open Ownership:
Regulating the Purchase of Capacity rather than its Rental

the textbook case

First, we consider the textbook case of our markets where we impose open ownership, a rule designed to move the equilibrium outcome towards the zero-profit objective by breaking down barriers to entry, and thereby create an incentive to choose a capacity nearer the optimal level.

(1.a) *open ownership* — Any potential owner $i = 1,2,3,...$ can claim ε units of capacity if it pays the average fixed cost of the new total capacity $\mathbf{C}(k+\varepsilon)/(k+\varepsilon)$ for each unit of capacity.

This open ownership requirement is similar to the common carrier pricing requirements except that they apply to the purchase of capacity instead of its rental. Both attempt to limit economic profits to zero and to limit discrimination.

To analyze Stage 1, each owner and potential owner needs to anticipate the others' behavior in Stage 2. Here, we first assume that the choices in Stage 2 would yield the market-clearing price of $\mathbf{P}(k)$ for any given capacity of k chosen in Stage 1.

With this assumed behavior in Stage 2, open ownership must lead the owners to choose a total capacity that earns zero profit if potential entrants facing identical costs and market opportunities are present. Any equilibrium must yield zero profits because any positive profit leads to a larger capacity, as open ownership makes a small scale addition profitable, and any negative profit leads to a smaller capacity, as existing owners prefer to exit to avoid the losses.

The argument about small-scale entry, the addition of a small amount of capacity from someone outside the group of existing owners, is quite basic, but it drives much of our results. Assume that capacity k were chosen with positive profit. This means the average profit would be $\mathbf{P}(k) - \mathbf{C}(k)/k - c > 0$. With open ownership, any potential entrant could add ε capacity and earn $(\mathbf{P}(k+\varepsilon) - \mathbf{C}(k+\varepsilon)/(k+\varepsilon) - c) \cdot \varepsilon$, which must be positive with a small enough $\varepsilon > 0$ as the existing firms earn a positive profit, $\mathbf{P}$ is continuous, and $\mathbf{C}(k)/k$ declines. With a small enough $\varepsilon > 0$, the potential entrant could, at the least, earn an average profit arbitrarily close to the positive average profit that the existing owners earn. This argument shows that open ownership and efficient choices in Stage 2 would give a potential entrant the incentive to enter whenever the current owners earn a positive profit, so that such an outcome, with existing owners earning a positive profit, is not an equilibrium.

Also, as expected, if capacity k were chosen with negative profit, then any existing owner i would prefer to change k_i to zero to earn a profit of zero. In addition, if profit were zero, then the equilibrium capacity must exceed any capacity that would earn a positive profit, one where the demand curve lies above the average cost curve. Otherwise a firm could earn a positive profit by increasing total capacity to such a capacity. Together these arguments imply that if there were a potential entrant, the owners must in equilibrium earn zero profit and choose a total capacity that exceeds any capacity that yields a positive profit.

Thus, if Stage 2 does produce prices equal to $\mathbf{P}(k)$, then open ownership produces an outcome where a capacity k° is chosen where $\mathbf{P}(k^\circ)\cdot k^\circ - \mathbf{C}(k^\circ) - c\cdot k^\circ = 0$. This outcome is illustrated both in Figure 1, where the demand curve $\mathbf{D}$ intersects the long-run average cost curve at the capacity k° and the price $p^\circ = \mathbf{P}(k^\circ)$, and in Figure 2, where $\mathbf{D}$ intersects the short-run marginal cost curve at p°, a price just sufficient so that $(p^\circ - c)$ covers the average cost of capacity $\mathbf{C}(k^\circ)/k^\circ$.

Further, if we were to assume more generally that the average revenue that would be earned in Stage 2 for any given capacity $\mathbf{R}(k)/k$ is continuous, this argument still follows if we substitute $\mathbf{R}(k)/k$ within it for $\mathbf{P}(k)$. Thus, if the Stage 2 outcome does yield a continuous average revenue with a change in capacity, the equilibrium outcome must yield a zero profit. Potential entry now possible with open ownership drives profit for the active firms down to zero and increases capacity above any that would earn a positive profit.

To better understand open ownership, contrast the entry decision into a competitive joint venture to the one within a standard Cournot model. Say each active seller i in a Cournot model earns $\mathbf{P}(q)\cdot q_i$ - $\mathbf{C}(q_i)$ - $c\cdot q_i > 0$ where q_i is the quantity that seller i chooses and $q \equiv \Sigma_i q_i$. An outside potential entrant could add ε capacity, constructing its own individual facility, and earn ($\mathbf{P}(q+\varepsilon)$ - $\mathbf{C}(\varepsilon)/\varepsilon$ - c) · ε. With declining average cost, the average profit available to a small-scale entrant, one that cannot take advantage of any economies of scale, is substantially smaller than the average profit earned by the existing active firms. This smaller profit available to the potential entrant may, in fact, be negative. This would lead the potential entrant to choose not to enter, even though existing active firms were earning a positive profit. The difference here between the Cournot entry decision and the competitive joint venture entry decision is an entrant's access to an average cost of $\mathbf{C}(\varepsilon)/\varepsilon$, where a small scale entrant has a substantial disadvantage, versus an average cost of $\mathbf{C}(k+\varepsilon)/(k+\varepsilon)$, where it does not. (Figure 1 illustrates the high cost a Cournot entrant pays for a small-scale entry with new facilities, and the contrasting low cost that a new entrant to a competitive joint venture pays far down the average cost curve, sharing the industry-wide average cost.) Open ownership allows a small-scale entrant to take advantage of any economies of scale since the owners share common facilities, but a Cournot entrant cannot since it must construct separate facilities.

When considering possible applications, another important difference between a Cournot entry decision and a competitive joint venture decision is the number of potential entrants likely to be available that face the same costs as the existing firms. If new facilities must be constructed to enter the market, there may be relatively few firms not presently in the industry that face these same costs. Other potential entrants may, at least temporarily, face higher costs as they do not instantly have access to all industry know-how. By contrast, potential entrants in a competitive joint venture all instantly share the same production costs as all firms now in the industry. Conceivably, in a more general environment some potential entrants might face different marketing or transactions costs, but these are not industry specific and the cost-minimizing knowledge is widely held. In fact, if a difference were to exist, users, in particular, would likely face lower costs for the marketing and transactions to itself.

If the pool of potential entrants for a competitive joint venture were limited, all potential entrants would join the joint venture in an equilibrium and the argument above does not apply, because it is driven by the presence of a potential entrant. In this situation, the outcome depends upon the owners that have joined the competitive joint venture and their behavior. Gale (1994) shows for this textbook case that, as the number of owners increases, the outcome approaches the zero profit outcome described above.

We see the effect of this open ownership requirement is to reduce the cost of entry as far as we can go, given our short-run behavior, to increase the incentive to invest efficiently. We could not require a lower cost for entry, because if we did, all potential owners would want to wait and pay the lower investment costs available to later owners, resulting in no early owners and no project. Further, no owners have the incentive to voluntarily offer an outsider a lower cost of entry than open ownership requires,[4] and thus, open ownership would lead to a cost of capacity for each owner equal to the average cost. This outcome maximizes consumer plus producer surplus, our measure of welfare, if all consumers must face the same price and owners must earn a nonnegative profit.

short-run uncertainty

If we add short-run uncertainty to our market environment, as long as average expected revenues are continuous, our argument remains about potential entrants driving costs to zero and capacity above any quantity that would earn a positive profit.

long lives and overlapping vintages

With overlapping useful lives of production assets, the fixed costs for constructing the same level of total capacity at any point in time can vary depending upon capacity already in place. The technological options for constructing capacity, those that determine costs, clearly differ with different production assets in place. After initial assets are in place, the monopolist cannot now consider, say, a small increase in capacity at the same small increase in cost that it could have before any assets were in place. New assets that work with the existing assets in place are

4 Otherwise, each owner has an incentive to wait and be an outsider. If the existing owners were to make an offer below the existing average cost to someone else, say to a user with quite elastic demand, the expansion would decrease the average cost, and the existing owners would have to agree to pay more than this new average cost. Open ownership would then allow new owners to enter at the new average cost, with lower costs than the existing owners. Expansion continues until the new owners earn zero profits, while the existing owners earn negative profits.

now necessary, and they may require substantial costs for even a very small increase in capacity. At the same time, the average incremental costs of any additional capacity may still decline as capacity is added and otherwise have similar characteristics to the initial cost function. The new twist is that economies of scale may be present every time facilities are built, but with additional new facilities, average incremental costs may exceed the new total average costs.

With this new possibility, the existing open ownership rule may yield an expansion where its incremental cost exceeds its value, a clearly inefficient result. In such a situation, the open ownership rule should be generalized so that we can assure that new owners cover the incremental cost of any expansion under all market conditions. Now, substitute for (1.a):

(1.a)′ *open ownership* — Any potential owner can claim new capacity if it pays, for each unit of capacity, the greater of the average of the new total fixed cost or the average incremental fixed cost of the new capacity.

With this generalization, we can assure that, under all market conditions, existing owners are not hurt when an additional owner joins, and the new owner has the appropriate incentive to decide to join separately or when others are adding capacity.[5]

long-run uncertainty and irreversible investments with flexible timing

When irreversibility of investments along with some flexibility in timing investments are added, along with uncertain long-run demand, we have the environment described in Dixit and Pindyck (1994). As they show, economic costs include the options value lost when an investment is undertaken, as investing now prevents the possibility of modifying the investment choice later after new demand information is revealed and a better choice is then indicated. We return in the next section to examine a rule designed to reduce this options value.

common costs

If we add to the markets above the possibility of multiple services, concerns arise over common costs between these multiple services, costs that would be faced even if any one of the services were to be discontinued while others remained. The resulting problems from common costs with setting regulated prices, and the resulting regulatory costs that they add, are now relatively well understood within the literature.[6] Even though separate production facilities have a much lower pro-

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5 As it would with common carriage, if we add various vintages of production assets, we must also modify our calculations of the new total fixed cost. See the Appendix for further discussion.

6 See, for example, Baumol, Koehn, and Willig (1987).

portion of common costs than do multiple services, to avoid these regulatory costs, and reduce the cost of enforcing open ownership, we require:

(1.b) *common ownership* — Each owner has an undivided common interest in all of the competitive joint venture's facilities, or, if its facilities can be partitioned into zones with no significant economies of scope between zones, in each zone of its facilities.

Each owner then owns the rights to a specified percentage of the capacity of the system as a whole or in each zone; within such an area, different owners do not own different parts of the system, but share all of it. With this undivided common interest, each owner has the same opportunity to supply any service to any other customer as any other owner.

We require common ownership within each zone of the system, rather than the entire system, because some user owners may primarily be interested in services produced only from a relatively small part of the system, and restricting such a requirement to each zone of the system can more accurately capture the costs of the services these users desire while still efficiently isolating the effect. We don't go further and allow a single user total rights over specified assets, requiring common ownership instead, to blunt the incentive that a single owner of specified assets might have to bias operations in its favor.

asymmetric information

With a competitive joint venture, the regulator's duties for curbing market power are only to enforce the open ownership and competitive rules. (The regulator may remain to review safety and environmental effects of plans to expand capacity, as well.) Private incentives are insufficient to enforce these rules, so the regulator must. If the open ownership rules or the required competitive structure of the market for services limits the use of any market power, as they are intended to do, the owners would agree to eliminate them if they could.

If regulators had the same information about market conditions as those companies to be regulated, they could impose their choices at low cost. Nevertheless, asymmetric information is prevalent throughout monopoly industries, and this asymmetric information may make regulating these industries quite difficult and costly. If such an industry were operated as a competitive joint venture, the costs to enforce some of its rules would be virtually zero, while others could be substantial, depending upon market conditions. Importantly, as we will see later, the resulting regulatory costs for a competitive joint venture are below the regulatory costs associated with common carriage.

The cost of enforcing any rule depends upon the ease of detecting a violation and any costs associated with a response to any violations. Of the open ownership rules, the common ownership requirement, the estimation of incremental costs, and the estimation of average costs at the time of initial construction would all be easy to enforce, with the exception of calculating any appropriate options values. The rights to an undivided common interest in well-defined zones and the expenses incurred for current construction are both quite visible and clear. By contrast, costs necessary to estimate average cost when assets have different vintages, where some costs were incurred substantially before others, is more difficult. Factors not easily observed in the marketplace, such as appropriate economic depreciation, now become important, as they are in common carriage. Similarly, the real cost of the options value foregone when one is committed to a particular investment is difficult. This options value depends upon unobservable probabilities about when certain information is to be revealed and upon unobservable profit opportunities available at that time.

Further, and at least as important as the relatively low costs of enforcement described above, open ownership also provides opportunities to dramatically decrease any harm that any violations might cause to users. Open ownership allows each user to own capacity that it expects to use itself and suffer no cost disadvantage. If a user joins the competitive joint venture when enforcement costs are particularly low, say at the time of the initial investment, and then owns what it expects to use itself, then the market for services, and how well it performs, does not affect the provision of the bulk of the services that the user actually uses. In the extreme, when the user's demand is certain, the user is totally protected if it owns exactly what it uses. With uncertainty, for the user to end up ultimately with the amount it wishes, some re-allocation of available services is necessary from the market for services. Open ownership, then, may reduce the role of the formal market to one of fine-tuning the allocation of available services.

With this opportunity, we may re-interpret our two-stage model. The process where each user decides on the capacity it will own (Stage 1) can be seen as the primary "market" for allocating services to users. The sale of services to others that follows (Stage 2) is then a secondary market for allocating services to users. The better the primary market performs, the less the secondary market must.

III
Durable Assets and Long-run Uncertainty

As described in Dixit and Pindyk (1994), adding long-run uncertainty along with long-lived production assets, irreversible investments, and some flexibility in timing these investments creates the necessity of including among the costs of any investment the options value foregone when an investment is undertaken. To better understand the role of this options value within a competitive joint venture, consider the following example.

Say future demand may be either high or low, and the efficient capacity to construct is between the high and low levels. One set of alternatives is to construct capacity now, and possibly add more later. If the high demand were realized later, constructing at the low level initially would require an expensive addition, but with an intermediate level of investment initially, while it would "overbuild" capacity if the low level of demand is realized, only a relatively inexpensive addition would be necessary to satisfy the high demand. Another alternative is to delay construction until the high or low demand is realized, constructing the high capacity if high demand is realized and low capacity for low demand.

In this example, when considering when to invest, the owners must consider that open ownership leads to instantaneous entry and profits dropping to zero when new profit opportunities become apparent. With an intermediate level of capacity constructed initially, this means that once the demand uncertainty is resolved, owners would earn zero profits if the high demand were realized, because of a quick expansion spurred by entrants, and negative profits if the low demand were realized, because they would not earn revenues sufficient to cover the large fixed costs of the initial investment. Unless sufficient profits are earned prior to the demand uncertainty being resolved, this one-sided bet would lead these owners to choose an inefficiently low capacity.

This one-sided bet is avoided if the appropriate options value for delaying investment and gaining new information is incorporated as part of the cost calculations necessary to implement open ownership. Appropriately calculated, open ownership would then allow profits prior to the demand uncertainty being resolved that would be just sufficient to eliminate the one-sided bet. Unfortunately, these options values can be quite difficult to estimate in a regulated environment with asymmetric information. They depend critically upon the probabilities of different possible states of the world in the future and the profit opportunities that would then be available, both known much more clearly by the regulated firms than by the regulator.

An unusual aspect of these options-value costs is that they are not paid at the time of construction. They are opportunity costs that are "assessed" only as lost profit opportunities when later information indicates a different investment than the one constructed earlier would be optimal. This difference changes the penalty for underestimating this cost. With other costs, underestimating them may lead to inefficiently expanding capacity. If the regulator underestimates the options-value cost, however, informed potential entrants know this true cost anyway, and their entry decisions incorporate this known cost appropriately, eliminating the possibility of an inefficient entry by these entrants. Given this, one option for dealing with the options value is to not estimate it at all, and allow entry based upon costs that do not include it.

Another alternative approach is to alter the rules to reduce the uncertainty of possible profit streams that could be realized, and thereby reduce these options values and the regulatory costs to calculate them. We suggest the following alternative that raises profits in weak states of the world while leaving profits unchanged in strong states of the world:

(1.c) *owner-determined capacity* — The owners may, if all owners agree, set total owned capacity artificially below physical capacity, and each owner would then be limited to its new owned capacity. The owners pay all costs for any new estimates needed of average cost.

The effect of having owner-determined capacity, along with open ownership, is to avoid or at least reduce negative profits in many of the otherwise negative-profit states of the world. Reducing owned capacity moves the market price up the demand curve, which raises price and profit, often allowing the owners to avoid a negative profit, but reducing owned capacity so far as to expect a profit would invite new owners. A new owner could profitably claim capacity any time the existing owners choose owned-capacity constraints where the potential owner expects a profit. (To illustrate the effect of owner-determined capacity, the higher market-clearing price resulting from a smaller capacity can be seen in Figure 2 when one considers the adjustment to the weak demand $\mathbf{D'}$ with the reduction of capacity from k° to k and the increase of price from p° to p.)

Applied to the previous example, adding the owner-determined capacity rule can lead to market prices that yield zero profits at any point in time. Zero profits are earned, in the same manner as before, if high demand is realized and it generates the small expansion, but it can also if low demand is realized. With low demand realized, the owners may be able to choose to reduce total owned capacity to the point of zero profits henceforward. This new result with low demand, in turn, would lead to zero profits at the time of the initial investment, even with the "overbuilding" from the intermediate-sized investment. With this rule, there would be no options value in the initial investment. The important implication is that this rule allows owners to earn zero profits over the remaining life of the assets regardless of the time at which these assets are evaluated, and the options value for any investment would be eliminated.

Zero profits would be earned for much the same reasons as with open ownership. Say first that Stage 2 generates the continuous revenue $\mathbf{R}(k)$ for any capacity k in some future state of the world. Say further that this state generates losses ($\mathbf{R}(k^\circ) < \mathbf{C}(k^\circ)$) given the capacity k° that was actually constructed earlier. Now allow owners to choose a $k < k^\circ$ if they all agree and if they are all subject to open ownership.

These owners would not choose a new owned capacity k that generates positive profits where $\mathbf{R}(k) > \mathbf{C}(k^\circ)$. Otherwise, a potential entrant could choose some sufficiently small ε capacity and earn $(\mathbf{R}(k+\varepsilon)/(k+\varepsilon) - \mathbf{C}(k^\circ)/(k+\varepsilon) - c) \cdot \varepsilon > 0$, and k would be expanded. Open ownership allows this potential entrant a small ε capacity if it pays the average total cost that would now be calculated $\mathbf{C}(k^\circ)/(k+\varepsilon)$ for each unit of capacity. (The incremental cost of providing this capacity is zero.)

Each owner wants to reduce k as much as possible towards the revenue maximizing capacity without generating positive profits and losing capacity to an entrant. Thus, if a capacity exists that earns a nonnegative profit, the owners choose a k such that $\mathbf{R}(k) = \mathbf{C}(k^\circ)$, and if not, they choose a k that minimizes their losses. Also, as with open ownership without owner-determined capacities, if more than one zero-profit outcome exists, owners choose a quantity above all positive-profit quantities.

These are the effects of owner-determined capacity on the decisions of an owner that sells all of its capacity to others, one whose sole role is as a marketer. Owner-determined capacity affects an owner who is also a user of the competitive joint venture's services somewhat differently, and these effects restrict the equilibrium further.

The benefits a user owner earns from a competitive joint venture come from two sources. First, as with any owner, it receives the revenues that it earns from selling services to others. Second, unlike a marketer owner, it receives the value it gains from services kept and consumed for its own use. The value a user owner gains from its own use derives from its demand for these services, where its inverse demand function can be interpreted as describing the marginal value the user gains for each unit of these services that it uses. If we reinterpret Figure 2 to illustrate the user-owner's short-term decision, we could illustrate the total value a user owner gains from k services for its own use by the area under its demand curve up to the quantity k, and the revenue from selling to others by the area $p^\circ \cdot (k^\circ - k)$, where p° is the market price and k° is the total capacity that the user owns. The net benefit that a user would gain from owning capacity in a competitive joint venture is the difference between these benefits and its cost of participating, which would be the average cost times the capacity to be owned.

One observation follows immediately. Each user prefers to own, at a minimum, the capacity necessary to provide any services that would be valued above average cost in the weak state of the world. Otherwise, it would lose that value above the average cost if owners reduce their owned capacity and raise the price this user must pay. This means the highest valued portion of the demand curve is withdrawn from the secondary market, as the user protects this capacity from the owners' higher prices.

Further, unlike a marketer, a user owner can guarantee itself the net benefit indicated by the area under its demand curve up to k° and above the operating cost c. This means that if any restriction to its capacity is to be accepted, higher revenues that it receives from a restricted capacity must exceed any lost value it would have gained from its own use otherwise, in addition to lost revenues that it would have earned with the larger capacity by selling to others. Any restriction of capacity in a weak state of the world would come from capacity that might be used to sell services to others, not from capacity that would always be kept for the owner's use.

Now consider two proposed projects, one smaller than the other. With uncertain long-term demand, users typically join either project, but tend to take a larger capacity in the larger project. The average cost is lower in the larger project, so that a typical user wants to protect a larger capacity that can provide services it now values above average cost in the weak state of the world. This removes more capacity from the secondary market, and increases the capacity reductions marketers must make for any given increase in revenues. As a result, the extra capacity in the larger project reduces the revenues that may be gained by restricting capacity. The extra capacity not only increases cost, it decreases the revenues that can be regained by restricting capacity, and furthermore, marketers must decrease their capacities disproportionately, so that marketers face a disproportionate loss in the weak state. Marketers, or users that own capacity beyond their demand and are also selling to others, are at greater risk than users that own only capacity that they keep for their own use.

Given these incentives from potential entrants, if the worst state of the world that could be revealed after an investment is one in which capacity could be reduced to avoid any losses, then having owner-determined capacity may eliminate any options value for this investment. Even with uncertain demand, regardless of the state of the world finally realized, the owner will earn zero profit. If not all losses can be avoided in the weak state of the world, then marketers expand to the point of zero profits overall, which allows some positive profit in the period before the uncertainty is resolved to balance the possible loss in the weak state.[7]

We should note that this rule that allows owners to change capacity in response to unexpected changes in long-run demand or costs also allows them to change capacity in response to expected changes in demand or costs. In particular, if demand is expected to be cyclic, with peak and off-peak periods, owners may choose to have different capacities in different seasons. For example, owners may choose the full physical capacity in the expected peak period but a lower capacity in the expected off-peak period, which would then see a higher ceiling price with discriminatory pricing below it. Again, owners cannot choose capacities that generate positive profits overall without also generating entry, and restricting capacities in off-peak periods, with the attendant price increases, leads users to own a capacity sufficient to provide services that they expect to use in off-peak periods. Further, with the higher profits that marketers may earn and the higher values user-owners may gain in the off-peak periods, zero profits would now be earned with a larger, more efficient physical capacity.

In addition to the benefits from reducing the opportunity cost of an investment due to its options value, this rule is offered, along with a modification to a competitive rule, for a second purpose as well. This tandem of changes allows extra profits to be earned in weak states of the world using price discrimination that has been found to be acceptable within a common carriage setting. With open ownership these extra profits lead to a greater, more efficient initial capacity.[8]

collusion

One potential concern from allowing owners to jointly choose capacity, even with open ownership, is the possibility of collusion. Nevertheless, this argument that open ownership leads potential entrants to drive profits to zero has equal force if a repeated-game collusion model were constructed. Since potential entrants earn zero profits already, owners have no punishment strategies with which to threaten potential entrants and keep them out. If a positive profit were being earned from a collusive outcome, a user can always purchase a small capacity and use it for its own use: other owners could not reduce this value to the new owner after it entered. A marketer, too, cannot be made to lose by rival owners, since the worst case is for the rivals to increase their capacity to the point of negative profits, but this results with some of this increased capacity being supplied by the recent entrant as

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7 See the Appendix for further discussion of owner-determined capacity. The elimination or reduction of options values is revisited when Stage 2 is examined in the next section, as some rules for Stage 2 can reduce resulting options values more than others.

8 See the next section, especially its subsection on long-run uncertainty, for further discussion.

it exits. In any event, even in a collusion model, if existing owners earn a positive profit, there is an incentive for capacity to increase and profit to fall.

IV
Towards Efficient Short-run Behavior with a Competitive Joint Venture

In this section, we return to the secondary market in Stage 2 of our model to examine behavior within it more carefully. To complete our competitive joint venture, we introduce three competitive rules, each intended to promote the efficient use of existing capacity. We find that these rules tend to produce an efficient outcome in the short run.

the textbook case

If, as with most joint ventures, only one company marketed the output from the capacity of the single facility of a competitive joint venture, the standard monopoly outcome would result in Stage 2 of this market. By contrast, we may achieve a more efficient outcome than with a monopoly marketer if we establish incentives for the joint owners to compete with each other.

To introduce some competition, we impose a competitive rule that separates production and marketing, and creates competition between the owners:

(2.a) *independent marketing* — Each owner i independently sells the services it may obtain from its capacity k_i. Owner i pays the operator its share of the variable cost for these services $c \cdot q_i$.

Independent marketing requires not only the structural independence of the marketers, but also operating rules that minimize the flow of marketing information between owners, including information passed through the operator.

Removing the marketing function from the joint venture and requiring it to be done independently transforms the market outcome at this stage from a monopoly outcome to a standard oligopoly outcome with the same number of firms as there are owners. The expectation now, even if no other rules were imposed, is that if enough owners share the facilities, Stage 2 would achieve an outcome at least close to the competitive outcome.

Our textbook market environment is quite like that described in Davidson and Deneckere (1986). They, too, have a two-stage model, where capacities are chosen in the first stage, and the quantity of services to be produced and sold from these capacities, and their prices, are chosen in the second stage. As their arguments clearly demonstrate for our markets, the specific outcome depends upon details such as the residual demand that remains for a seller not offering the lowest price. A mixed-strategy Edgeworth outcome more efficient than the Cournot outcome is typical. Their arguments also clearly demonstrate that revenue is continuous with respect to changes in capacity.[9]

As a further inducement to compete, we also require:

(2.b) *use or lose* — Any owner's capacity not used to provide output is made available to other owners to use or sell.

The use-or-lose condition allows a seller access to more capacity than it would have access to otherwise, especially when some seller attempts to withhold capacity. If one owner were to attempt to withhold capacity from the market, the other owners and the operator now have the option of selling services from it. The arguments in Gale (1994) demonstrate that, for our textbook case, these opportunities from a use-or-lose rule eliminate incentives to withhold any quantities from the market below the total quantity owned, improving the efficiency of the resulting outcome. Any withholding of capacity that occurs within a mixed-strategy outcome is eliminated with a use-or-lose rule, and the secondary market in Stage 2 does indeed yield prices equal to $\mathbf{P}(k)$. With this rule, owners have the incentive to assure that all capacity is used or sold in the secondary market.[10]

short-run demand uncertainty

Adding uncertain demand in the short run does not affect the efficient behavior in the short run. The secondary market establishes its prices at the time of consumption *after* any uncertainty has been resolved. (Figure 2 illustrates the market-clearing prices achieved in the short run for various realizations of demand.) We will see in the next section, by contrast, that the common carriage regulator must determine prices *before* any uncertainty is resolved and the result is generally inefficient.

One effect that adding short-run uncertainty may have in the secondary market is reducing the need for the use-or-lose rule. If realized demand is high enough, capacity is so restricted that an otherwise-inefficient oligopoly price now may be efficient, and if realized demand is low enough, any incentive to withhold capacity may disappear, because if it did, rivals could satisfy any unmet demand from their existing excess capacity.[11]

The framework and conclusions that could be developed for markets with short-run uncertainty also would apply if, instead of short-run uncertainty, the short run consisted of several periods in which demand varied deterministically. In

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9 See the Appendix for further discussion of independent marketing.

10 See the Appendix for further discussion of the use-or-lose rule.

11 These results are described in Davidson and Deneckere (1994).

particular, they would apply if demand were cyclic, as it is for many industries with natural monopoly characteristics, as weather often drives demand in these industries. With this interpretation, that is, if demand is cyclic, the two situations described above where a use-or-lose rule is not necessary become more likely.

long lives and overlapping vintages

Prices determined in the short run track changes in demand whatever their cause, including growth in the long run. If demand grew, for example, short-run prices would start low and, once all the capacity were demanded, increase as demand grew further. Similarly, if demand withered, short-run prices would start high and then fall with demand.

One problem may arise with long lives and uncertain demand. Owners that sell rights to future services may not time these sales optimally. A use-or-lose rule can only apply to services sold and then used in the same period; one cannot identify future services that may eventually be unused until they are to be used. Thus, while the efficient quantity of services may be used when that time comes, future price risks may not be distributed optimally. Two factors ameliorate this concern. First, given the incentives for entry, especially for users, a large number of owners are expected. Even delaying the sale of future rights is difficult if several owners have them available. Second, the long lives and uncertain demand make the high or low demand situation discussed earlier even more likely, so that efficient outcomes occur without a use-or-lose rule.

long-run uncertainty and irreversible investments with flexible timing

With long-run demand uncertainty, to reduce the options value in any investment, we have added the possibility that owners may reduce their owned capacity below actual physical capacity. With this owner-determined capacity rule, to prevent inefficient use of all available physical capacity, we substitute for (2.b):

(2.b)′ *use or lose* — Any owner’s capacity not used to provide output is made available to other owners to use or sell. Any physical capacity not used to provide output is made available to the operator to sell.

This option for the operator avoids the situation where all owned capacity is used but more capacity is available and some users have unserved demand for services valued more than the operating cost. With this option, the operator, the only one that may sell services from physical capacity beyond the owned capacity, has the incentive to sell any remaining physical capacity, and as the only remaining seller, it may discriminate among any unserved buyers. If it can perfectly price discriminate, it can capture any unearned surplus below the market clearing price for the total owned capacity and above the operating cost. With this rule change, all available physical capacity that can provide services valued above their marginal cost is used, though with price discrimination below the price established by the owners in the secondary market. (Figure 2 illustrates this outcome with demand **D′**.) Thus, this rule change preserves an efficient secondary market when physical capacity exceeds the total capacity owned by all owners.

Another consequence of allowing this price discriminating operator, and the resulting extra profits from the operator's sales distributed to the owners, is that owners choose to reduce owned capacity less than without it. Because of the extra profits from the operator, owners can regain a zero profit with a higher capacity or earn profits closer to zero than would be possible otherwise. Thus, this rule change eliminates or reduces options values more often, since it raises profits for low performing states of the world. More low performing states of the world can now reach zero profits, and even those that still cannot, the losses are reduced.

This modification of the use-or-lose rule is really offered in tandem with the owner-determined capacity rule. One intention for offering this tandem of rule modifications is to gain the efficiency benefits of price discrimination that has been seen to be acceptably within the necessary, but not well-defined limits on price discrimination. The extra profits now possible due to price discrimination in the weak states of the world and in foreseen off-peak periods with cyclic demand lead, along with open ownership, to the construction of larger, more efficient capacity choices. This is expected to be the primary efficiency benefit from this tandem of rule modifications.

common costs

Having user-owners, along with the provision of multiple services, reveals another potential problem. An owner, or a small group of owners, that controls the operator may have the incentive to use operating information that the owners cannot easily verify to set operating rules that favor them and disadvantage others. For example, the operator may tell an owner that a particular service, one that competes with a service offered by another owner who controls the operating rules, cannot be offered at that time for technical reasons difficult to verify. To reduce this problem, we require:

(2.c) *independent operator* — The operator is independent of any individual user, or any subgroup of users, and it is charged to act neutrally with respect to all owners.

The objective is to not let any individual user, or any subgroup of users, control the operator to the disadvantage of any owners. If any owner felt that operations were biased, it would have the ability to initiate an investigation by the regulator, and have the operating rules changed if necessary.

asymmetric information

Enforcing the independent marketing and use-or-lose rules are easy. The owners' organizational structures necessary to implement them and the current operating costs are easy to observe.

Enforcing the independent operator rule should be easy for typical competitive joint ventures, but it may be difficult for others. Having an independent operator is a natural result, and easy to enforce, if no owner has a dominant share of capacity, and, thus, a dominant share of votes on a Board of Directors responsible for approving operating rules for the competitive joint venture. This is expected as the usual situation because of the strong incentives for users to become owners. On the other hand, a single owner, or a small group of owners, with majority control over a Board may have an incentive to set rules that disadvantage others. In this situation, the regulator may need to review detailed operating rules and the procedures for their approval. Such a review is not likely to be necessary unless an owner outside such a majority group complains.

Further, collusion cannot be supported because open ownership eliminates any barriers to entry.

V
A Sketch of Common Carriage

To better understand where some problems with common carriage develop, we will now sketch an analysis of common carriage within the same series of markets that we have considered previously, adding complicating market characteristics incrementally.

the textbook case

The objective of the common carriage regulator is to establish minimal prices that allow the monopolist a nonnegative profit and that limit price discrimination. In the textbook case, it both chooses the smallest single price $p°$ that allows a nonnegative profit for the monopolist and obligates the monopolist to serve all market demand at that price. The regulator imposes the "obligation to serve" to prevent the monopolist from attaining the monopoly outcome by choosing the monopoly level of capacity. Thus, consumers demand $\mathbf{D}(p°)$, the monopolist provides $k° = \mathbf{D}(p°)$, and the regulator chooses the smallest $p°$ such that $(p°\text{-}c)\cdot\mathbf{D}(p°) = \mathbf{C}(k°)$. Together, this means $p° = \mathbf{C}(k°)/k° + c$. This outcome is illustrated both in Figure 1, where the demand curve $\mathbf{D}$ intersects the long-run average cost curve at the price $p°$ and capacity $k°$, and in Figure 2, where **D** intersects the short-run marginal cost curve at $p°$, a price just sufficient so that ($p°$-c) covers the average cost of capacity.

For this textbook case, the outcome is efficient among those where all consumers face the same price and the firm earns a nonnegative profit. Unfortunately, the textbook case omits some important market characteristics for markets where common carriage is actually applied, and common carriage outcomes do not perform as well with these features included.

short-run demand uncertainty

One important characteristic is demand uncertainty in the short run at the time when capacities and regulated prices must be chosen under common carriage. To include this in our model, demand in Stage 2 is now given by **D**(p)+w, where w (generically thought of as "weather") is a random variable whose expected value is zero. The cost and time of the regulatory process requires that the regulator must choose the regulated price, and implicitly set the capacity, in Stage 1 when w is uncertain, even though w is realized in Stage 2.

With this uncertain demand, in Stage 1 the regulator chooses the smallest $p°$ that allows a nonnegative expected profit and the monopolist faces an obligation to serve, and in Stage 2 consumers demand **D**($p°$)+w. The obligation-to-serve requirement is often not well defined with this uncertainty. It surely requires at least a capacity sufficient to cover expected demand **D**($p°$), and may require a larger capacity determined on a political basis. The obligation to serve generally does not require capacity sufficient to cover all possible realizations of demand.

Thus, depending upon the capacity k constructed in Stage 1 and the realization of w in Stage 2, all consumer demand might not be satisfied with the capacity available. Whatever the obligation to serve might require, the outcome is generally inefficient. The regulated price chosen in Stage 1 is unlikely to be the efficient single price within Stage 2 for any realization of demand. In the short run, the services that can be produced are either not produced at an efficient level or they are not allocated to those consumers that value them most highly. These observations are illustrated in Figure 2.

For some realizations of demand, such as in Figure 2 where w' or w'' is realized, the regulated price is above an efficient price for the short run, so that some capacity valued above the variable cost would go unused during those periods. The quantity of services produced is inefficiently low. These instances of excess capacity at $p°$ can be called "off peak" periods. For other realizations, such as with w''', the regulated price is below an efficient price, so that excess demand exists for them, which would require a non-price rationing mechanism, and its outcomes are highly unlikely to allocate available services to the highest valued uses in this "peak" period.[12] With any non-price rationing mechanism, some consumer is likely to obtain services for a use whose value exceeds p° but falls below the market-clearing price, and for each such purchase, some other consumer has unserved desires with a use whose value exceeds the market-clearing price. This allocation of services is inefficient. The remaining possibility, an outcome where the amount demanded at p° exactly equals k, would be efficient in the short run. Unfortunately, this outcome can have zero, or near zero, probability.

As an alternative, the price discrimination constraint could be defined with a second, more refined interpretation. Discrimination may not be seen as undue if no consumer is worse off than with no discrimination. Specifically, the monopolist may be able to price discriminate below a regulated price ceiling such that no consumer is worse off. Such discounting under a regulated price ceiling is often an acceptable form of price discrimination, and may not trigger findings of "undue" or "unreasonable" discrimination, which are usual statutory requirements.

The more refined version of common carriage that only prevents undue discrimination does perform better. For those periods where unused capacity is available, the regulator allows the firm to sell services at prices discounted below p° for whatever it can earn. The regulator might also in the process decrease the regulated price ceiling in Stage 1 to "share" the new earnings with other customers. The effect of allowing this discounting is that, if the monopolist can perfectly price discriminate, it eliminates the short-run inefficiency during the off-peak periods where excess capacity would otherwise exist. Of course, the inefficiencies in the peak periods from the use of a non-price rationing mechanism remain.[13]

Here, too, any framework or conclusions that we could develop for these markets with short-run uncertainty would also apply to markets with multiple periods in the short run where demand varied deterministically. At the regulated price, peak periods have excess demand and off-peak periods have excess supply.

If we interpret the short run as having multiple periods, the institutions of common carriage might also adapt to the uncertainty by adopting long-term contracts. Consumers in actual markets with natural monopoly characteristics often purchase services continuously from the monopolist, which allows this possibility. With pervasive long-term contracts, the obligation to serve is defined more naturally to require the monopolist to produce any capacity that consumers are willing to put under a long-term contract. Now, the consumer chooses a capacity to put under

12 In this paper, common carriage does not necessarily imply prorata rationing with excess demand, as some forms of common carriage do.

13 See the Appendix for further discussion of common carriage and short-run uncertainty.

long-term contract in Stage 1, with a charge for the capacity reserved, and it chooses the services to use from this capacity in Stage 2, with charges for the services actually used. Second, the consumer's choices in Stage 2 may provide some of the short-run efficiency benefits of price discrimination. Further, the monopolist may also sell services from unused capacity on an as-needed basis in Stage 2, and if only undue discrimination is to be prevented, the monopolist may be allowed to offer discounts below some price ceiling.

This form of common carriage may share a number of features with a competitive joint venture. If contract holders have the right to sell services from their capacity, the long-term contract, in effect, may offer rights similar to those of ownership, especially as "long term" approaches the life of the assets. In addition, the resulting secondary market may look much like the short run described in this paper for a competitive joint venture, especially if it includes independent marketing and the operator selling services from unused capacity. Not all features are shared, though, as no counterpart to open ownership exists. Prices to reserve capacity are not set at the time of contracting, but are reset in the future and, thus, remain uncertain. Further, while anyone can reserve capacity not currently under contract at the regulated prices (and terms), no one has the right to initiate new construction that melds with the old. Also, without the safeguards that open ownership provides, the right to resell capacity rights may be constrained with a price cap, so that the inefficiency with excess demand during peak periods remains.

In practice, relatively few markets have this form of common carriage regulation with long-term contracts and the right to resell capacity rights, but they do include markets for U.S. interstate pipeline transportation for natural gas.[14]

long lives and overlapping vintages

With overlapping vintages of production assets, the regulator with the same basic objectives must now choose when to set prices (effectively, when to have "rate hearings"), and how revenues should be split across time periods (effectively, a "depreciation policy"). In actual application, common carriage regulators sometimes set prices only when investment occurs, sometimes they add hearings whenever the regulated firm calls for new rates, and sometimes prices are set at regular intervals. Depreciation policy usually is constrained so that regulated prices stay constant between rate hearings.[15]

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14 See the discussion for Spyder Pipeline in Section VI for an application of a competitive joint venture that starts with this form of common carriage.

15 See the Appendix for further discussion of rate hearings and depreciation in common carriage with overlapping vintages of durable production assets.

In this environment, inefficient expansions can occur when the average incremental cost of the expansion exceeds the old average cost, because now the value of new uses may not cover their incremental cost. These inefficient expansions can occur because, while the regulated price rises for all consumers after the expansion, the new regulated price is based upon the new average cost, and the incremental revenues from new capacity may not cover its incremental cost. Common carriage regulators often object to alternatives where incremental revenues are guaranteed to cover incremental costs, because generated revenues could exceed the total cost or prices for the same services could differ to different consumers.

Those versions of common carriage that allow secondary markets operate more efficiently than those that do not, but these secondary markets may not operate efficiently for rights to future services. The operator cannot sell unsold future services before they are to be used, and without these sales, the outcome is almost surely inefficient.

long-run uncertainty and irreversible investments with flexible timing

When options values are part of an investor's costs, the common carriage regulator, in practice, does not incorporate any options value component of cost directly, but it may indirectly as it incorporates a premium within the rate of return for assuming risk. It also often significantly reduces the options values, and risk, by protecting profits if demand is lower than expected with an increase of the regulated prices for capacity already in place. If a new rate hearing is held, regulators tend to respond to this lower demand by increasing regulated prices so that the smaller quantity of services actually served now covers the costs for all capacity constructed, not the lower capacity revealed to be needed now.

common costs

Allowing multiple services from the single set of production assets often leads to an expensive regulatory process for allocating common costs. An efficiency consequence is the provision of a restricted menu of services to the monopolist's customers. Some potential services cannot provide enough additional revenue to cover the additional regulatory costs for approval.

asymmetric information

Adding asymmetric information can dramatically decrease the performance and increase the cost of regulation. The literature concerned with this asymmetry within common carriage, and the attempts at constructing "incentive regulation" to deal with the regulator's principle-agent problem in gaining appropriate information from the monopolist, is relatively well developed.[16] A generic result from this literature is that regulators end up setting prices that allow the monopolist to profit from the informational asymmetry to yield better information for the regulator. One form this may take is allowing a generous rate of return, which in turn leads to the long-known inefficiency from the incentive to "gold plate" production assets, over-investing in capital relative to other inputs.

The combination of asymmetric information along with long-run uncertainty and long-lived assets leads to inefficiencies from several sources. One consequence is the high direct cost for regulating with common carriage. High regulatory costs are paid with common carriage to deal with rate of return and depreciation issues, in particular. This would be inefficient if we could find an alternative regulatory regime that reduces these costs while achieving the regulatory objectives.

Other inefficiencies stem from changes in behavior due to these high regulatory costs. One example is the regulator's inefficient response to varying demand or costs. If the regulator were to allow regulated prices to vary with demand and costs, and have a depreciation policy to match, the outcome could be more efficient. Prices could more closely follow efficient prices. Greater, more efficient capacities could be constructed that still earned zero profits, sometimes even with current demand below the proposed capacity. It could prevent investments to replace over-depreciated but still useful assets, investments undertaken solely to raise the regulated rates closer to their efficient levels. Nevertheless, to do so would require knowledge of both the changing market-clearing price over time as demand varies plus the timing and cost of the next capacity expansion, knowledge much more likely to be with the regulated monopolist and not the regulator. To avoid the regulatory costs due to raising these issues, the common carriage regulator typically does not change rates in response to changes in demand or costs, with the exception of raising rates at a rate hearing when long-run demand is lower than expected. Generally, rates are to be constant between rate hearings,[17] and, even after an intervening rate hearing, rates are not to rise if demand or future costs increase, even though this, in turn, would increase the underlying value of the existing assets.

Another example is the use of historical costs to estimate costs rather than current economic costs. Historical costs are easy to observe, but current economic costs may not be, especially for investments not currently being made. While at-

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16 For a view into this literature, see Laffont and Tirole (1993) and Baron (1988).

17 An exception is the incentive regulation used for U.K. telecommunications, where a ceiling on regulated rates falls by an adopted percentage each year due to expected technological change.

tempts have been made to use current economic costs,[18] and there has long been agreement that they would be appropriate if available, historical costs are usually used instead due to the lower regulatory costs in using them. Over time, resulting rates can then have little relation to those that would result with economic costs. Rates are often inefficient in the short run and offer no reliable market signal for the value of any future investment.

VI
Common Carriage versus Competitive Joint Ventures

In this section, to compare the two regulatory approaches, we pull together conclusions reached earlier about the performance of common carriage and competitive joint ventures.

the textbook case

Both common carriage and a competitive joint venture produce investments that yield zero profits and prices that equal the average cost of producing the services for all customers, which is the efficient outcome among those that require no price discrimination and firms that earn non-negative profits.

short-run uncertainty

With uncertain short-run demand, common carriage inefficiently uses existing capacity. When the market-clearing price exceeds the regulated price, common carriage constrains the monopolist to charge all users the regulated price. A non-price rationing mechanism is then needed to allocate services with the resulting excess demand. With a market-clearing price below the regulated price, the monopolist charges the regulated price for those services demanded at that price, and excess capacity results. If price discrimination is allowed, the monopolist then perfectly price discriminates among customers with any remaining demand. It offers services to those with the highest value first until either capacity is exhausted or the value drops below the operating cost, and it charges customer-specific prices that recover all of the customer's value for these services. This price discrimination eliminates the short-run inefficiency that occurs with the excess capacity otherwise.

Common carriage, thus, produces markets that do not adjust well when underlying market conditions are uncertain and change. Further, contentious issues arise for the regulator that deal with a non-price rationing mechanism necessary whenever the regulated price is below the market-clearing price.

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[18] An example is the attempt to use forward-looking costs for setting rates for various components of the telecommunications network in response to the U.S. Telecommunications Act of 1996.

With potential entrants present, a competitive joint venture yields efficient secondary markets, regardless of any changes in underlying market conditions since the last investment. This market efficiently follows the path of underlying market conditions as they change. Competition between owners independently selling output in the secondary market, along with the use-or-lose threat, is sufficient to generate an efficient outcome in the short run.

With these outcomes, both a competitive joint venture and common carriage lead to zero expected profits. Nevertheless, since these profits are earned differently in the secondary markets, with a competitive joint venture earning more in peak periods with its higher peak prices and common carriage earning more in off-peak periods with greater price discrimination, the zero-profit capacities ultimately chosen may differ.

Allowing owners to determine capacity regains, for weak states of the world and foreseen off-peak periods, the benefits of price discrimination gained under common carriage. These benefits lead to larger, more efficient capacity choices for the competitive joint venture than otherwise. Also, when compared to common carriage, in the short run, the competitive joint venture earns higher profits in peak periods, earns the same benefits in foreseen off-peak periods, and faces lower profits only in unforeseen off-peak periods.

long lives and overlapping vintages

With overlapping vintages of production assets, common carriage may lead to investments in capacity whose value does not cover its incremental cost, but a competitive joint venture does not. Common carriage establishes rates based upon average costs that may not cover the incremental cost of the expansion, so that its value to users may not reach its incremental cost. Such inefficiency is avoided with a competitive joint venture, where open ownership requires prices for any expansion to cover incremental cost. This price behavior with a competitive joint venture also provides a price signal, one unavailable under common carriage, that more accurately measures the value of capacity, and in turn, can itself improve entry decisions.

long-run uncertainty and irreversible investments with flexible timing

Another observation made of common carriage, where it performs differently than a competitive market, is that lower-than-expected demand growth can increase regulated prices for capacity already in place. To an extent, even though user owners mute the effect, a competitive joint venture with owner-determined capacity does the same. In our competitive joint venture rules, as does common carriage, we trade off consumers bearing risk about future uncertain demand for reducing regulatory costs by eliminating the options value component of cost. In each regulatory regime, the market response to a lower-than-expected demand is a higher ceiling price with price discrimination below it.

Also, both a competitive joint venture and common carriage gain efficiencies from this price discrimination below a price ceiling. These higher profits with weak demand allow a greater, more efficient initial capacity choice. This effect is exploited further, though, with a competitive joint venture when demand is expected to be cyclic. The competitive joint venture encourages owners to adjust the capacity they own in different seasons, these adjustments generate greater profits in the off-peak seasons, and with open ownership, they generate a greater initial capacity choice. With common carriage, seasonal pricing is often discussed, but rarely implemented because of the difficulty of its implementation.

common costs

The regulatory costs that develop with common carriage often lead to a restricted menu of services because of the regulatory costs of dealing with more services. In a competitive joint venture, by contrast, owners have incentives to provide an efficient menu of services since no regulatory approval is necessary to offer any particular service. Each owner can offer any portfolio of services that it wishes from its capacity. Common costs between services, which lead to high regulatory costs with common carriage, are not an issue for a competitive joint venture regulator.

asymmetric information

With asymmetric information, the role of the regulator is quite different with a competitive joint venture than under common carriage.

First, open ownership provides users opportunities to protect themselves with virtually no regulatory costs. A user can join the competitive joint venture when enforcement costs are particularly low and own what it expects to use itself. This alone drastically decreases the scope of any potential harm. It also reduces the user's incentive to challenge the regulator's choices, which itself reduces regulatory costs.

Second, when compared to common carriage, competitive joint ventures reduce any information asymmetries. Within these two regulatory regimes, private parties have quite different incentives for presenting cost information to the regulator. While existing owners of a competitive joint venture have an incentive to over-estimate competitive joint venture costs, as would a single regulated firm under common carriage, potential owners that open ownership creates, some with good cost information of their own, have an opposing incentive to under-estimate these same costs. Instead of one informed and biased party interacting with a relatively uninformed regulator, a competitive joint venture provides several informed parties, some with opposing biases, interacting with the regulator. Incentives are greatly reduced for the regulator to "pay" for appropriate market information.

Third, a number of contentious issues under common carriage largely disappear with a competitive joint venture. One is the concern over the appropriate rate of return. As with common carriage, the options value component of risk has been reduced, if not eliminated, but other risks faced in common carriage disappear with a competitive joint venture. In common carriage, the regulated monopolist faces a risk from the remaining uncertainty in future regulated rates. By contrast, in a competitive joint venture, because capacity is owned for its life and the owner is to pay the price of the capacity now, the owners face no risk of the regulator reassessing the value of existing capacity and changing the value of the future profit stream.

Similarly, depreciation issues, determining the time path of revenues coming from this capacity, whether, for example, revenues are front- or back-loaded, become much easier because capacity is owned for its life with a competitive joint venture. The issue of depreciation either disappears entirely or is needed only for large blocks of time, not the quite small ones necessary when this capacity is rented. The regulator needs to assess depreciation only at the time of a new investment if the new average cost may exceed the average incremental cost of a new investment, and when it does need to consider depreciation, it does not need to determine depreciation for each moment in time, as is necessary in common carriage, but only for the difference in value since the last investment.

Further, allocating common costs across services is completely absent. Since assets are owned in common, all owners have the same opportunity to use or sell any service mix, so that this allocation process is not needed.

The result of these differences in the role of the regulator is that enforcing the rules of a competitive joint venture is easier than implementing common carriage. Of the competitive rules for the secondary market, the independent marketing and use-or-lose requirements are nearly costless to enforce. Assuring an independent operator is usually expected to be easy, but under some market conditions, it could be more difficult, giving us one exceptional task not addressed in common carriage. These rules alone lead to efficient performance in the short run and virtually no regulatory costs with a competitive joint venture, while with common carriage, inefficiency in the short run is pervasive and regulatory costs are substantial.

Of the open ownership rules, the estimation of incremental costs, the estimation of average costs at the time of initial construction, and the common ownership requirement are virtually costless to enforce. These rules alone create efficient incentives for an initial investment or for an efficiently-sized investment later, once the first investor has its information to decide to invest. Once the first investor decides to invest, these rules give everyone else appropriate incentives to expand sufficiently to assure an efficiently-sized investment. A competitive joint venture yields this efficiency with virtually no extra regulatory costs, while for common carriage inefficient capacity choices are common and extra regulatory costs necessary to deal with the size of an expansion are often substantial.

If the regulator must estimate average cost, because a new investment may have a new average cost that exceeds the average incremental cost, assessing this cost is more difficult. Even so, estimating this average cost raises no new issues over those already addressed in common carriage, and for the reasons discussed above, this estimation is easier with a competitive joint venture than in common carriage. For these situations, the regulatory costs necessary to enforce competitive joint ventures rules may be substantial, but at the same time, the regulatory costs necessary to implement common carriage in these same situations would be even larger.

In general, not only are direct regulatory costs reduced with a competitive joint venture, behavioral responses to these regulatory costs are more efficient. Importantly, market prices automatically adjust with varying demand or costs. Short-run prices remain efficient. Greater capacities can be constructed while earning zero profits when growth is expected because owners envision rates efficiently varying over time between investments. No still-useful assets are inefficiently retired. Further, the need to use historical costs is reduced. Costs need not be reassessed after an investment to set rental rates for services, as with common carriage, but only to set a purchase price at the time of an investment, and then, not for an initial investment or when incremental cost is appropriate. To the extent historical costs might be used at all, these same situations would lead to their use in common carriage.

VII
Two Applications to Natural Gas Pipelines

Now consider U.S. interstate natural gas pipelines as a potential application for a competitive joint venture. Pipelines exhibit a natural monopoly characteristic of declining average cost: if the volume to be transported were set to match the design capacity of a pipeline, the average cost of transporting gas falls as the volume transported increases.[19] The greatest costs for pipeline transportation are fixed costs for pipeline, right of way, and installation; variable costs for fuel and operations are relatively small. Pipelines are also quite long lived, sunk costs are substantial, and like many durable assets, investment costs for new pipeline capacity depend upon capacity that already exists. Demand uncertainty is a prominent characteristic for pipelines, both in the short term, primarily due to the weather's effect on the primary use of gas for heating and cooling, and in the long term, especially from electric generators and industrials. And pipelines can offer multiple services, with varying origins and destinations, and varying levels of reliability.

These pipelines now have their rates set directly by the Federal Energy Regulatory Commission (FERC) using a cost-of-service methodology. The FERC is required to find that rates are "just and reasonable" and "not unduly discriminatory." After its transition to "open access," the FERC has adopted common carriage-type requirements for transportation services now required to be unbundled from the natural gas itself.[20]

A primary market for natural gas transportation is established with long-term contracts between pipelines and their customers. Such a contract, called a service agreement, specifies a maximum daily quantity the customer is entitled to claim, the "contract demand." The service provided from such a contract is a non-interruptible or "firm" service. Service agreements do not specify pricing; the FERC is to set the prices to be used. A secondary market is created when firm shippers resell some of their capacity rights to others.[21] Many "owners" reselling capacity rights in the secondary market use some services themselves, but other owners (natural gas marketers) only resell to others. Resold rights may be for firm service or for an interruptible service, if the shipper retains the right to recall this capacity under certain circumstances. The pipeline also offers interruptible service using unclaimed contract demand or any other available capacity. The FERC allows discriminatory discounting below the maximum allowed rates. The FERC has not seen that most transportation markets could be workably competitive, except possibly secondary markets created by the resale of long-term capacity rights.[22]

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19 This alone, of course, does not make pipeline transportation a natural monopoly. Countering examples are destination markets such as Chicago or New York or origin markets along the Gulf Coast, each served by a relatively large number of pipelines.

20 See FERC (1992), *Order 636*.

21 Rights to transportation capacity may be sold directly under FERC rules for "capacity release," or they may be sold to others bundled with natural gas in the so-called "gray" market. See Marston (1994).

22 See Terzic Competition Task Force (1992).

In this environment, the FERC's implementation of common carriage-type regulation yields the following problems. In peak periods, services are not allocated to the highest valued uses. In off-peak periods, the pipelines often leave uses unserved that are valued more highly than the operating cost. Expansions occur whose revenues do not cover their incremental cost. Neither market participants nor regulators have the appropriate market signals to properly evaluate capacity choices. And moreover, this performance has been bought with a high-cost and time-devouring regulatory process.

Straightshot Pipeline

This sub-section illustrates how a competitive joint venture might be implemented with a formal joint venture for a hypothetical Straightshot Pipeline, and how the resulting markets may operate with only light-handed regulation. The structure and conditions facing this joint venture is similar to many actual U.S. interstate pipelines.

At the time of the initial construction for Straightshot Pipeline, no one wishes to add capacity under open ownership beyond the initial amount. At a later time, parallel facilities need to be constructed to add capacity, and for this capacity, the incremental cost of the expansion exceeds the new average cost. One owner believes that its capacity would be unprofitable after an expansion, so that it sells its capacity to one firm wanting more capacity, lowering the size of the eventual expansion.

All transportation on Straightshot Pipeline is from end to end, and each owner has an undivided common interest in the entire pipeline. Once capacity is in place, each owner uses itself or markets to others services to which it is entitled independently of the other owners, and it keeps all revenues from these sales. Some owners sell transportation services separately, and others bundle transportation services with their own gas. Some services are sold under long-term contracts, where all terms, including prices, are specified in the contracts. Other firm services are sold under contracts of intermediate length, where the special needs of some customers are met. These contracts generally have two-part prices. Some transportation services are sold on the spot market, where a one-part rate is established. In the summer, price is near the average operating cost, and in the fall and winter, price is significantly higher than in the summer, sometimes significantly higher than the average cost of all gas transported. Spot prices move directly with the weather. Each owner pays Straightshot Pipeline, the operator of the pipeline, a small per unit fee equal to the average operating cost.

Straightshot Pipeline sells interruptible services produced from any capacity that an owner does not use or any capacity available above the pipeline's design capacity, as long as the price covers the operating cost. Any profits from the interruptible service are distributed to all owners according to their ownership shares. These are the only transportation services that Straightshot Pipeline sells. Interruptible service from the pipeline is rarely available, usually only when cold weather leads to an actual capacity that exceeds the design capacity of the pipeline.

Open ownership and the threat of interruptible service from the pipeline allow the regulator to grant "light-handed" regulation. No rate hearings are needed to set prices for any services, and no hearings are needed for any economic regulation to expand the capacity of the pipeline or for ending service after contracts expire. The cost of enforcing open ownership is easy for Straightshot Pipeline, since the operation of the pipeline is simple and no estimate of average costs is needed.

Spider Pipeline

This sub-section discusses a different implementation of a competitive joint venture on a second hypothetical pipeline. Spider Pipeline is a complicated pipeline network with several main lines and many branches and laterals. It has many receipt and delivery points dispersed throughout its system, most of which involve relatively small volumes of gas. Demand growth in different areas of the network varies significantly. Spider Pipeline's structure and the conditions it faces are similar to most existing, major U.S. interstate pipelines.

"Owners" on Spider Pipeline have life-of-the-pipeline service agreements, while Spider Pipeline formally owns the capacity. Each service agreement specifies the fixed costs that each owner is to pay. Owners have undivided common interests in each of several zones of Spider Pipeline. Open ownership applies to each zone independently. Spider Pipeline formally owns any new capacity, but the company or companies paying for the expansion control it with the rights granted within life-of-the-pipeline service agreements.

Spider Pipeline, unlike Straightshot Pipeline, also allows owners to set capacity constraints below actual capacity. For each zone of the network, the owners of the zone may mutually agree to set total capacity constraints below the total physical capacity. Initially, total capacity constraints on Spider Pipeline are based upon physical capacity. After several years, demand for services from one zone is drastically lower than expected. The owners of this zone unanimously choose to lower the total capacity available for this zone. Spider Pipeline sells interruptible services from available physical capacity, price discriminating below the market price established by the owners. These tighter constraints lead to higher revenues. Later still, demand for these same services rises, and with expectations that revenues will exceed costs, the owners increase the total capacity.

No one wishes to expand capacity now, but later several companies want to add capacity in one zone by adding compressors, and with such an expansion, the average incremental cost for this expansion is less than the new, average cost of all capacity. Thus, to apply open ownership, an estimate of the new average cost of all capacity in the zone is needed. Estimating this new average cost is more difficult than estimating incremental cost, but it's substantially easier than estimating the firm's "rate base" under cost-of-service regulation.

VIII
Concluding Remarks

To summarize, we define a competitive joint venture as a single set of facilities shared by multiple owners satisfying the following open ownership and competitive rules:

open ownership rules

(1.a) *open ownership* — Any potential owner can claim capacity if it pays, for each unit of capacity, the greater of the average of the new total fixed cost or the average incremental fixed cost of the new capacity.

(1.b) *owner-determined capacity* — The owners may, if all owners agree, set total owned capacity artificially below physical capacity, and each owner would then be limited to its new owned capacity. The owners pay all costs for any new estimates needed of average cost.

(1.c) *common ownership* — Each owner has an undivided common interest in all of the competitive joint venture's facilities, or, if its facilities can be partitioned into zones with no significant economies of scope between zones, in each zone of its facilities.

competitive rules

(2.a) *independent marketing* — Each owner may use or independently sell the services it may obtain from its capacity. Each owner pays the producer its share of the variable cost for these services.

(2.b) *use or lose* — Any owner's capacity not used to provide output is made available to other owners to use or sell. Any physical capacity not used to provide output is made available to the operator to sell.

(2.c) *independent operator* — The operator is independent of any individual user, or any subgroup of users, and it is charged to act neutrally with respect to all owners.

These open ownership and competitive rules are to be the only regulatory restrictions to address market power concerns. Market forces determine the services to be provided and traded, their prices, their quantities, and the remaining elements of the market institution within which this trading is to be done.

Throughout this paper, we have argued that such a competitive joint venture would lead to more efficient investment, pricing, and output decisions and lower regulatory costs than common carriage. The major benefits of a competitive joint venture stem from open ownership, which creates a primary market that allows anyone to purchase capacity at a cost that exploits all available economies of scale. Rules that create competitive secondary markets provide other benefits.

We expect that the thrust of a competitive joint venture's rules have general applicability for facilities that generate market power concerns. The specific rules chosen here were designed to yield a market structure that closely resembles the existing market structure now used for U.S. interstate natural gas pipelines. With little change, this same structure could be applied to facilities where market power concerns exist with oil pipelines, railroads, airports, and seaports. Other possible applications could become competitive joint ventures if they were restructured as wholesale suppliers to firms that would provide retail services. Possible applications such as this include intrastate pipeline networks, the telecommunications network, the post office, and air traffic control. Other forms of these rules might be used to accomplish the same objectives, especially for industries where other concerns must also be addressed. For example, for the electric power industry and the externalities that the laws of physics create in a transmission network, a smart market that leads to the efficient operation of the transmission network could be used among the competitive rules.[23] For each of these possible applications, more work is needed.

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[23] See McCabe, Rassenti, and Smith (1991) for a discussion on applying smart markets to electric power on a transmission network.

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Appendix

independent marketing

Our two-stage model with an independent marketing requirement that yields owners independently offering prices to consumers falls within the market environment considered in Davidson and Deneckere (1986). They show specifically for a duopoly where **D** also is differentiable, bounded, and has a finite choke price; the revenue function has a unique peak and is strictly concave to the left of the peak; and customers face a "Beckmann" rationing rule to determine the demand remaining for a higher-priced firm, that

- there exists a unique Nash equilibrium in prices;
- if the smaller capacity can satisfy demand at the marginal cost, that the competitive outcome holds [the Bertrand result];
- if the market clearing price is the monopoly price or higher, that the competitive outcome holds [this outcome is also the monopoly outcome];
- otherwise, the Nash equilibrium exhibits non-degenerate mixed strategies [the Edgeworth result]; and
- equilibrium profits are continuous with respect to capacities.

The arguments they present make clear that each of these results does not require each of these assumptions. For an oligopoly with *n* firms, even without the additional assumptions above, the efficient Bertrand outcome holds when capacities are large enough so that the capacity of each group of (*n*-1) firms exceeds the efficient quantity, the efficient outcome again holds when capacities are small enough that the monopoly and competitive outcomes converge, and the Edgeworth result holds otherwise. The assumptions above are used to derive the equilibrium mixed strategies.

Davidson and Deneckere contrast their results to those in Kreps and Scheinkman (1983), where a similar market environment is considered but with a different rationing rule. While an equilibrium in the Kreps and Scheinkman environment yields the Cournot outcome, Davidson and Deneckere interpret their results as an indication that the Cournot equilibrium outcome provides an upper bound to performance. For our model, these results indicate that, with only the independent marketing required for the second stage, performance in that second stage would typically approach that of the competitive outcome as the number of active owners increases.

use or lose

A use-or-lose requirement is analyzed for our textbook case in Gale (1994). Gale allows owners the opportunity to sell services from their own capacity, but any remaining capacity becomes available to others in a second selling period. It is shown there that for any number of multiple owners and for any rationing rule, the equilibrium market price is the market-clearing price, if that exceeds the marginal cost, and the marginal cost otherwise. The addition of the use-or-lose requirement leads to the Bertrand outcome, where without it the mixed-strategy Edgeworth outcome typically prevails.

The use-or-lose requirement recaptures the Bertrand outcome because any unused capacity later becomes available to any rival, often increasing the profits from undercutting the price of a rival. First consider when all prices are above the market-clearing price. Consumers attempt to purchase from the lowest cost firm, but if the lowest-cost firm's own capacity is insufficient, they wait for unused capacity, which there will be with these strategies from the consumers, and they purchase then. Given this, whenever prices exceed the market-clearing price, some owner has an incentive to undercut the lowest-cost rival's price. Alternatively, when some prices are below the market-clearing price, all of the capacity offered at these prices, even if they differ, is sold. This implies that firms offering such prices have an incentive to raise their prices. Further, as always, no firm has an incentive to price below marginal cost. Together these incentives dictate that an equilibrium must be a Bertrand outcome.

owner-determined capacity and the user owner

First consider a user owner j in the basic two-stage model. Let $\mathbf{V}_j$ = the inverse demand function for user j, k_j = the capacity j keeps and consumes itself, and $k_j°$ = the capacity j owns in the competitive joint venture. The net benefits that user j receives with its participation in the competitive joint venture are then $\int_0^{k_j} \mathbf{V}_j(k)dk + (\mathbf{R}(k°)/k°)(k_j°-k_j) - (\mathbf{C}(k°)/k°)\cdot k_j° - c\cdot k_j°$. If marketers earn zero profits, $\mathbf{R}(k°)/k° - \mathbf{C}(k°)/k° - c = 0$, which then implies j's net benefits are $\int_0^{k_j} \mathbf{V}_j(k)dk + (\mathbf{R}(k°)/k°)\cdot k_j = \int_0^{k_j} \mathbf{V}_j(k)dk + ((\mathbf{C}(k°)/k°)+c)\cdot k_j$. These net benefits are the same as those for j acting as a buyer. User j is indifferent between owning capacity for its own use or purchasing the same services from the competitive joint venture.

Now consider user owner j in a model with two cycles of the two-stage model, where the first cycle is as above, but the second cycle is uncertain and may result in a weak state of the world or a strong one. The structure of the weak and the strong states are the same as for our two-stage model above, except that $\mathbf{V}_j$, $\mathbf{R}$, and k_j may differ, so that we add the superscript w or s for the weak or strong states, respectively. For a project where ρ is the probability of the weak state occurring and were expansion yields zero profits for marketers in the strong state, the net benefit for user j is

$\int_0^{k_j} \mathbf{V}_j(k)\mathrm{d}k + (\mathbf{R}(k°)/k°)(k_j°-k_j) - (\mathbf{C}(k°)/k°)\cdot k_j° - c\cdot k_j°$

$+ \rho\cdot(\int_0^{k_j^w} \mathbf{V}_j^w(k)\mathrm{d}k + (\mathbf{R}^w(k°)/k°)(k_j^{°w}-k_j^w) - (\mathbf{C}(k°)/k°)\cdot k_j° - c\cdot\min\{1,\mathbf{D}^w(c)/k°\}\cdot k_j^{°w}$

$+ (1-\rho)\cdot(\int_0^{k_j^s} \mathbf{V}_j(k)\mathrm{d}k + ((\mathbf{C}(k°)/k°)+c)\cdot k_j^s.$

The first term describes the benefits earned before the uncertainty is resolved, the second is the added benefit from the weak state, and the third is the benefit contributed from the strong state, which is the same as that received by j as a buyer. In the weak state of the world, capacity is restricted, the market price established by the owners independent marketing is higher, and the operator sells services from remaining physical capacity, offering discounts that perfectly price discriminate among remaining customers. Even so, demand may be so weak that all available capacity may not be used. In the weak state, the user owner will accept a reduced capacity $k_j^{°w}$ (and an altered $\mathbf{R}^w$) only if it generates a higher value to the user than j can obtain without any reduction. This means the user will not accept any reduced capacity below the k_j^w that would obtain with the higher revenues with the reduced capacities.

With these net benefits for the user owner, it chooses the initial quantity to own $k_j°$, the quantity to own in the weak state $k_j^{°w}$, and, for the initial state, the weak state, and the strong one, the quantities to keep and consume itself k_j, k_j^w, and k_j^s. In each of these states, it chooses to keep and consumer itself any quantity more valuable in this use than to sell to others, or that quantity up to $\mathbf{V}_j(k) = \mathrm{d}\mathbf{R}(k)/\mathrm{d}k$,

In this same environment, the marketer i chooses the initial quantity it's to own $k_i°$ and the quantity to own in the weak state $k_i^{°w}$. It then receives

$((\mathbf{R}(k°)/k°) - (\mathbf{C}(k°)/k°) - c) \cdot k_i°$

$+ \rho\cdot(\mathbf{R}^w(k°)/k°)\cdot k_i^{°w} - (\mathbf{C}(k°)/k°)\cdot k_i° - c\cdot\min\{1,\mathbf{D}^w(c)/k°\}\cdot k_i^{°w}$

$+ 0.$

In the weak state, the marketer will accept a reduced capacity $k_i^{°w}$ (and an altered $\mathbf{R}^w$) only if it generates a higher revenue than otherwise. The marketer, though, can only guarantee to itself the revenues from the market-clearing price $\mathbf{P}(k°)$.

common carriage with short-run uncertainty

When short-run uncertainty is added to common carriage that allows no price discrimination and has consumers purchase services as needed, consumers receive the smallest of the actual demand or the capacity available, the quantity $\min\{\mathbf{D}(p)+w,k\}$. Whatever the obligation to serve might require, this means that, for whatever k is chosen, a risk-neutral regulator that must prevent all price discrimination finds a $p°$ in Stage 1 such that $(p°–c)\cdot E(\min\{\mathbf{D}(p°)+w,k\}) = \mathbf{C}(k)$, where $E(\cdot)$ denotes the expected value of the operand.

For common carriage that only prevents undue discrimination, when the monopolist can perfectly price discriminate, consumers receive $\min\{\mathbf{D}(p)+w,k\}$ at a price p, as above, but if $\mathbf{D}(p)+w < k$, they receive the larger total of $\min\{k,\mathbf{D}(c)\}$ where each unit of the remainder is purchased at a price equal to its value. Here, the regulator finds a $p°$ yielding a zero profit, including all costs necessary for the monopolist to perfectly price discriminate.

If k does not satisfy all realizations of demand, then $(p–c)\cdot E(\min\{\mathbf{D}(p)+w,k\}) < (p–c)\cdot E(\mathbf{D}(p)+w) = (p–c)\cdot\mathbf{D}(p)$, which implies that short-run uncertainty leads the regulator to choose a higher regulated price than it would in an otherwise identical market without this uncertainty. This price is higher if the regulator interprets the obligation to serve with uncertainty to require the same k to be constructed as with no uncertainty, and is higher still if a higher k is required.

The same framework and conclusions also apply if there were multiple periods in the short run with varying deterministic demand.

common carriage with long lives and overlapping vintages

To incorporate long-run demand uncertainty into the model, consider our model repeated over multiple cycles with a useful economic life of two cycles for any capacity investment and with demand $(\mathbf{D}(p^t)+w^t)\cdot(\Pi_{I=1}^{t} g^i)$ in cycle t, where p^t is the single market price, w^t the realization of the "weather," and g^t the growth rate for cycle t. Further, with overlapping useful lives of production assets, fixed costs for constructing capacity can vary depending upon capacity already in place, as the technological options for constructing capacity, those that determine costs, clearly differ. We denote the fixed costs in any cycle t by $\mathbf{C}^+(k^{t-1},k^t)$, where k^{t-1} is the capacity constructed in cycle $t-1$ and k^t is the additional capacity constructed in cycle t, and assuming $k^0 = 0$. The total capacity available in cycle t is $k^{t-1}+k^t$. For all k^{t-1} and k^t, we assume $\mathbf{C}^+(0,k^t) = \mathbf{C}(k^t)$, and $\mathbf{C}(k^{t-1}+k^t) \leq \mathbf{C}(k^{t-1})+\mathbf{C}^+(k^{t-1},k^t) \leq \mathbf{C}(k^{t-1})+\mathbf{C}(k^t)$. Thus, the monopolist faces the same cost conditions as before if capacity were constructed all at once, constructing capacity at once may be cheaper than constructing the same total capacity at two different times, and the cost of constructing capacity with existing assets in place may be cheaper than with no assets in place. We consider this new structure for the fixed costs because it allows economies of scale to be present every time facilities are built, and because average incremental costs $\mathbf{C}^+(k^{t-1},k^t)/k^t$ may exceed the new average costs $(\mathbf{C}(k^{t-1})+\mathbf{C}^+(k^{t-1},k^t))/(k^{t-1}+k^t)$.

Overlapping vintages makes the common carriage regulator's depreciation policy important. For any regulated monopolist, the economic value of the monopolist's assets at any point in time depends upon when the regulator allows the monopolist to earn revenues with these assets. Without any overlapping vintages, as long as the totals over the life of the assets match up, a depreciation policy that does not reflect this underlying economic value has no efficiency consequences. With overlapping assets, however, the depreciation policy can affect the timing of investment, and may have efficiency consequences.

In the multi-cycle model of common carriage, the regulator chooses p^t and p^{t+1} such that the assumed operating revenue earned in this cycle and the next equals the new capacity's cost plus the depreciated cost of the last cycle's capacity, or $\mathbf{C}^+(k^{t-1},k^t) + (\mathbf{C}^+(k^{t-2},k^{t-1})-(p^{t-1}-c)\cdot k^{t-1})$. With uncertain growth or weather, expected operating revenues are substituted for operating revenues. If the regulator knew demand growth and future costs as well as the regulated monopolist, then the choice of prices would likely depend upon these factors and the future investments they would induce. With this symmetric information, investment and prices could be chosen simultaneously so that one expected to efficiently clear the market every cycle and to yield zero profits for every investment. With asymmetric information, however, the common carriage regulator often modifies this behavior to avoid large regulatory costs.

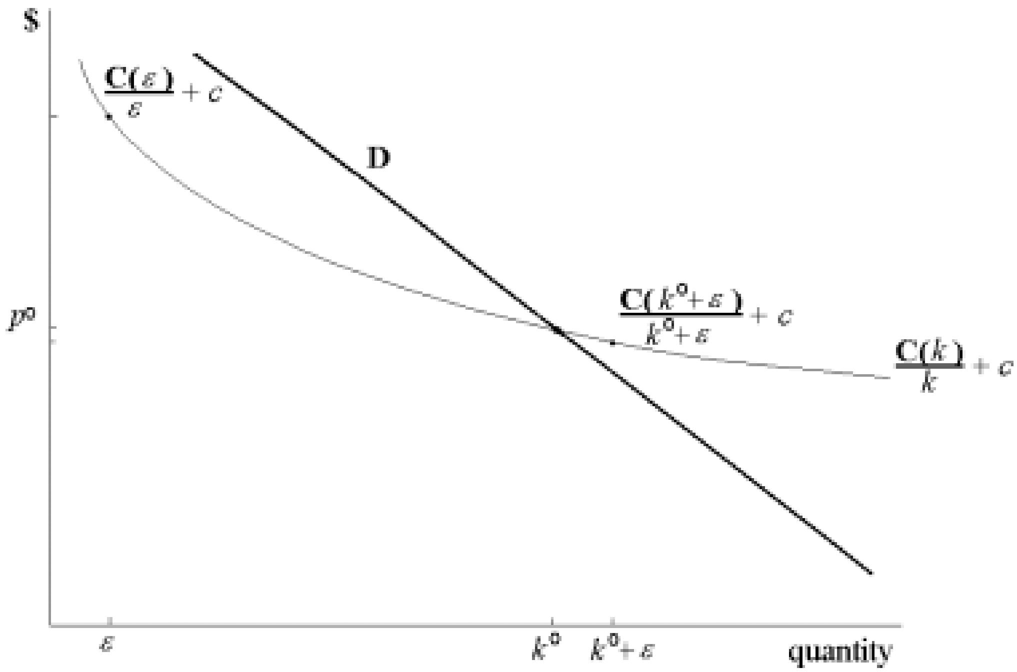

Figure 1: Capacity in the Long Run

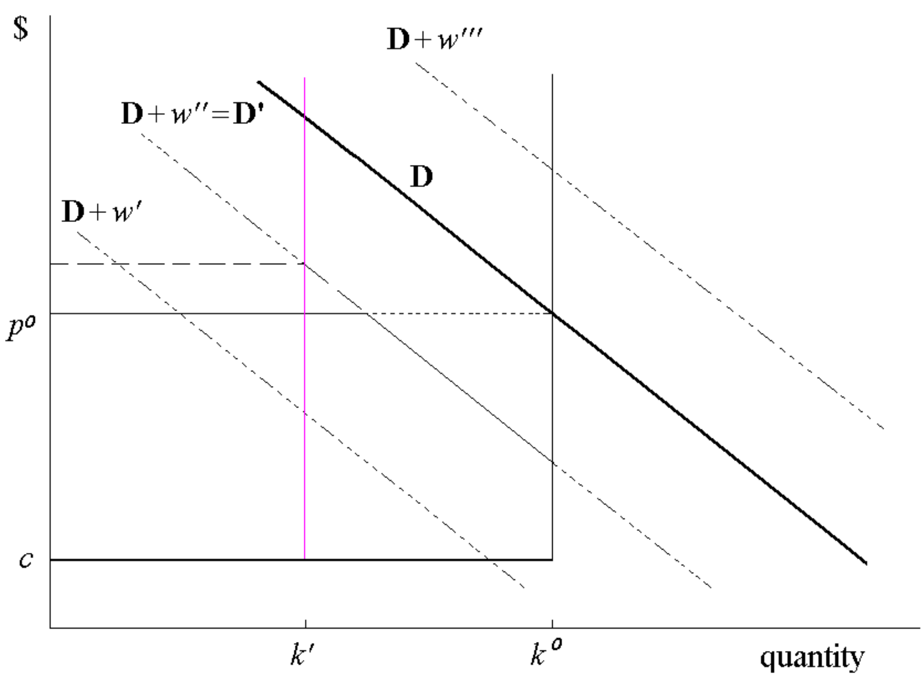

Figure 2: Price and Output in the Short Run