SUBSIDIES, MARKET CLOSURE, CROSS-BORDER INVESTMENT, AND EFFECTS ON COMPETITION: The Case of FDI in the Telecommunications Sector

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INTRODUCTION AND MOTIVATION

Telecommunications long was a sector where sellers of services operated in protected local markets, where law and government regulation created and enforced barriers to entry, especially by foreign firms.[1] In many nations, in fact, the provision of telecommunications services was reserved for state-owned monopoly suppliers. During the late 1980s and through the 1990s, however, many of these barriers have been removed while formerly state-owned firms have been partially or wholly privatized.[2] This has in turn engendered some cross entry by telecom service providers; firms that once were purely domestic in the scope of their operations thus have become multinational.

During the summer of 2000, however, US Senator Ernest Hollings, with co-sponsorship of 29 other US Senators, introduced a bill (S.2793) in the US Congress that would have effectively blocked non-US telecommunications service providers from acquiring US telecom firms if the former were state-owned, or even only partly state-owned. The bill was aimed specifically at the proposed acquisition of US mobile telecommunications service provider Voice Stream by the German firm Deutsche Telekom (DT), but the language of the bill would have served to block virtually any non-US state-owned firm in the telecom sector from buying a US firm. While the bill did not become law, it reflected a long history of efforts in Congress to prevent US firms from being acquired by state-owned non-US firms (e.g., a legislative bill to do this had been introduced by Senator Frank Murkowski during the late 1980s, and while this bill also failed to be passed into law, some provisions from the bill were incorporated into the Exon-Florio legislation that was first enacted as a temporary measure in 1988 but subsequently made part of US permanent law in 1992).

The Hollings bill was doubtlessly motivated in part by xenophobia (Senator Hollings is himself of the American generation that fought Germany during World War II). But it was also motivated, as was the Murkowski bill a decade earlier, by fears that subsidies and/or monopoly profits accruing to state-owned firms in their home markets might be used to affect operations in the US market to the detriment of locally-owned competitors. The extreme case of such behavior would be predatory pricing by the state-owned firm aimed at bankrupting its competitors, where temporary losses created by below-cost pricing in the US market would be offset by subsidies or monopoly profits in the home market. The ultimate goal of the predatory firm would be to establish a monopoly in the United States. In fact, the Hollings bill was shelved in part because DT was able to establish that it was neither a recipient of significant subsidies in Germany nor a monopoly service provider in the German market (although the

[1] See, for example, Sidak 1997 for a history of US law and policy that effectively blocked foreign entry in telecom; the United States was one of the less overtly protected of the world's major markets.

[2] See, for example, Ergas 1997 and Wilson 1997.

firm once held a statutory monopoly there, the market has been opened to competition and some new entry has occurred[3]). Also figuring in the shelving of the bill was argumentation that competition in the US market for wireless telecom services would be enhanced by the entry of DT.[4] However, fears have persisted about the possibly deleterious effects of subsidies or monopoly profits garnered by a firm in its home market on competition in a geographically separate market in which that firm (or a subsidiary of that firm) is a seller. Indeed, the issues raised by the Hollings bill pertain to numerous sectors in which multinational firms compete. Accordingly, the US Council of Economic Advisors was ordered by the US President following the introduction of the Hollings bill to advise on what might be the effects of such competition.

Even with deregulation, markets for telecom services are oligopolistic in nature, as indeed are most markets in which multinational firms operate, a fact long-recognized in the literature on multinational firms. In spite of the latter, however, surprisingly little research on these firms, or on foreign direct investment in general, accounts for the oligopolistic nature of competition in the markets in which they operate. This paper thus is an attempt to apply models of oligopoly competition to address some of the issues raised in the context of the Hollings bill.

Specifically, the paper looks at these issues in the following context: There exist two separate markets for identical goods. The markets are separate in the sense that sellers in one market do not, initially at least, sell in the other market and, in fact, there exist barriers to entry that deter them from doing so. The sellers operate with cost structures typical of telecommunications—much of the cost of providing the relevant services is fixed in nature (i.e., does not vary directly with the volume of service provided or at least not in the short run). The barriers can be naturally occurring or governmentally imposed. Given this, we ask in the sections following what the effects are on competition in each market that result from entry into one market by a firm that has not previously been a seller in that market but has been a seller in the second market, and how these effects are themselves affected by subsidies and/or closure of a market.

The analytic aspects of the model developed in the following section to explore these issues are based on standard oligopoly theory and, in particular, upon results shown by Kreps and Scheinkman (1983). The model as used here is deliberately kept simple -- it is at heart simply a standard Cournot

[3] Nonetheless, because of incumbency advantages that are strong in the telecommunications sector, DT has remained the dominant supplier of telecom services in Germany.
[4] Both these arguments favoring the acquisition of Voice Stream by DT are elaborated in Hufbauer and Graham 2000. See also Sidak 2000.

model but with some nonstandard twists to it -- reasons of tractability. Even so, as will be seen, some of the conclusions that can be drawn are not those normally accepted as “common wisdom”.

The next section develops the basic model, and this section can be bypassed by readers familiar with Cournot oligopoly models. The section on “Applying the Model to Competition in the Telecom Sector” modifies the standard model to try to fit the circumstances of the telecom industry. The “Cross-Border Investment” section then uses the modified model to examine issues specific to cross-border investment in telecom markets. The concluding section examines what directions for future research all this suggests.

A SIMPLE BUT SUITABLE MODEL

Any appropriate model for examining rivalry among firms where at least one of these firms operates in two distinct markets (and thus is a multinational firm) must be one that embodies oligopolistic competition. Indeed, that markets (or sectors) characterized by the presence of multinational firms are typically oligopolistic in nature is one of the important threads in the literature on multinationals dating at least to Stephen Hymer’s influential 1958 doctoral dissertation (published as Hymer 1976). However, the dynamics of oligopolistic competition are notoriously difficult to model. The key aspect of such competition that differentiates it from competition in monopoly or competitive markets is that, in making profit-maximizing decisions regarding price or output, an oligopolist must take into account not only the relationship between supply and demand but also the expected responses of rival firms to its own price or output decision.

To formalize this last aspect somewhat, let us assume that a firm sells a single undifferentiated product and must decide at what quantity of this product to offer in order to maximize profits. If price is given by p and the quantity offered is q such that total costs are $TC(q)$, then the problem is simply to maximize profits π, where

$$\pi = pq - TC(q)$$

The term pq is, of course, revenue. In a competitive industry, p can be taken as exogenous and constant, so that profit maximization is achieved under standard regularity conditions at the point where price, which identically equals marginal revenue (the first derivative of revenue with respect to q), also equals marginal cost (the first derivative of total cost with respect to q). This follows immediately from the first order conditions for maximization of π. If, by contrast, the firm is a monopoly seller in the market not worried about the possibility of entry by new sellers if realized price rises above the competitive price,

price can still be taken as exogenous, but not constant. Rather, it is a function of q, so that profit maximization still occurs where marginal revenue equals marginal cost, but where marginal revenue now is a function of q but still is deterministic.

In the case of an oligopoly, however, things are not as straightforward. Price will in general be a function of the total quantity offered by all sellers, and this quantity will in turn be a function of the quantity offered by any one seller where that quantity is, *inter alia*, a function of expected reactions (quantities offered) of other sellers to this quantity. Thus, if Q is total quantity offered, then $p = p(Q)$ where $Q = Q(q)$ and is now most appropriately considered not to be a deterministic function but rather a random variable (the seller is not certain what the reactions of other sellers might be). Thus, p also is a random variable. First order conditions for profit maximization for the firm are given by

$$\frac{d\pi}{dq} = 0 = p + q\frac{dp}{dQ}\frac{dQ}{dq} - \frac{dTC(q)}{dq}. \qquad (1)$$

Because Q is a random variable, the term dQ/dq is not a known quantity and, indeed, necessarily involves a conjecture by the firm as to how rivals will react to a change in quantity offered by the firm (e.g., the term is an expected value given some conjecture about rivals' behavior). A naïve conjecture is that the rivals do not react at all but rather hold quantity constant. This conjecture, known as the Cournot conjecture after French economist Augustin Cournot who first employed it in 1838, is naïve because not to change quantity in response to quantity changes by a rival firm is not itself, in general, a profit-maximizing strategy by a firm. (In the parlance of modern game theory, for firm j to respond to a quantity change by firm k by holding its own quantity offered constant is not a best response to the move of the latter by the former.) Nonetheless, employment of the Cournot conjecture often leads to a tractable result, because the conjecture implies very simply that $dQ = dq$, such that $dQ/dq = 1$ (or, if one prefers, $E(dQ/dq) = 1$).

The fact that it tends to lead to tractable results is certainly one main reason that the Cournot conjecture has in fact become a standard facet of oligopoly theory. Plainly put, it keeps things simple, while many other conjectures lead one down paths to non-tractable results. But, fortunately, a body of literature has developed showing that at least some other plausible conjectures or strategies of oligopolists can, under certain assumptions, lead to the same equilibrium (see just below) as do strategies based on the Cournot conjecture.

For example, in the telecommunications services sector, firms are generally not price takers, but price setters. That is, they offer telecom service at a specified price, and then meet the demand for the service at that price, subject to constraints imposed by capacity (the firm cannot, for example, switch more calls than it has capacity to do, as any telephone user who has received a trunk-line "busy" signal can attest). Under these circumstances, a Cournot conjecture would not seem appropriate to modeling a telecommunication firm's behavior. If anything, the appropriate conjecture would seem to be a so-called "Bertrand" conjecture, where the firm sets prices rather than outputs under a conjecture that rivals make no price response to any change of it own price at which it offers the relevant services. However, even so, use of Cournot equilibria can be appropriate. In particular, if oligopolists must first create capacity, then compete on the basis of setting prices following a Bertrand conjecture subject to the constraint imposed by the capacity they have created, these oligopolists arrive at a Cournot equilibrium (Kreps and Scheinkman *op. cit.*).

To derive the equilibrium just mentioned, let us return to a world in which firms compete by setting quantities offered rather than prices and note that in a Cournot model of oligopolistic competition, not just one, but rather all firms selling in a given market must follow the Cournot conjecture. This implies, of course, that none of these firms conjectures correctly about its rivals' quantity adjustments and thus, when it becomes apparent what these adjustments actually are, each firm realizes that it initially got it wrong and therefore must reset output. But, in doing so, each firm again uses the Cournot assumption (or, in other words, no firm learns from its mistake but, rather, all firms keep repeating the mistake!). Eventually, under normal conditions of demand, however, repeated adjustments of output by each firm leads to an equilibrium where no firm can improve its profits via further quantity adjustment, such that the best response of each firm to the given price/quantity configuration then is to do nothing further.[5] This equilibrium is given in the case of *n* firms by solving simultaneously *n* equations of form (1) above, subject to a market clearing condition, where of course the variables π, q, and TC are specific to each firm. Thus, the i^{th} equation (remembering that dQ/dq_i is unity) becomes

$$\frac{d\pi}{dq} = 0 = p + q\frac{dp}{dQ} - \frac{dTC(q)}{dq}$$

This equation is often termed the "reaction function" for the i^{th} firm. The market clearing condition is simply $\Sigma q_i(p) = D(p)$, where $D(p)$ is quantity of the product demanded at price p. This condition is needed in a technical sense; the reaction functions yield *n* equations but in *(n+1)* variables (these variables are the *n* q_i*'s* and *p*), and an (*n*+1)th equation is necessary (but not sufficient) to solve all variables simultaneously.[6] Obviously, for this to be the case, there must be an explicit relationship between *p* and *D(p)*, i.e., a demand function must exist.

Although the Cournot conjecture is implausible, the equilibrium to which it leads has some ring of plausibility to it and, as noted above, the same equilibrium is attained in certain models where oligopolists follow other, and arguably more plausible, conjectures. Thus, in what follows, the assumption will be that telecom firms behave *as per* Cournot conjectures.

As noted in footnote 4, for a solution to the *n* reaction functions and the market clearing condition to exist and be unique, it is sufficient (albeit not necessary) that the *n+1* equations be linear and independent of one another. For the market clearing function to be linear, it is necessary and sufficient that the underlying demand function also be linear. Fortunately, the latter can be assumed to be the case, as demand in almost all economic theory is treated as a linear function of price, or sufficiently nearly so that a linear approximation is close to the true demand function. If demand for telecommunications services is indeed linear and if *Q* is quantity of this service demanded, then $Q = A - Bp$, where *A* and *B* are constants. Then also $dQ/dp = -B$, where *B* is the magnitude of the slope of the demand function. The reaction function for the ith firm then becomes:

$$p = \frac{1}{B} q_i + \frac{dTC_i(q_i)}{dq_i}. \tag{1a}$$

To go further than this, we need to know something about $TC_i(q_i)$, the cost structure of the typical firm. In the telecommunications sector, the cost structure for a typical seller is such that there is a recurring fixed cost and a marginal cost where the latter is, for all practical purposes, constant. Thus, $TC_i = F + q_i c_i$, where *F* and *c* are both constants but where *F* is per unit of time, for example, $X per month. However, as is well understood, no cost is truly fixed in the long run and, in particular, *F* depends upon capacity sup (q_i), where the latter indicates the maximum output of the ith firm (i.e,. its capacity). We can

[5] Specifically, this is a Nash equilibrium. In the context of oligopoly, firms are in a Nash equilibrium if the best response of each firm to the current quantities offered by rival firms is to continue to continue to offer that quantity that currently is offered.

[6] In fact, at this point, of course no solution is guaranteed and, if a solution does exist, it is not necessarily unique. A sufficient condition for a solution to exist and be unique is that the n+1 equations be linear in the n+1 variables and be linearly independent of one another. See below.

assume that capacity is fixed in the short to middle run and hence that F is constant in this time frame, but we have to recognize that, in the long run, capacity can be adjusted.

If the costs of each firm are the same as for any other firm, the solution for the equilibrium is then quite easy. If there are n firms selling the service at a constant marginal cost c (where each firm also incurs a recurring fixed cost F), then for all firms $dTC_i(q_i)/dq_i = c$, so that (1a) simply becomes

$$p = \frac{1}{B} q_i + c$$

and the market clearing condition is simply

$$Q = \sum_{i=1}^{n} q_i = A - Bp\,.$$

It is obvious that if for all i and j, $c_i = c_j$, then also $q_i = q_j = q$, so that $Q = nq$. Hence, the unique solution for the equilibrium is

$$p = \frac{A + Bcn}{B(n+1)}$$

$$q = \frac{A - cB}{n+1}\quad.$$

If this result does not seem familiar to persons who have some familiarity with Cournot equilibria, the likely reason is that the result is usually expressed in terms of an "inverse" demand function $p = f^{-1}(Q)$ rather than a demand function $Q = f(p)$. A linear function is invertible, of course (mathematically, linear functions with finite, non-zero slope belong to the class of one to one, differentiable functions from $\Re^1$ onto $\Re^1$ and hence are invertible) and hence the inverse of a linear demand function exists and, for the function $Q = A\text{-}Bp$, is easily seen to be

$$p = \frac{A}{B} - \frac{1}{B} Q\,.$$

If we let $A_{new} = (A/B)_{old}$ and $B_{new} = (1/B)_{old}$, then the equilibrium relationships above become

$$p = \frac{A_{new} + cn}{n+1} \qquad (2a)$$

$$q = \frac{A_{new} - c}{B_{new}(n+1)} \quad . \qquad (2b)$$

Then, for example, dropping the "new" subscripts and letting *n=2*, the familiar Cournot duopoly solutions appear:

$$p = \frac{A + 2c}{3}$$

$$q = \frac{A - c}{3B}$$

Likewise, if *n=1*, the familiar solutions for monopoly price and quantity appear. However, although these are all familiar results, they are not especially useful ones, because we will be largely interested in cases where $c_i \neq c_j$. Even so, these familiar results do illustrate one point, which is that it is algebraically easier to use inverse demand functions than demand functions when considering Cournot oligopolies (and so we shall do so henceforth). Also, before we go further into the case where firms do not have equal costs, let us note two more things that follow from developments thus far.

First, it is necessary for the i^{th} firm to be profitable that it cover its fixed costs, i.e., in the case where costs for all firms are the same, that $(p-c)q > F$ for each firm. Because

$$(p-c)q = \frac{A^2 - 2Ac + c^2}{B(n+1)^2}$$

and letting *NR* (for net revenue, i.e., revenue minus variable costs) = $(p-c)q$, it is clear that $d(NR)/dn < 0$ *for* $2Ac < (A^2+c^2)$, this latter being a condition that must hold because, otherwise, no firm can participate in the market without incurring a loss. Also, for all finite *n*, it is clear that $NR > 0$ and that $NR \to 0$ as $n \to \infty$. Given this, and assuming that at least one firm can profitably operate in this market, i.e. that $F < (A^2\text{-}2AC+c^{2)}/4B)$, it follows that there is some value of *n*, call this value *N*, such that if $n > N$, no firm can operate profitably. If *N* is such that firms can operate profitably, this would be the expected number of firms in the market:[7] if there were more firms than *N*, some of these would exit, whereas if there were

[7] Otherwise, this number would be N-1.

less than *N*, there would be profits to be had for new entrants and these would be expected to enter the sector until further profit entry had been bid away.

A second point is that if there are significant barriers to entry (or, equivalently, there are incumbency advantages) such that *F* for a new entrant is significantly higher than for an incumbent, then firms can do better than achieve the profits implied by (2a) and (2b) above. Instead of competing, firms could act collusively to charge the monopoly price and agree to split profits among them. To do so would Pareto-dominate the Cournot equilibrium, for example, every firm would be better off to collude rather than to engage in oligopolistic competition. As is widely noted, however, for firms to collude and share profits does not achieve a Nash equilibrium, because there is an incentive for each firm to cheat on the collusion by undercutting the monopoly price and taking market share away from rival firms. (To cheat is a best response of firm *i* to the expectation that other firms will collude.) Such a "market share" strategy, if played by each firm, leads to the Cournot equilibrium (Rickard and Murray 1978). However, if firms explicitly realize that collusion creates an incentive to cheat and that this leads to a Pareto-inferior outcome, they might then agree to "punish" any price-cutter by, for example, moving immediately to the Cournot price if cheating is detected, so that the price cut is ineffective for any firm as a means of capturing market share. If such an agreement to punish is credible (see just below), the conditions of the "folk theorem" for repeated non-cooperative games are met, such that collusion does become a Nash equilibrium, or at least so if firms expect to remain in the market in perpetuity (Friedman 1971). The credibility of the agreement to punish deviant firms depends upon whether the agreement is "sub-game perfect" or, more rigorously, "ε-perfect" (Selten 1965), that is, whether those firms that must implement the agreement stand to gain or lose from doing so in the event of a deviation by a rival firm. (Otherwise put, to punish must be, for non-cheating firms, a best response to a rival firm's cheating.)

Friedman (1971) argues that an agreement to move to the Cournot equilibrium in the event of a price cut is sub-game perfect because, if a deviant firm cuts price, that deviant will gain 100 percent market share and all other firms will be left with nothing, or at least so until they adjust their prices. Thus, it is better for each firm, in the event of price cutting by a deviant, to move immediately to the Nash equilibrium rather than to suffer being shut out of the market, even if this shut-out might be short lived (because customers would switch back once non-price cutting firms responded to the price cut by the deviant firm).

But for Friedman's reasoning to hold, it must be assumed that short run price elasticity of demand is very high (indeed, infinitely high, implying that consumers care only about price and not at all about other attributes of the product or service in question) so that customers will switch from one supplier to another even in response to small and possibly short-lived price differences. In practice, some such switching does seem to occur in response to price cuts by telecom service providers (otherwise, why else would every residence in North America be subject to telephone solicitations from telecom firms seeking to get that residence to switch its service provider?). But available evidence does not suggest that short run price cutting in practice leads to massive shifts by consumers or to volatility of market share among telecom services providers. Thus, whether the Friedman approach to a punishment strategy is, in fact, sub-game perfect remains an open issue.

In practice, there is some evidence that in telecom markets, the presence of five or six sellers tends to be associated with something like competitive pricing (or at least a Cournot equilibrium) whereas the presence in the market of fewer sellers tends to be associated with non-competitive pricing (the firms agree even if only implicitly to price monopolistically and share monopoly rents).[8] One possible reason why a small number of sellers in this sector is able to sustain monopoly pricing is that they can keep track easily of capacity of each of their rivals, and additions to capacity are necessary for a price cutting strategy to be implemented (if a firm cuts price in the expectation of gaining market share, it must have the capacity to service the additional demand). Thus, there is in effect an advance warning of any firm's intent to change strategy, and given a signal that a rival might be about to do so, a firm can take countermeasures (e.g., increase its own capacity, thus signaling a willingness to match price cuts). Exactly why this signaling should work if there were, say, five sellers in the market but not if there were six or more is not, however, quite clear.

It should go without saying that outcomes wherein monopoly prices are sustained are not in the interests of consumers or, indeed, in the interests of economic efficiency. The goal of public policy thus is to prevent such outcomes and, rather, to promote competitive outcomes, even if in this case "competitive outcome" means not one that would prevail under perfect competition (hard to achieve when fixed costs place an upper bound on the number of sellers that can participate in a market!) but rather a Cournot equilibrium. As just stated, these points should go without saying, but they are points that sometimes are missed in places like the US Senate.

APPLYING THE MODEL TO COMPETITION IN THE TELECOM SECTOR

Thus far, about all that has been accomplished is presentation of more or less standard ideas regarding the dynamics of competition in oligopoly markets under Cournot conjectures, with some reference to why these ideas can be applied to telecom markets. In this section, the goal is to extend this application to

[8] For illustrations see Atje and Hufbauer (1996).

include more about the dynamics of competition in these markets. Then, building upon developments in this section, the following section discusses specific issues surrounding cross-border investment when the investor might be a recipient of a subsidy or monopoly rights in its home market.

To begin, the following assumption is made: in the provision of telecom services, marginal cost c_i can be reduced by increasing total capacity. However, to do so raises the recurring fixed cost F_i. Marginal cost, holding capacity constant, is itself constant. Thus, c_i is a function of sup (q_i) but not of q_i. This would imply that there is some scale economy associated with total capacity beyond that which is implied by the presence of a fixed cost. The presence of a fixed cost implies, of course, that average cost declines or that there is a scale economy even if marginal cost is constant with respect to capacity. This additional scale economy might be the result of organization scale economies (it might be possible, say, to add automated capacity without adding additional staff, or at least to add capacity without an equi-proportional increase in staff). In the case of telecommunications, it plausibly could originate from an ability to increase capacity by adding capital to an existing network (e.g, cables, switching equipment) while holding constant the land over (or under) which the cables pass or the buildings housing the equipment stand.

At this point, an admission must be forthcoming: the above considerations would suggest not that marginal costs decline with increased capacity as claimed, but rather that fixed costs per unit of capacity decline. This is because it is the marginal cost of additional capacity, not the marginal cost of providing additional units of service that would seem to fall as a function of total capacity. The consequence of this, however, is that the industry would be expected to evolve towards a single seller and, indeed historically, telecom has often been cited as an example of a "natural monopoly" for exactly these reasons. However, experience in modern times has been that evolution of the industry has been in the exact opposite direction, i.e., in almost every major national market worldwide, the number of sellers has increased rather than decreased.

One possible reason for this is that firms' cost structures are, in some sense, path-dependent. This could be the result of rival firms possession of somewhat different technologies, at least some of which have evolved from each firm's own *sui generis* experience (such that firms, in essence, do things somewhat differently but such that the techniques of one firm might simply not fit into the *modus operandi* of another firm). Thus, cost structures of different firms could be different, but such that a less efficient firm cannot readily replicate those attributes of a more efficient rival that give rise to the efficiencies.[9] Also, capacity additions might be associated with technological advances, where the advance does reduce the cost of actually operating the network over which telecom services pass. Otherwise expressed, the realization of technological advances that reduce marginal costs might require capacity augmentation.

The latter does not necessarily imply, nor even guarantee, that those firms that make the heaviest investments in capacity necessarily would have the higher operating efficiencies than rivals that make lower investments. This is because of the path-dependency of individual firm's technologies. Rather, there might be no predictable relationship between total investment in capacity and operating efficiency; it could even happen that the firm with the highest fixed cost per unit of capacity also had the highest marginal cost of all firms selling in a market. What is claimed is only that, to reduce marginal costs, the firm must increase total capacity and hence total fixed cost.

A second assumption, and one that is important in what follows, is that the total costs of the firm are dominated by the fixed cost component, which is to say that at equilibria that are reached, $F_i >> c_i q_i$ for each firm. This assumption is in accord with reality. In the telecom sector, fixed costs indeed are significantly greater than variable costs.

Further, in what follows, there is an implicit assumption that firms behave according to some precept of "bounded rationality" in the sense of Herbert Simon. That is to say, no firm holds perfect information regarding rival's costs and capacities, but all firms are able to make reasonably good estimates as to what currently are these costs and capacities. Also, firms have reasonably accurate expectations regarding equilibrium prices and outputs given, albeit again not perfect information. Were information perfect, firms might be able to calculate the long-term equilibrium that would be attained in the market and move immediately to install capacity that is compatible with this equilibrium.[10] But, in what follows, we assume that this does not happen. This would lead to an unrealistic, static, and not very interesting outcome. Rather, we assume that, by whatever means, the market has evolved to some equilibrium. We then examine circumstances under which this equilibrium might change when firms move somewhat cautiously.

The main analytic task is to examine equilibria where marginal costs of sellers are not all the same and then to explore how these equilibria change in response to changes in cost structure. Alas, the algebra of Cournot equilibria where different firms have different marginal costs becomes increasingly

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[9] The possibility of such path-dependency is explored by Cantwell (1991), who finds it a plausible reason for variance in cost structures among firms that compete in end-markets.

[10] The possibility that technological change that alters firms cost structures in fact largely rules out such an outcome.

unwieldy as the number of firms increases, even if the marginal cost of the individual firm is assumed to be constant and demand linear. Price in this general case is given by

$$p = \frac{A + \sum_{i=1}^{n} c_i}{n+1}$$

and quantity for the i^th firm by

$$q_i = \frac{A + \sum_{i=1}^{n} c_i - (n+1)c_i}{B(n+1)}$$

such that considerable unwieldiness is created by the multiplicity of cross product terms that are implied by the above. (For example, the cross terms become unwieldy if one wishes to consider net revenue, $(p-c_i)q_i$). Fortunately, without loss of much generality, we can look at the case of $n=2$ (duopoly) without becoming too overwhelmed by unwieldiness.

If demand is as before (the inverse demand function is $p = A - BQ$), and there are two sellers in the market with marginal costs c_1 and c_2, equilibrium price and quantities are

$$p = \frac{A + c_1 + c_2}{3} \quad \text{(3a)}$$

$$q_1 = \frac{A - 2c_1 + c_2}{3B} \quad \text{(3b)}$$

$$q_2 = \frac{A - 2c_2 + c_1}{3B} \quad \text{(3c)}$$

Adopting a convention that π = net revenue (i.e., π henceforth is not profit), then

$$\pi_1 = \frac{A^2 - 4Ac_1 + 2Ac_2 + 4c_1^2 + c_2^2 - 4c_1c_2}{9B} \quad \text{(4)}$$

Noting that the conditions that each firm participate in the market remain $\pi_1 > F_1$ and $\pi_2 > F_2$, taking first and second partial derivatives of π_1 with respect to "own" marginal cost, we observe that

$$\frac{\partial \pi_1}{\partial c_1} = \frac{-4A + 8c_1 - 4c_2}{9B}. \quad (5)$$

This implies that a decrease in marginal cost creates an increase in net revenues if $2c_1<(A-c_2)$, where this last condition is necessary if the firm is to have positive net revenue with $q_1>0$, i.e., the firm's output is feasible. Thus, the firm can, as one might expect, increase its net revenue by lowering its marginal costs. But, to do so, the firm must increase its capacity or, in terms of our model, increase its recurring fixed cost. Obviously, the firm will do so only if the increase in net revenue per period exceeds the additional fixed cost required to achieve this increase. But also

$$\frac{\partial^2 \pi_1}{\partial c_1^2} = \frac{8}{9B}$$

which is unambiguously positive so that as marginal costs decline, net revenue increases at an increasing rate in the range of feasible output, but the total additional revenue is bounded (the maximum is reached where c_1 is zero, because negative marginal costs are of course not feasible). If fixed costs per unit of additional capacity are constant, there does exist an optimum capacity for firm 1 for a given c_2. Because analogous results hold for firm 2, there likewise does exist an optimum capacity for this firm given any c_1. Thus, as noted previously, under circumstances of perfect information, the two firms might each independently be able to calculate by induction a long-run equilibrium. Again, however, we assume this away, and rather assume that each firm, perhaps because of some uncertainty about the cost structure of the other firm, makes capacity decisions somewhat cautiously, but moving in a direction in which it believes it can increase net revenues.

However, we shall assume that each firm understands the following: Because

$$\frac{\partial q_1}{\partial c_1} = -\frac{2}{3B}$$

$$\frac{\partial q_2}{\partial c_1} = \frac{1}{3B}$$

$$\frac{\partial Q}{\partial c_1} = \frac{\partial (q_1 + q_2)}{\partial c_1} = -\frac{1}{3B}$$

a lowering of firm 1's marginal cost results in an increase in total quantity demanded at the equilibrium (and hence a drop in price, which can easily be shown analytically) but a loss in the total quantity serviced by firm 2. Absent some response on its part, firm 2 thus suffers an absolute loss and not simply a relative loss. Firm 2 loses net revenue. Correspondingly, and obviously, firm 1 gains market share as well as net revenue, a result of course consistent with its increase in capacity. Analogous results follow if firm 2 lowers marginal cost by increasing capacity.

It is possible that capacity expansion/marginal cost reduction by one firm, in the absence of a corresponding move by the other, could force the other out of the market. This would happen if, at the new equilibrium, the non-expanding firm could not meet its fixed cost (and recall that fixed costs dominate total costs; if a firm loses market share, its revenue is reduced, but this to some extent is offset by reductions in variable costs. But the dominant cost, the fixed cost, by definition remains fixed. Average costs (total costs divided by quantity) necessarily go up and, indeed, because average fixed cost is hyperbolic in q, the more q falls, the faster these costs rise.

However, this firm can recapture market share, and increase its net revenue by expanding capacity and reducing marginal cost in order to regain market share. If, by expanding capacity, this firm can increase net revenue in excess of the required increase in recurring fixed cost, so as to put itself back into the black, it would of course be expected to do so. Otherwise, it indeed would exit from the market. This suggests that, starting from one equilibrium, it is possible that capacity expansions resulting in marginal cost reductions by both firms could benefit both. Such moves would (clearly) also benefit consumers because price would fall). A best response of either firm to a capacity increase of the other can be to increase its own capacity.[11] However, each firm might be reluctant to be the first mover to increase capacity if each is uncertain about the consequences of such a move in terms of the response of the other.

This would especially be so if, rather than competing in the market, the two firms were to be cooperating to achieve a monopoly price and to split monopoly profit. As noted earlier in the previous section, to maintain this strategy as a (repeated game) Nash equilibrium it is necessary that both firms be able to detect and respond to cheating by the other (i.e., to be able to implement punishment strategies). In such a case, addition of capacity might be seen as a signal by one firm of the other's intent to cheat. In this case, both firms would have an incentive not to add capacity, for fear of transforming a monopolistic equilibrium into a Cournot equilibrium, with attendant loss of rent to both firms.

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[11] Indeed, in the situation as posed, it would be in either firm's interest to increase capacity even in the absence of an initiating move on the part of the other firm.

If firm 1 were to receive an operating subsidy, this would be equivalent to a lowering of marginal cost without a corresponding increase in recurring fixed cost. This would enable the firm to capture market share from its rival, but it could only realize this additional share if it were to increase its capacity. But, in this case, the increase net revenue enabled by a capacity increase is augmented by the subsidy. The opportunity cost associated with the reduction of marginal cost rather is borne elsewhere in the economy (or, in the event that firm 1 is foreign-owned, perhaps in some other economy). Under most circumstances, this latter would be undesirable, because a wedge would be created between prices and the opportunity costs associated with meeting demand at those prices. This would in turn result in a misallocation of resources; excess resources would flow into telecoms, at the expense of better opportunities elsewhere in the economy. However, it is possible by the above reasoning that a recipient of a subsidy might be less adverse than an unsubsidized firm to investing in a capacity increase because it can be more certain of a positive outcome, i.e., increased market share and increased profit. This in turn could drive a positive outcome if the result were to be that rivals also would make such an investment such that all firms (and consumers) were to be better off than before. But, as already suggested, the outcome could also be bad, if the non-subsidized firm would be driven from the market that would otherwise, in the absence of subsidies, be viable participants in the market. Exactly what outcome would prevail, or would likely prevail, depends upon specific circumstances, e.g., the exact cost structures of firms including the relationship between marginal cost and capacity.

More consideration of subsidization is provided in the following section.

CROSS-BORDER INVESTMENT

Now, consider the following: there are two geographically separated markets for our stylized telecom services, and each market is initially structured as a government-enforced monopoly. We adopt the following convention: for market-specific variables or parameters, a single subscript will be used to denote the market to which that variable or parameter applies. Thus, we write for example inverse demand functions as $p_i = A_i - B_iQ_i$ where the subscript i ($i = 1$ or 2) indicates that the relevant variable or parameter is for market i. However, for variables that are specific to firms, we use two subscripts to indicate both the identity of the firm (first subscript) and the identity of the market in which it operates (second subscript). Thus, for example, q_{12} would indicate quantity offered by firm 1 in market 2. This second convention is to take account of the possibility that each firm sells in both markets.

If at the outset, both markets 1 and 2 are monopolies, and assuming that firm 1 is the monopoly seller in market 1 and firm 2 is the monopoly seller in market 2, then, in the absence of government regulation, each firm would be expected to price monopolistically in the market in which it operates. In the case of telecommunications, the assumption of no government regulation would not be wholly realistic, or at least not in all markets. However, in many national markets, for example, France, historically telecom service providers have been state-owned firms whose role has been seen by the government as net revenue generators. Such firms indeed have tended to act as unregulated monopolists. In other markets, for example, the United States, a privately-owned monopoly supplier has existed, but subject to price regulation such that the firm was unable to practice monopoly pricing. In order to keep things somewhat simple, in this section we assume that, at the outset at least, the two national markets are more like France than the United States.

In this case, each firm will price to achieve maximum profit in each market, so that price, quantity, and net revenue will be

$$p_i = \frac{A_i + c_{ii}}{2}$$

$$q_{ii} = \frac{A_i - c_{ii}}{2B_i}.$$

Now, consider what might happen if both countries were to end the government monopoly and open these markets to new entry. Suppose that each firm calculates that it can create capacity in the foreign market such that both fixed costs per unit of capacity and marginal cost of production are as in its home market. (This is tantamount to saying that each firm believes that it can transfer technology to the foreign market costlessly, or nearly so.) In that case, $c_{11} = c_{12}$, and also $c_{21} = c_{22}$, so that we can continue to write cost to firm 1 as c_1 and marginal cost of firm 2 as c_2 irrespective of the market to which this relevant cost applies.

From firm 1's perspective, if it enters into market 2, price will fall to the duopoly Cournot level, so that it will increase its net revenues by

$$\pi_{12} = \frac{A_1^{\;2} - 4A_1c_1 + 2A_1c_2 + 4c_1^2 + c_2^2 - 4c_1c_2}{9B_1}$$

and, of course, if $\pi_{12} < F_{12}$, this firm will not enter this market. Note of course that F_{12} must create enough capacity for firm 1 to be able to service q_{12} of demand, where q_{12} is the demand at the Cournot equilibrium. For the moment, let us abandon the assumption of the previous section that marginal cost declines as capacity is increased, but retain an assumption that the recurring fixed cost per unit of capacity is constant. We can see from above that

$$\frac{\partial \pi_{12}}{\partial A_1} = 2A_1 - 4c_1 + 2c_2$$

So, subject once again to a feasible operation condition $2c_1 < (A_1+c_2)$, the net revenue realizable from entry into market 2 rises as the size of market 2 increases. Also,

$$\frac{\partial^2 \pi_{12}}{\partial A_1{}^2} = 2 > 0$$

so this net revenue increases without bound and at an increasing rate. If unit fixed cost of capacity is constant, there is some size of market for which firm 1 would want to enter market 2, i.e., there exists some K for which $\pi_{12} > F_{12}$ if $A_1 > K$.

However, it is also true that firm 1 faces the possibility of entry of firm 2 into its home market. If this were to occur, firm 1 would lose net revenue in the home market equal to the difference between net revenue at the monopoly position minus net revenue at the duopoly position. This firm might however be able to recoup part of its loss by shutting what now would be redundant capacity and reducing the recurring fixed cost. Net lost profit in market 1 for firm 1 would be

$$\delta_{11} = \frac{5A_1^2 - 2A_1c_1 - 7c_1^2 - 8A_1c_2 - 4c_2^2 + 16c_1c_2}{36B_1} - \Delta F_{11}$$

where the last term is any recovery of fixed costs in market 1.

The situation for firm 2 is, of course, analogous. Each firm might thus contemplate whether or not it might make more sense to come to an agreement to stay out of each other's market than mutually to enter these markets, in the event that both markets become open to new entry. Such an agreement would be desirable if, for each firm,

$$\pi_{ij} > F_{ij} \text{ but } (\pi_{ij} - F_{ij}) < \delta_{ij}. \qquad (6)$$

In this situation, a strategy for each firm to agree to stay out of each other's markets, with a punishment strategy of "if you enter my market, I will enter your market", Pareto-dominates the strategy "I'll enter your market, and you can make up your own mind whether to enter my market". Importantly, the punishment strategy is clearly sub-game perfect.

What is interesting to contemplate at this point is the situation where only one market is open, but the other remains a governmentally enforced monopoly. In this case, the firm whose home market is closed has an incentive to enter the other market. The punishment strategy is moot, because entry by the other firm is not possible. Hence, the following rather provocative (and, to most observers, counter-intuitive) possibility opens itself: if a government seeks to achieve more competition in its home telecom market, its best strategy might be unilaterally to open this market, without insistence that there be any reciprocation on the part of governments of countries in which potential new entrants currently act as suppliers. Indeed, reciprocal opening could retard entry.

Is there a downside to a government doing this? One downside is that the foreign entrant will garner some rent from the home market, creating a claim by foreigners on national resources.[12] Another downside occurs if the new entrant believes that it can force the incumbent firm out of the market so as to establish itself (the new entrant) as the monopoly supplier. This, as touched upon in the previous section, requires that the new entrant prices in such a way so that the incumbent is unable to earn enough net revenue to cover fixed costs.[13] But, also, it requires that the new entrant be able to raise prices to monopoly levels after the exit of the incumbent and to do so without risk that the incumbent will re-enter the market.

Under these circumstances, does it pay for the new entrant to use monopoly rents garnered in its home market to subsidize its operation in the foreign market in order to drive out the incumbent? Perhaps the first thing to be said is that subsidization of the foreign operation is not, in general, a profit-maximizing strategy, and hence the only reason that the strategy would be rationally pursued is to attempt to drive out the incumbent to establish a monopoly. To show that the strategy is not profit-maximizing, suppose that marginal cost is again c_1, but that the firm prices below the Cournot price implied by c_1, where this price p is given by (3a). Call the subsidized price p_s, where $p_s = (1-k)p,\ \ 0 \leq k < 1$. Note that

[12] This possibility has been one of the major concerns of the "new trade theory", which is of course no longer so very new; see Brander and Spencer (1985) for a full treatment of this issue.

$$p_S = (1-k)p = (1-k)\frac{A_2 + c_1 + c_2}{3} = \frac{A_2 + (c_1 - s) + c_2}{3}$$

where $s = k(A_2+c_1+c_2)$, such that a new Cournot equilibrium is reached where firm 1 behaves as though marginal cost is $(c_1\text{-}s)$ where s is a subsidy component. At this new equilibrium, total revenue, using (3a) and (3b), is

$$p_S q_{12S} = \frac{A_2 + (c_1 - s) + c_2}{3} x \frac{A_2 - 2(c_1 - s) + c_2}{3B_2},$$

where the subscript s indicates that these are at the subsidized price. The net gain or loss in revenue from subsidization is just the terms involving s, or

$$\Delta revenue = \frac{A_2 s + 4c_1 s + c_2 s - 2s^2}{9B_2}.$$

This term is unambiguously positive for small k because, given the definition of s, $2s < (A_2+4c_1+c_2)$ if $k < 0.5$. The change in variable costs (i.e., not counting any increase in recurring fixed costs required to meet the additional demand created by the subsidized price) is $c_1(q_{12S}\text{-}q_{12})$, where q_{12S} is given, using (3b), by

$$q_{12S} = \frac{A_2 - 2(c_1 - s) + c_2}{3B_2}.$$

Thus, the change in cost is

$$\Delta cost = \frac{2c_1 s}{3B_2}$$

The change in net revenue thus is

$$\Delta NR = \frac{A_2 s - 2c_1 s + c_2 s - 2s^2}{9B_2}.$$

[13] If there are costs to exit, the incumbent might not exit even if net revenue fails to cover recurring fixed costs, especially if the incumbent believes that the adverse situation will not be sustained. This reluctance to exit will be reinforced if there are costs associated with re-entry. On this, see Dixit, Pindyck, and Sodal 1999.

But is ΔNR positive or negative? A condition for it to be negative is that $2(c_1 + s) > (A_2 + c_2)$. But, again, $s = k(A_2+c_1+c_2)$, so this condition is equivalent to

$$c_1 > \frac{(A_2 + c_2)}{2} x \frac{(1-2k)}{(1+k)} ;$$

in fact, however, for small k this condition is likely not to be fulfilled, because the dominance of fixed costs in the total cost structure of the firm implies that, in order to be in business, $c_1 << A_2$. However, this reminds us that a condition for the subsidy to be warranted (in the absence of the possibility that the subsidy will serve to put a rival out of business) is not simply that it result in an increase in net revenue, but that increase in total costs be covered. In other words, it is not sufficient that $\Delta NR > 0$, but that $\Delta NR > \Delta F$, where the latter is the increase in recurring fixed costs associated with the increase in capacity necessary to service the additional demand placed on firm 1 by virtue of the subsidy. Without specifying what the exact cost of capacity is, we cannot explicitly evaluate whether this condition is met or not. What we argue is, it is likely not met.

Let us now return to the case where both markets have opened. We have argued that mutual market opening might not lead to each firm electing to enter the other's market, a desirable outcome from the perspective of public policy. However, the conditions for mutual non-entry to be a sub-game perfect repeated non-cooperative Nash equilibrium (6) might not hold. It in fact might be optimal for one firm to enter the other's market even if to do so would almost surely mean that the move would be reciprocated, i.e., the second firm would enter the home market of the first. However, this situation will always be asymmetric—if one firm prefers cross entry of both firms into each other's home markets to each firm staying at home, the other firm will prefer that both firms stay at home. If the cost structures of the two firms are not too different from each other, the firm from the smaller market will be the "aggressor" (again, assuming that (6) does not hold), but if the cost structures do vary, the aggressor could be the low-cost firm. In other words, foreign direct investment could be driven by either "market pull" or considerations of relative efficiency.[14]

[14] In an earlier article (Graham 1998), I have shown that in an oligopoly context, and contrary to much of the literature on FDI, it is not necessarily the most efficient firm that becomes a foreign direct investor.

CONCLUSIONS AND SOME DIRECTIONS FOR FUTURE RESEARCH

As noted in the introduction, issues addressed in this chapter go beyond the specific circumstances of the telecommunications sector. Issues such as under what circumstances will a firm cross national boundaries to invest in markets in which other firms already participate, where these latter incumbent firms might react to this move by themselves investing in the home market, are obviously ones that are raised in virtually all sectors. Indeed, the sector specifically considered in this chapter, telecommunications, is one in which cross-border direct investment until relatively recently generally did not take place. If nothing else, this paper strives to show that the oligopolistic nature of this, and many other sectors, complicates the answer to this issue. It is not, for example, necessarily true that cross-border entry can be expected whenever the would-be investor can expect to garner satisfactory returns in the new market by investing there. Rather, the investor has to take into account the possibility of lost profits in its home market.

Alas, the modeling of the dynamics of competition in an oligopolistic market remain difficult. The Cournot conjecture used in this chapter is not wholly satisfactory in terms of a “reality test” (i.e., does it capture anything like real firm behavior) and, accordingly, one does not have full faith in the equilibria that are derived from employment of this conjecture. This remains true in spite of work that suggests that Cournot equilibria might be more robust than the conjecture from which they are derived.

This type of objection notwithstanding, amazingly little research on multinational firms takes into explicit account the fact that these firms participate in oligopolistic markets whereby the strategic moves of any one firm must always be conditioned upon the expected response of rival firms. Indeed, given the lack of accounting for this important but difficult-to-model aspect of the dynamics of competition among these firms, one can legitimately question whether many of the conclusions arrived at regarding the benefits of multinational investment are wholly correct. It is therefore hoped that this paper both makes a little headway in addressing this lack of research and, at the same time, points the way for future research.

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