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By

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ABSTRACT

THREE ESSAYS ON THE STRATEGIC BEHAVIOR OF PARTIALLY-REGULATED FIRMS

By

Leslie Margaret Schenk

(1) Strategic Behavior of Partially-Regulated Multiproduct Firms

This paper examines several effects of partial regulation of a multiproduct firm with common costs of production across regulated and unregulated markets. Contrary to previous results, it is shown that the spillover effects regulation has on firm behavior in unregulated markets is dependent on the level of common costs. Spillover effects occur whether the regulated firm is a price taker in unregulated markets or has market power. Consumer welfare in the regulated market can actually be lower under partial regulation than if the firm were an unregulated monopolist in that market. Partial regulation is also shown to have non-negligible effects on the strategic positions of duopolists in unregulated cost-related markets.

(2) Turning Top Dogs into Fat Cats -- Is Partial Regulation a Form of Genetic Engineering?

The role that the form of market competition plays in the effects of partial regulation is explored in this paper. In a duopoly model under both quantity and price competition, it is shown that under certain cost conditions partial regulation forces the regulated firm away from its otherwise optimal

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business strategies in its unregulated markets. Under other cost conditions, total output in the unregulated market will be closer to the monopoly level under partial regulation, with regulation providing the commitment necessary to achieve this result. The effects of partial regulation in both static and dynamic settings are examined.

(3) Spillover Effects of Partial Price-Cap Regulation

In contrast to previous work, this paper demonstrates that spillover effects existing under partial FDC regulation still can be experienced under price-level regulation. The model developed here sets price caps more realistically than did previous work, and considers the effect the price cap *level* has on the partially-regulated firm's behavior in both its regulated and unregulated markets. Even under price capping, the partially-regulated firm must take into account the opportunity cost production in the unregulated market has on the level of allowable revenues in the regulated market. This internalization of marginal costs occurs even in the absence of artificial cost allocation mechanisms such as those used under FDC pricing.

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I would also like to thank Paul Segerstrom for his assistance at defense time. Early encouragement from Richard Greenberg and Bill Becker cannot go unmentioned. Discussions and assistance from Hailong Qian were invaluable. Thanks also to Paul Loetscher, fellow A.A.Milne aficionado, for being a frequent sounding board.

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CHAPTER 1

STRATEGIC BEHAVIOR OF PARTIALLY-REGULATED MULTIPRODUCT FIRMS

1. Introduction

This paper examines several effects of partial regulation of a multiproduct firm. A firm is said to be partially regulated when economic regulation[1] (i.e. restrictions on price, investment, entry and/or exit) is imposed on a proper subset of the firm's output range. Partial regulation can result when a regulator opens a previously regulated market to entry and/or relaxes pricing restrictions in that market, or when a regulated firm is allowed to enter unregulated markets it did not previously operate in. Partial regulation of multiproduct firms has recently been the focus of major regulatory proceeding, as exemplified by the move to reregulate some products in the cable television industry and by recent changes in the regulation of telecommunications firms and electric utilities. Regulation of a multiproduct firm in one product market can affect that firm's behavior in its unregulated product markets if the markets are linked. Links between the product markets can result when the goods are cost-related, e.g. because they use common production facilities, (for example, local telephone operating companies provide both residential and business services with the same switching facilities).

Previous studies by Sweeney (1982) and Braeutigam and Panzar (1989) (hereafter BP) have modeled a multiproduct firm selling output in an unregulated marke

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market while under 'cost-based' regulation in another product market, where the product markets are linked by a fixed common cost of production which cannot be attributed to either product market. BP found that the firm will not produce the unregulated service in a perfectly competitive market up to the level at which price equals marginal (social) cost in that market. The firm is Pareto inefficient -- given any observed level of the regulated service, the firm chooses an inefficiently low level of the unregulated service. The firm underproduces the unregulated service because every unit of this service produced not only costs the firm the marginal production cost, but also reduces the amount of common cost that can be allocated to the regulated market. Sweeney found qualitatively similar results, assuming that the multiproduct firm had market power in the unregulated market.

In this chapter I first relax assumptions of BP and Sweeney concerning the regulatory constraint to show that for certain levels of common cost, the multiproduct firm will produce more in an unregulated market when regulated in a related market than they would if they were unconstrained (i.e. faced no regulatory constraint) in any product market. In this 'overproduction equilibrium', the elasticity of the regulatory constraint, which is a link between the two markets, plays a crucial role. This result holds when the multiproduct firm is a price taker or has market power in the unregulated market. In the case of imperfect competition in the unregulated market, where the effects of partial regulation on the multiproduct firm's rivals have not previously been addressed, regula

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regulation in one market is shown to have a non-negligible impact on the strategic positions of both duopolists in the related unregulated market. In addition I show that there is a strategic effect to partial regulation: the conditions under which partial regulation results in this 'overproduction equilibrium' are weaker when the firm is a Cournot duopolist in the unregulated market than when it is a price taker and therefore cannot act strategically with regard to competitors in that market.

These spillover effects of partial regulation onto an unregulated product market, and the strategic effect when the firm is not a price taker in that market, indicate that regulators should consider the level of common costs and the market structure most likely to result in the unregulated product market when deciding whether to partially deregulate a firm, or when addressing the issue of the regulated firm's entry into unregulated markets. This is true if the regulator is concerned with the effects of partial regulation on total welfare in all the multiproduct firm's markets, but especially if it is concerned only with welfare in the regulated market, because consumer surplus in the regulated market can be less under partial regulation than when the multiproduct firm is an unregulated profit-maximizing monopolist in that market.

2. Literature Review

Partial regulation of multiproduct firms is increasingly being employed as a regulatory policy-making tool. Under partial regulation, the market for some regu

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regulated products or services are opened to entry, pricing restrictions are lifted, or markets are otherwise (economically) unregulated while the markets for other services produced by the firm are regulated. A regulator may partially deregulate a firm which was fully regulated as an intermediate step to full deregulation, or may continue to regulate a firm's existing product markets as a means to protect some set of 'core' customers from monopoly power while freeing the firm to enter other product markets. For example, after the breakup of its telephone monopoly under the Modified Final Judgement (MFJ), AT&T faced competition in the provision of long-distance telephone service, although still subject to some restrictions on this and other services, while being allowed to enter some unregulated markets (e.g. computers, real estate). After divestiture of AT&T, local operating companies (former Bell Operating Companies or BOCs) were also allowed to enter certain unregulated markets through line-of-business waivers, while still regulated in the provision of local exchange services. By 1980 (after the Interstate Commerce Commission (ICC) liberalization of rail rates and contracting in the late 1970's and the Staggers Rail Act of 1980) railroad could set their own rates, except for certain commodities which were subject to market dominance and rate reasonableness guidelines (to protect 'captive' customers)[2].

Justification for partial deregulation in telecommunications, cable television, and other industries has followed from the original justifications for regulation. Regulation of a natural monopoly typically occurs under conditions

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of economies of scope or scale, subadditivity of costs, or when policy goals warrant regulation. Due to technological changes in certain industries, some traditionally regulated services are no longer most efficiently provided by a single, protected monopolist. Regulators are redefining the regulatory domain to include goods or services characterized by large sunk costs (e.g. in telecommunications: local cable and wires), while opening to entry portions of the regulated monopolist's product mix that have technologies or manufacturing processes that are more inherently capable of competitive supply (e.g. terminal equipment and wireless transmission services) (Bailey and Friedlaender, 1982).

The efficiency case for government regulation requires demonstration of market failure. Regulation of a natural monopoly in practice is often a third-best solution, and if competition can be promoted on some product lines without exposing the firm to operation at negative total profits, total welfare could be raised. It has been argued that continued full regulation of the incumbent firm, while competitors are allowed to enter some of its product markets and operate freely, will lead to 'cream-skimming,' with the regulated monopolist left only the most costly, unprofitable services to offer (Brock and Evans, 1983). Such entry could be inefficient if economies of scope or scale exist, but the incumbent firm can no longer fully exploit them. Cream-skimming can also lead to increases in regulated service prices (to meet the profit constraints) and therefore may threaten regulatory goals such as universal service.

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Prohibiting regulated firms from entering other (unregulated) markets can be anticompetitive (artificially limiting the number of firms in those markets) and inefficient (firms should diversify to the full extent that production minimizes costs) (Bork (1978) and Brennan (1987)). Full deregulation is not always preferable though. Partial regulation may still be desirable to ensure that consumers of products that cannot be competitively supplied (e.g. due to high fixed costs or economies of scale) will still be protected from monopoly power. Recent experience with the U.S. cable television industry illustrates this: the Federal Communications Commission (FCC) has re-regulated certain product lines after deregulation of the industry failed to create competitive environments.

When a multiproduct monopoly is partially deregulated, policy rules implemented in the still-regulated product markets may facilitate the use of regulation as a 'predatory'[3] tool in the deregulated markets when these markets are linked. One linkage between product markets exists because inputs can be used to provide multiple services, with the costs of such inputs not accurately attributable between each service. For example, in railroad transportation the cost of the track is common to both passenger and freight transport, while the cost of the different cars to carry each type of traffic is attributable to the specific market. Generators and switching equipment are common inputs shared by business and residence customers in electric utilities and telecomm

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telecommunications, respectively, while the cost of wire leading from a trunk line to the individual subscriber is an attributable cost.

When a multiproduct firm has cost-related outputs, the regulator cannot determine the appropriate pricing rule, because it cannot determine the true (social) cost of producing each product. One typical way multiproduct firms with common costs have been regulated is by a method generally known as 'cost-of-service' or fully-distributed cost (FDC) regulation. The regulated firm is allowed to choose output levels (prices) that maximize profits subject to the constraint that total revenues in that market can be no more than 'total' costs, which include both costs directly attributable to that product plus a 'fair' share of common costs. 'Fair' shares have generally been considered those which avoid cross-subsidization of one product at the expense of customers of another product[4]. The share of common costs to assign to each product market has been in practice determined by some (ad hoc) allocation rule. Allocation rules used have been based on relative outputs, relative attributable costs, and relative gross revenues, among other specifications[5]. Tariffs based on FDC pricing have been used, for example, by the FCC and the ICC.

In the early literature on fully-regulated firms (Averch and Johnson (1962) is the seminal work in this area), it was argued that predatory behavior could result under rate-of-return regulation[6] because a firm pricing below cost in one market to forestall entry in that market could cross-subsidize the loss by allocating that service's share of common costs to other services. As long as the incre

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the increased net revenues in the monopoly market more than offset the losses encountered in the competitive market, sales below long-run marginal cost in the competitive market would be profitable. This overproduction (compared to the efficient case) in one market could result in inefficient entry, as more efficient firms (e.g. firms able to adopt new technology more quickly) would be discouraged from entering. But such studies assume, contrary to observed regulatory behavior, that the firm itself chooses the level of common costs to allocate to each market, rather than be subject to an allocation rule chosen by the regulator, thus allowing for predatory behavior. Baumol et al. (1979) and Braeutigam (1980) examine rate-of-return regulation and the effects of different cost allocation schemes under FDC regulation respectively, also in the context of a fully-regulated multiproduct firm.

An important consideration in examining the effects of partial regulation is the influence of the market structure in the unregulated market. Early work on the regulation of multiproduct firms focuses on firms that operate as a monopolist in all markets they serve (Averch and Johnson; Baumol and Bradford, 1970). Others examined a firm with economies of scale who faces intermodal competition with no scale economies (Braeutigam, 1979), a firm with economies of scale facing competition in homogeneous products where all firms are regulated (Baumol, Panzar and Willig, 1982), and a competitive unregulated market where all firms have economies of scale but rivalry takes place i

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place in differentiated product markets (Braeutigam, 1984). These papers examined the determination of efficient Ramsey prices for multiproduct firms.

BP assume that a partially-regulated multiproduct firm under FDC pricing is a price taker in the unregulated market. They find that the partially-regulated firm will underproduce the unregulated products relative to the unconstrained level. Common costs are reallocated to the regulated markets to gain permanent additional profits[7] in those markets at the expense of a permanent sacrifice in profits in the unregulated market.

When the market to be deregulated is one in which there are multiple firms operating (e.g. the U.S. airline or trucking industry), or when deregulation involves allowing a regulated firm to enter unregulated product markets it did not previously operate in (e.g. AT&T supplying computers after divestiture), an assumption of perfect competition in the unregulated market may be reasonable. If instead a regulator opens a previously regulated market to entry and/or lifts pricing restrictions in that market, imperfect competition may be the more appropriate post-deregulation market structure characterization for that market, especially if regulation was originally imposed because of market or production conditions that may still exist. Economies of scope or scale may still be operating to some degree (even though regulation on these product lines is now deemed unnecessary -- perhaps for political reasons only), or substantial investment in fixed costs may be needed to enter the market, thus limiting potentia

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potential entrants. Strategic behavior by the now partially-regulated firm, and the unregulated entrant(s) should then be addressed.

Sweeney obtains qualitatively similar results to BP, although he assumes that the multiproduct firm faces downward-sloping demand curves in its unregulated markets and therefore has market power in those markets. He also finds that output in the unregulated market is lower in the partially-regulated case -- production is at a level where marginal revenue exceeds marginal cost. Sweeney does not however address strategic behavior in his model, as the demand faced by the partially-regulated firm in any unregulated market is a function only of its own output in that market. He does however state (without explicitly modelling it) that changes in output induced by the FDC rate-of-return regulation in the regulated market could affect prices faced by rivals in the unregulated market. Sweeney and BP's results however are dependent on strict assumptions on the level of common costs.

The aim of this work is first to generalize the results of previous models by relaxing restrictions imposed on the level of common costs, and then to determine the effect of partial regulation on the strategic behavior of the partially-regulated firm and its rival. The assumptions that Sweeney and BP make that restrict the level of common costs concern the relationship between the unconstrained (i.e. no regulation in any market) equilibrium output combination and the regulatory constraint. BP assumed that when the multiproduct firm is only producing one service and is unregulated, that it is

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earning extranormal profits. Sweeney assumes that at least one of the regulatory constraints[8] would be violated at the unconstrained profit-maximizing output combination, i.e. that 'the constraints are sufficiently restrictive to affect the firm's behavior'. Both assumptions in effect restrict the level of common costs for the multiproduct firm.

BP and Sweeney's restrictions eliminate interesting cases (from the regulator's point of view) from consideration. Cases may exist where, e.g. after demand or technological changes, the regulatory constraints are violated at the resulting output levels, and this violation is 'allowed' because of regulatory lags. In addition, regulators may implement partial regulation without regard to historical profit/loss figures, if regulation is deemed necessary on non-economic grounds. From an institutional standpoint, there is no justification for making such restrictions on the relationship between unconstrained output vector and the regulatory constraint (i.e. on the level of common cost for the multiproduct firm). No such restrictions are made in the models below; this paper examines more general cases than previously considered.

I also examine the strategic role of partial regulation. Market interaction affects incentives in the unregulated market. Sweeney, although incorporating market power in his model of the unregulated market, does not model the rival firm's reaction to the effects of partial regulation. Strategic interaction in the unregulated market is explicitly modeled in this paper, assuming Cou

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assuming Cournot duopoly. When common costs are allocated as a function of output, the multiproduct firm must incorporate some fixed costs into their decision-making process under cost-based regulation. In this way partial regulation changes the objective function in both the regulated and unregulated markets. For substantial levels of common costs, the feedback effects from the regulated market can force the multiproduct firm's rival into a weak position ('underproducing') with the result that the partially-regulated firm may be made a 'top dog'[9] in the unregulated market, to its advantage and the rival's detriment. The resulting 'overproduction' by the partially-regulated firm has commitment value, because it is controlled by the actions of a third party (the regulator). Therefore partial regulation can have a non-negligible impact on the strategic positions of duopolists in an unregulated market.

In addition, the level of common costs under which 'overproduction' in the unregulated market will occur is lower than the level of common costs for which this result obtains under perfect competition. The partially-regulated firm knows that as a Cournot duopolist in the unregulated market it takes into account the actions of his rival when making output decisions for that market. Therefore the firm knows that, compared to when it is a price taker in that market, it produces less as a duopolist. Effective average cost in the regulated market also depends on the type of competition faced in the unregulated market when common costs are allocated as a function of output, and so the output level

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The results show that partial regulation has differential effects depending on the level of common costs of production, and depending on the type of market structure in the unregulated market. Regulators need to take into consideration these conditions, therefore, when determining the welfare effects of partial regulation compared with full deregulation. Welfare effects are especially important from the regulator's standpoint: when common costs are substantial and the regulated firm is 'overproducing' in the unregulated market, output is lower (than the unconstrained level) in the regulated market, and therefore price is higher than what it would be if it were an unregulated profit-maximizing monopolist. In this case, consumer surplus in the regulated market is actually less under partial regulation than under no regulation. Partial regulation would be hurting the group it may be designed to protect.

In this model I assume a simplified version of partial regulation. The multiproduct firm is assumed to be operating under cost-of-service regulation in one market, while being free to choose the level of unregulated output, given common costs are allocated according to a rule. Partial regulation is usually more complex in structure and often involves nonprice operating characteristics. A firm may be restricted in what markets it can enter (under the MFJ breaking the AT&T monopoly, BOCs were restricted from entering the long-distance market), in what products it can produce (BOCs cannot produce but can sell

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but can sell customer premise equipment), or are restricted from discriminating between customers (BOCs must have facilities which can provide equal access to its customers to all long-distance carriers). These and other restrictions are sometimes seen in conjunction with pricing restrictions (e.g. some electric utilities are required to buy a certain portion of their power from independent producers, as well as are restricted by cost-of-service regulation). The model of partial regulation developed below abstracts from these complexities in order to focus exclusively on the issue of the spillover effects of regulation in one market on a related market. The clearest examples that fit the model below would be deregulation whereby a regulated firm under FDC pricing is allowed to enter unregulated product markets, e.g., BOCs entering unregulated businesses like real estate through line-of-business waivers.

The next section outlines the general model specifications and then examines the case of partial regulation when the unregulated market is perfectly competitive. Qualitatively similar results are found when the firm has market power in the unregulated market, but cannot act strategically against rivals. The basic model is then extended to allow for strategic behavior in the unregulated market. Cournot duopoly is considered as a simple way to model imperfect competition while focusing on the effects of partial regulation. In this case more general cost functions are considered than previous work in this area has examined. The results under perfect competition and Cournot duopoly will then be compared to demonstrate the differential effect partial regulation has under different market structures, therefore showing a strategic effect. The last section summarizes the results and discusses extensions of the basic model.

3. Partial Regulation with Perfect Competition in the Unregulated Market

First consider a baseline model of an unregulated firm serving two markets. This firm is a monopolist in market 1 (the 'core' service), producing a level of output given by q_r (as this will be the regulated market below). Inverse demand in this market is given by $P_1(q_r)$ and is assumed to be downward sloping. The multiproduct firm is a price taker in market 2, with output denoted by q_m (the 'noncore' service, where the subscript refers to output by the multiproduct firm). In this market the multiproduct firm faces many competitors, each producing a single[10] output q_s, with total cost function given by $c_s(q_s)$. Price in the noncore market is determined by the condition that all competitors (other than the multiproduct firm) are in long-run equilibrium, i.e. by the condition $P_2^* = c_s' = c_s/q_s$ (with the prime denoting the first derivative). The core and noncore services are not demand-related.

The cost function for the multiproduct firm has the form

$$C(q_r, q_m) = F + c_r(q_r) + c_m(q_m) \tag{1}$$

where $c_r(q_r)$ and $c_m(q_m)$ are the costs of production that can unambiguously be associated with the production of the core and noncore services[11]. F is a fixed common[12] cost that results from production of both services but which cannot be accurat

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be accurately assigned between the two services. Let $c_r(q_r)$, $c_m(q_m)$ and $c_s(q_s)$ be continuously differentiable over the interval $[0, \infty)$, with positive first derivatives. To ensure that the regulated firm is 'small' in the noncore market and therefore unable to influence the equilibrium price P_2^*, let $d^2c_m/dq_m^2 \geq 0$ at the optimum (i.e., the regulated firm has nondecreasing marginal costs in the noncore market)[13].

The model is one of full information: cost functions and demand conditions are assumed to be known by all agents before competition begins.

It is assumed that the multiproduct firm cannot change its technology to use production methods with only attributable costs -- if the multiproduct firm wants to continue producing both services it must use technology involving common costs (e.g. to offer both residential and business telephone service, the local telephone company must use the same switching equipment). The level of common costs is taken as given.

3.1 The Unregulated Benchmark Case

When the multiproduct firm is unconstrained by regulation in either market, it chooses output levels q_r and q_m to maximize profits

$$\pi(q_r, q_m) = q_r P_1(q_r) + q_m P_2^* - F - c_r(q_r) - c_m(q_m) \qquad (2)$$

The first-order conditions for the multiproduct firm are given by (with arguments omitted for brevity)[14]:

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$$P_1 + q_r \frac{\partial P_1}{\partial q_r} - \frac{\partial c_r}{\partial q_r} = 0 \tag{3}$$

$$P_2^* - \frac{\partial c_m}{\partial q_m} = 0 \tag{4}$$

The firm will choose output levels in each market at which marginal revenue is equal to marginal cost. Although production in the two product markets is linked for the multiproduct firm because of the common factors of production, the output decision rules for the two markets are unrelated. The common cost affects only the level of total profit for the multiproduct firm, not the level of marginal profit, and therefore does not affect its production level decisions (assuming an interior solution).

3.2 Partial Regulation

Common cost F plays a central role however in the behavior of the multiproduct firm under cost-based regulation. FDC pricing is assumed. Unattributable costs now enter production decisions because the multiproduct firm is required by the regulator to allocate a portion of the common costs to each service according to a formula in an attempt to assign a share of common costs to each service. Let the allocation function

$$0 \leq f(q_r, q_m) \leq 1$$

represents the portion of F allocated to the core market; $f(q_r,q_m)$ is assumed to be monotonically increasing in core output $(f_r>0)$[15] and monotonically decreasing in noncore output $(f_m<0)$. Common costs are fully allocated between the two services. The actual form of the allocation function is chosen by the regulator. For example, one frequently used allocation function is based on relative outputs (i.e. $f=q_r/(q_r+q_m)$)[16].

The regulator's goal is to maximize core consumer surplus subject to the regulated firm earning nonnegative profits in the core market. To achieve this goal it allows the regulated firm to choose quantity (price) so that the multiproduct firm's revenue from the core service[17] is no more than the total of the costs directly attributable to that service and the allocated share of common costs of production. Under this type of cost-based regulation, and assuming a binding regulatory constraint, the partially-regulated firm's output level in the regulated market is implicitly given by

$$q_r\, P_1(q_r) - c_r(q_r) - f(q_r\,,\, q_m)F = 0 \qquad (5)$$

Under general conditions the regulatory constraint has the following properties[18] at equilibrium: $dq_m/dq_r>0$, $d^2q_m/dq_r^2>0$. Intuitively, the first condition holds because, for a given level of common cost, as noncore output increases, allocated costs in the core market decrease, and so allowed 'operating profit' (revenue less attributable cost) must fall to maintain the constraint, i.e. core output must rise. In $(q_r,\, q_m)$ space, these conditions imply a regulatory constraint which is upward sloping and convex. These conditions imply that the point elasticity of the constraint, $\varepsilon_{rm} = (\partial q_r/\partial q_m)(q_m/q_r)$ is decreasing in q_r.

Given that the regulatory constraint is satisfied at a level of core output given by $q_r^{\bullet}(q_m)$, the multiproduct firm's objective function in the noncore market is to choose q_m to maximize

$$\pi_m(q_m, q_r^{\bullet}(q_m)) = P_2^{\bullet} q_m - c_m(q_m) - [1 - f(q_r^{\bullet}(q_m), q_m)]F \tag{6}$$

The first-order condition for the multiproduct firm in the noncore market is now given by

$$P_2^{\bullet} - \frac{\partial c_m}{\partial q_m} - F\left[\frac{\partial(1-f)}{\partial q_m} + \frac{\partial(1-f)}{\partial q_r}\frac{\partial q_r}{\partial q_m}\right] = 0 \tag{7}$$

Note that the equilibrium level of noncore output is now a function of core output.

Let

$$F\left[\frac{\partial(1-f)}{\partial q_r} + \frac{\partial(1-f)}{\partial q_m}\frac{\partial q_r}{\partial q_m}\right] = MRC_m \tag{8}$$

be known as 'the marginal regulated cost', which is the change in the amount of common costs allocated to the noncore market as the output level of the multiproduct firm in that market changes. MRC_m is the sum of two effects. There is the direct effect of a change in noncore output on the allocated costs. But there is an indirect effect which takes account of the relationship between the regulated and unregulated market: any change in noncore output affects the level of core output that satisfies the regulatory constraint, which in turn affects the level of allocated costs to the noncore market. The direct effect is positive: any increase (decrease) in noncore output will increase (decrease) the portion of common costs allocated to the noncore market. The indirect effect is negative: any increase (decrease) in q_m results in an increase (decrease) in q_r^*, because q_m and q_r are positively related along the regulatory constraint, but an increase in q_r will decrease the amount of allocated costs to the noncore market. In the range where the regulatory constraint is elastic, the indirect effect will dominate the direct effect, and MRC_m will be negative. This results from the fact that in this range, any increase in q_m will result in an even greater increase in q_r. Using the relative output allocation rule,

$$MRC_m = F\left[\frac{q_r}{(q_r+q_m)^2} - \frac{q_m}{(q_r+q_m)^2}\frac{dq_r}{dq_m}\right] \tag{9}$$

Multiplying the right-hand side by q_r/q_r,

$$MRC_m = F q_r\left[\frac{1}{(q_r+q_m)^2} - \frac{1}{(q_r+q_m)^2}\frac{q_m}{q_r}\frac{dq_r}{dq_m}\right] \tag{10}$$

Therefore $MRC_m < 0$ when $\varepsilon_m > 1$. A sufficient condition for $\varepsilon_m > 1$ is that the level of core output under partial regulation is lower than the unconstrained (no regulation) level (proof in Appendix A.2).

Since the marginal allocated cost is negative for the values of q_m in the range where the regulatory constraint is elastic, the effective marginal cost (where effective includes both attributable and allocated marginal costs) is less than the marginal (attributable) costs. For (q_r, q_m) in the inelastic portion of the regulatory constraint, MRC_m is positive, and the effective marginal cost in the noncore market is greater than the attributable marginal cost. The effective MC curve for the unregulated market under partial regulation will therefore pivot around the marginal attributable cost curve, as can be seen in Figure 1, which shows price and marginal cost in the noncore market, for increasing levels of q_m. Effective marginal cost curves shift right as common cost increases. EMC_m^1, EMC_m^2 represent effective marginal cost curves under increasing levels of F. As F increases, the elasticity of the regulatory constraint will be greater than 1 for higher levels of q_m. For high enough common cost, constrained noncore output (q_m^c) will exceed the unconstrained output level (q_m^*). Proposition 1 follows from these conditions[19].

> **Proposition 1:** A multiproduct firm operating under cost-based regulation in the core market while operating as a price taker in the noncore market can be Pareto inefficient. Given any observed level of the core service, the firm chooses a level of noncore service output greater than (less than) the unconstrained level when the level of common cost is sufficiently high (low). For some level of common cost, the constrained level of noncore output will be equal to the unconstrained level.

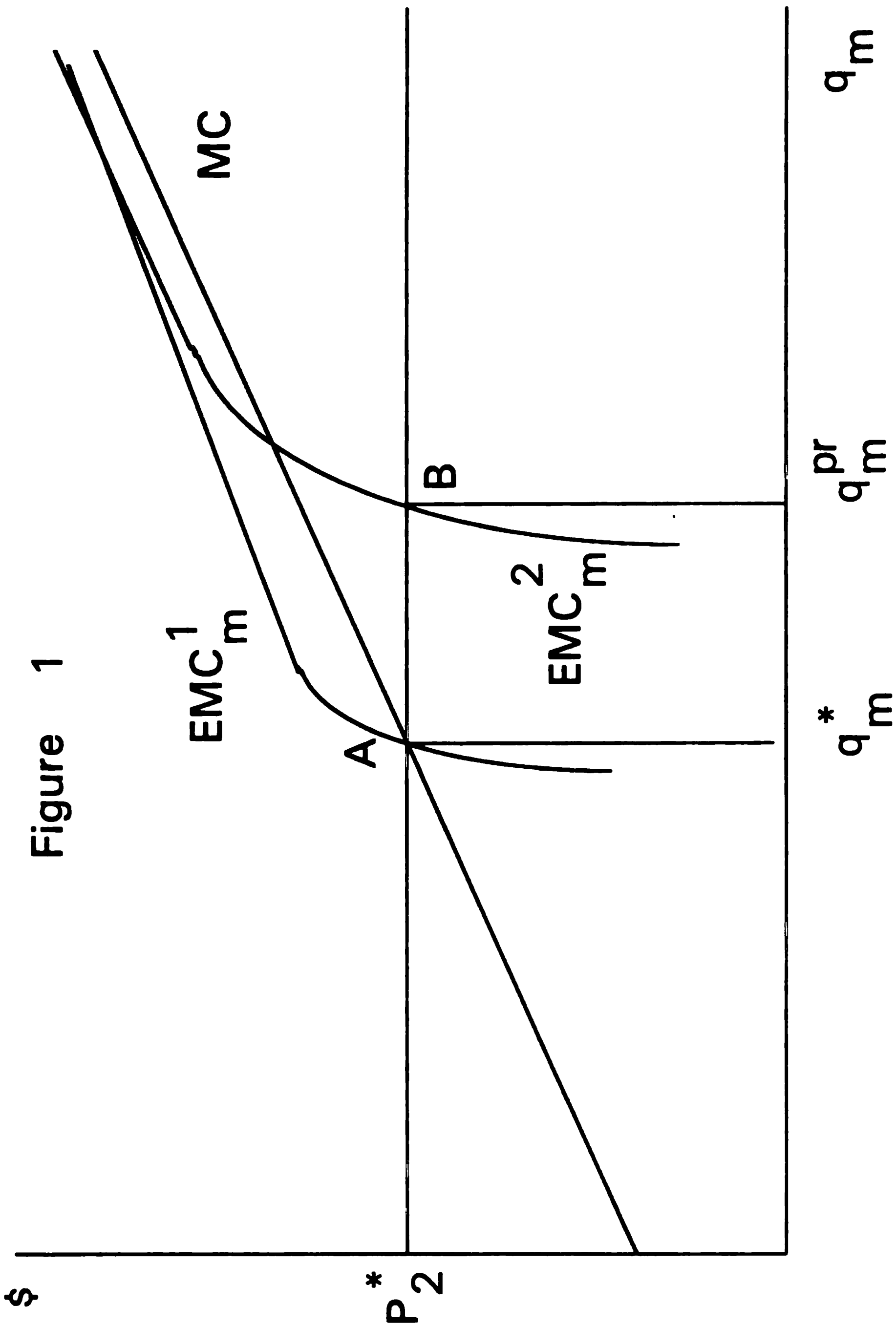

Figure 1

Production in the core market is subsidizing production in the unregulated market. That is, for high common cost, the effective marginal cost for the noncore market is less than the marginal (social) cost of production; the firm is in a sense 'paying itself' to produce noncore output, with revenues in the core market covering these payments. In essence, we get the Averch-Johnson effect ('predatory' behavior in one market 'subsidized' by production in another market) without the problems of the AJ model (i.e., firm choosing allocation of common cost, all revenues included in regulatory constraint).

In this circumstance, consumer surplus (ignoring income effects) is actually lower in the regulated market than it would be if the firm were unconstrained (output is less, price is higher). If a regulatory goal is to 'protect' consumers in this market, full deregulation would be preferable when common costs are high. Total profits of the multiproduct firm will however be less when it is partially-regulated than when unregulated (constrained profit in the core market is zero; in the noncore market, because price is constant and marginal cost is assumed to be nondecreasing, operating profits (total revenue less attributable costs) can be no more than the unconstrained level). Therefore, when common costs are substantial, total welfare will be lower under partial regulation than in the unconstrained case When common costs are low, consumers in the core market gain, consumer welfare in the noncore market is constant, while the multiproduct firm's profits are less than would be under no regulation in either market. The effect on total welfare when the firm has a low level of common costs is ambiguous.

3.3 Comparison with Previous Results

The results in Proposition 1 are more general than the result obtained by BP who found, under partial regulation as specified above, that the multiproduct firm would always underproduce in the noncore service compared to the unconstrained output level. They found that by allocating the common fixed costs based on output levels, for any given level of q_r and q_m, effective marginal costs, (i.e. all costs that are a function of the level of output), are greater under partial regulation in both the regulated and unregulated markets (because $f_m < 0$, $[(1-f)F]$ increases with q_m), resulting in decreased production in the noncore market. The partially-regulated firm is Pareto inefficient in the unregulated market: given any observed level of the core service, the firm chooses an inefficiently low level of the noncore service. Every unit of the noncore service produced not only costs the firm the marginal production cost, but also reduces the amount of common cost that can be allocated to the core market. This tightens the regulatory constraints on the revenues allowed in the core market. The firm will not produce the noncore service up to the level at which marginal production cost (i.e., social cost) and marginal revenue are equated in the noncore market.

BP, however, made an assumption on the relationship between the unconstrained output combination and the regulatory constraint that restricts their results. BP assumed that when the multiproduct firm is only producing the core service and is unregulated, it is earning extranormal profits. Figure 2 demonstrates why this assumption restricts the results. In (q_r, q_m) space, equilibrium core and noncore output levels when neither market is regulated are given by q_r^* and q_m^* respectively. R^i represent the family of regulatory constraints under increasing levels of common cost (i.e., as F increases, for a given level of noncore output, effective average cost in the core market rises, and so P_1 would have to rise to keep the constraint binding, therefore core output would have to fall). Output combinations on or to the right of the constraint are allowed under regulation. BP's assumption allows only regulatory constraints which lie strictly to the right of $(q_r^*, 0)$, e.g., R^1 as shown in Figure 2.

The concentric circles (π^i) in Figure 2 represent isoprofit curves around this unconstrained output vector; profit decreases as the loci move out from (q_r^*, q_m^*). The shape of the isoprofit locus is defined by the conditions that it must be vertically sloped[20] along the line where $q_m = q_m^*$ and horizontally sloped when $q_r = q_r^*$. The solution of equations (5) and (7) is equivalent to the firm choosing output on the highest isoprofit curve which is to the right or on the regulatory constraint (i.e. the point of tangency). Given that the regulatory constraint is positively sloped, equilibrium output levels have to be along the

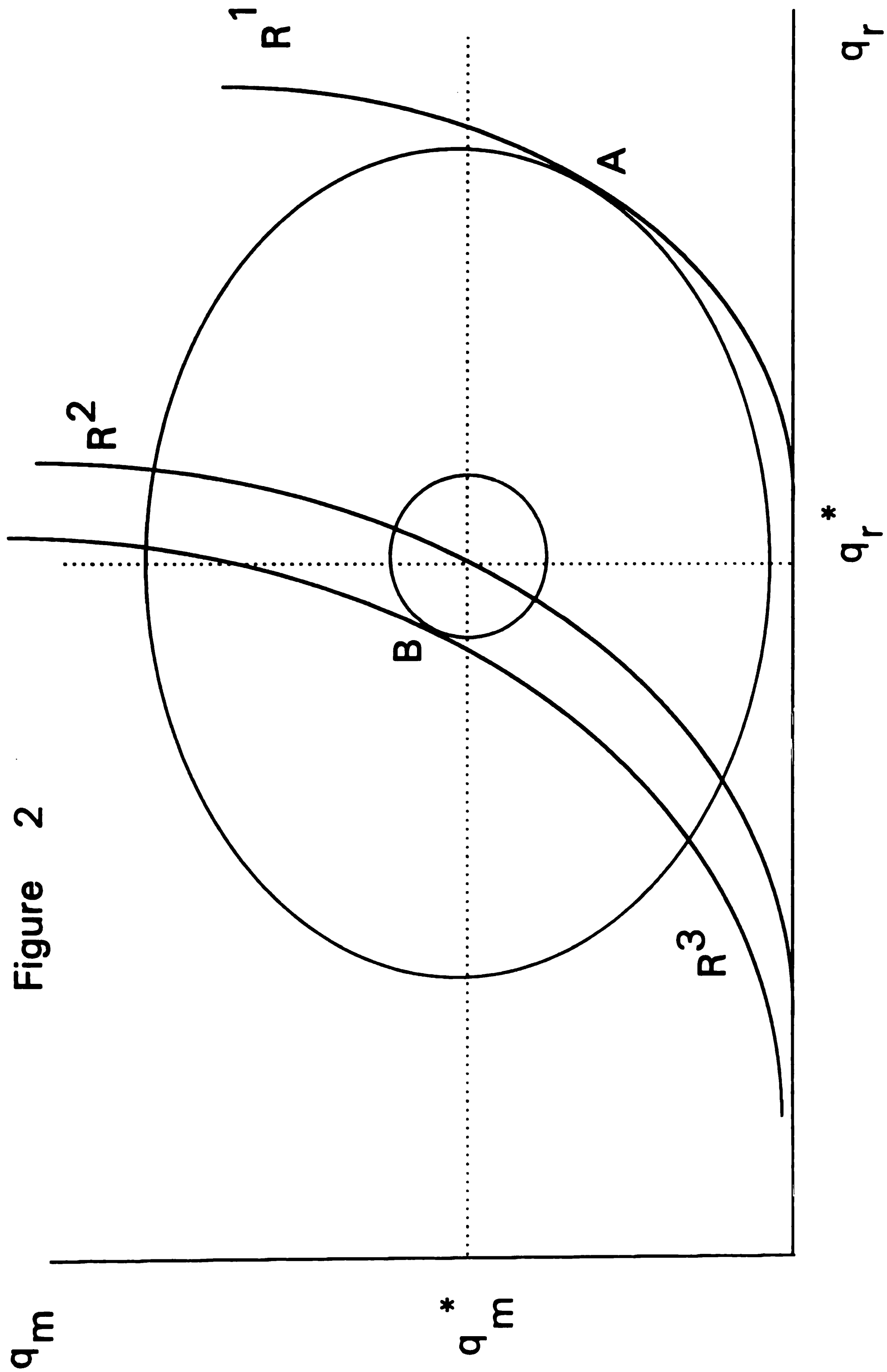

Figure 2

positively-sloped portion of the isoprofit curve. This fact together with BP's assumption therefore restricts the resulting constrained output levels to be in the quadrant southeast of (q_r^*, q_m^*) in Figure 2, with the relevant regulatory constraint given by R^1, i.e., at point A. Relaxing BP's assumption allows regulatory constraints R^2 or R^3 , i.e., allows for the firm to have higher levels of common costs. For high enough levels of common cost, the regulatory constraint can be satisfied at levels of noncore output equal to or greater than the unconstrained level, e.g., point B in Figure 2.

With common costs sufficiently high to result in a regulatory constraint such as R^2, the multiproduct firm would be earning negative profits at the unconstrained undiversified level of output $(q_r^*, 0)$. But it is clear that even if $\pi(q_r^*, 0)$ is negative, the firm's net total profits after diversification can be positive. The cost of common inputs can be spread across two markets, and the firm is guaranteed revenues to cover the share of common costs allocated to the core market. In fact, this is an interesting case to consider: the firm in this case actually prefers to be partially-regulated, as long as it can diversify, than to remain monopoly producer (and unregulated) in the core service only. Production in the core service is 'subsidized' by production in another (unregulated) market in which the firm is a price taker. Also, even though the unconstrained output vector is allowed under partial regulation, it no longer is the profit-maximizing one for the partially-regulated firm to choose: partial regulation changes the objective function for the multiproduct firm.

3.4 Market Power in the Unregulated Market

Qualitatively similar results occur when the firm has market power in the unregulated market, but cannot act strategically with respect to its rivals. When inverse demand in the unregulated market is given by $P_2(q_m)$, the firm's first-order condition in the noncore market in the case of partial regulation would be given by

$$q_m \frac{\partial P_m}{\partial q_m} + P_m - \frac{\partial c_m}{\partial q_m} - F\left[\frac{\partial (1-f)}{\partial q_m} + \frac{\partial (1-f)}{\partial q_r} \frac{\partial q_r}{\partial q_m} \right] = 0 \quad (11)$$

MRC_m is signed in the same way as for the perfect competition case. Again, $q_m^{pr} > q_m^*$ when MRC_m is negative (i.e., when $\varepsilon_m > 1$).

This result contrasts with Sweeney (1982). Sweeney however assumed that the regulatory constraint is violated at the unconstrained output vector, i.e., that $q_r^* P_r(q_r^*) - c_r(q_r^*) - f(q_r^*, q_m^*)F > 0$. Like BP's assumption on the unconstrained undiversified profit level, this assumption effectively restricts the level of common cost for the multiproduct firm, by restricting the regulatory constraints under consideration to be those below or to the right of R^2 in Figure 3 (i.e., R^1, with equilibrium at point A, would be allowed under Sweeney's assumption). Any level of common cost that would give regulatory constraint R^2 or R^3 are not allowed under Sweeney's assumption. As with BP's assumption[21], this assumption is unnecessarily restrictive.

In the constrained case when the firm 'overproduces' (point B in Figure 3), price for the multiproduct firm's customers in the noncore market is lower than in the unconstrained case, and so noncore consumer surplus is higher, while for this same case consumer surplus in the core market is lower than it would be if the firm were unconstrained.

4. Partial Regulation When the Noncore Market is Imperfectly Competitive

Assume now that the multiproduct firm is a monopolist in the core service and duopolist in the noncore service. The competing duopolist (the 'rival') produces only the noncore service[22]. Firms compete in outputs, levels of which are given by q_i, $i=r$, m, s denoting the multiproduct firm's output in the regulated and unregulated markets and the output of the single-product rival duopolist, respectively. The duopolists produce a homogeneous good. Inverse demand in the duopoly market is given by $P_2(q_m, q_s)$, and marginal revenue for each duopolist is assumed to be decreasing in the other firm's output. Marginal cost in the noncore market can be decreasing now, as long as marginal cost is such that the marginal revenue curve intersects the marginal cost curve from above. All other notation and assumptions are as given in Section 3.

4.1 The Unregulated Baseline Case with Cournot Duopoly

When the multiproduct firm is unconstrained by regulation in either market, it chooses output levels q_r and q_m to maximize profits

$$\pi(q_r, q_m, q_s) = q_r P_1(q_r) + q_m P_2(q_m, q_s) - F - c_r(q_r) - c_m(q_m) \tag{12}$$

Its rival in market 2 chooses output level q_s to maximize own profits: $\pi_s = q_s P_2(q_m, q_s) - c_s(q_s)$. The noncore market structure is Cournot duopoly, i.e. the firms choose output levels simultaneously, taking as given the actions of the other firm. The first-order conditions for the multiproduct firm are given by (with arguments omitted for brevity):

$$P_1 + q_r \frac{\partial P_1}{\partial q_r} - \frac{\partial c_r}{\partial q_r} = 0 \tag{13}$$

$$P_2 + q_m \frac{\partial P_2}{\partial q_m} - \frac{\partial c_m}{\partial q_m} = 0 \tag{14}$$

and for the rival duopolist by:

$$P_2 + q_s \frac{\partial P_2}{\partial q_s} - \frac{\partial c_s}{\partial q_s} = 0 \tag{15}$$

Each firm will choose output levels in their respective markets where marginal revenue is equal to marginal cost;[23] the simultaneous solution of (14) and (15) is a Nash equilibrium. Although production in the two product markets is linked for the multiproduct firm, the output decision rules for the two markets are separate. The common fixed costs affect only the level of total profit for the multiproduct firm, not the level of marginal profit, and therefore do not affect its production level decisions (given an interior solution).

4.2 Partial Regulation under Cournot Duopoly

Given that the regulatory constraint (Eq. 5) is satisfied by $q_r^*(q_m)$, the multiproduct firm's objective function in the noncore market is to choose q_m to maximize

$$\pi_m(q_m, q_s, q_r^*(q_m)) = q_m P_2(q_m, q_s) - c_m(q_m) - [1 - f(q_r^*(q_m), q_m)]F \quad (16)$$

The first-order condition for the multiproduct firm in the noncore market is now given by[24]

$$P_2 + q_m \frac{\partial P_2}{\partial q_m} - \frac{dc_m}{dq_m} - F\left[\frac{\partial(1-f)}{\partial q_m} + \frac{\partial(1-f)}{\partial q_r}\frac{\partial q_r}{\partial q_m}\right] = 0 \quad (17)$$

Note that the equilibrium noncore output is now a function of the equilibrium level of core output. The rival duopolist chooses q_S as given in the benchmark case. The last term on the left-hand side of (16) is the marginal regulated cost to the noncore market (MRC_m), and is signed in the same manner as in the perfect competition case in Section 3. Proposition 2 follows from the resulting conditions on MRC_m, with proof following along the lines of that given for the perfect competition case.

> **Proposition 2:** Cost-based regulation in one market has spillover effects on the behavior of a multiproduct firm acting as a Cournot duopolist in an unregulated market when the markets are linked by common cost of production. Given any observed level of the core service, the firm chooses a level of noncore service output greater than (less than) the

unconstrained level when the level of common cost is sufficiently high (low). For some level of common cost, the constrained level of noncore output will be equal to the unconstrained level. When the level of common cost is substantial, this overproduction is likely to be welfare enhancing, as the firm is less Pareto inefficient.

Cournot equilibria given increasing levels of common costs are depicted in Figure 4, which is drawn for linear noncore demand and constant noncore attributable costs for the multiproduct firm and the rival[25]. In (q_m, q_s) space, R_s represents the reaction curve for the rival, R_m the unconstrained reaction curve for the partially-regulated firm, and R_m^j its constrained reaction curves for increasing levels of common cost. For a given level of F, for levels of q_r and q_m that fall in the elastic portion of the regulatory constraint, MRC_m is negative, and therefore the constrained reaction function for the partially-regulated firm is above (to the right of) its unconstrained counterpart. For (q_r, q_m) combinations in the inelastic portion of the regulatory constraint, MRC_m is positive, and the constrained reaction function is to the left of the unconstrained one. For larger common costs we might expect the constrained reaction function to shift left (because 'marginal cost' increases), but this is only true for relatively 'high' levels of q_m, because of the feedback effects between the regulated and unregulated markets. For high enough F, the constrained equilibrium will be at point B, with noncore output greater than at the unconstrained equilibrium A, and rival output is lower than it would be if the multiproduct firm were completely unregulated.

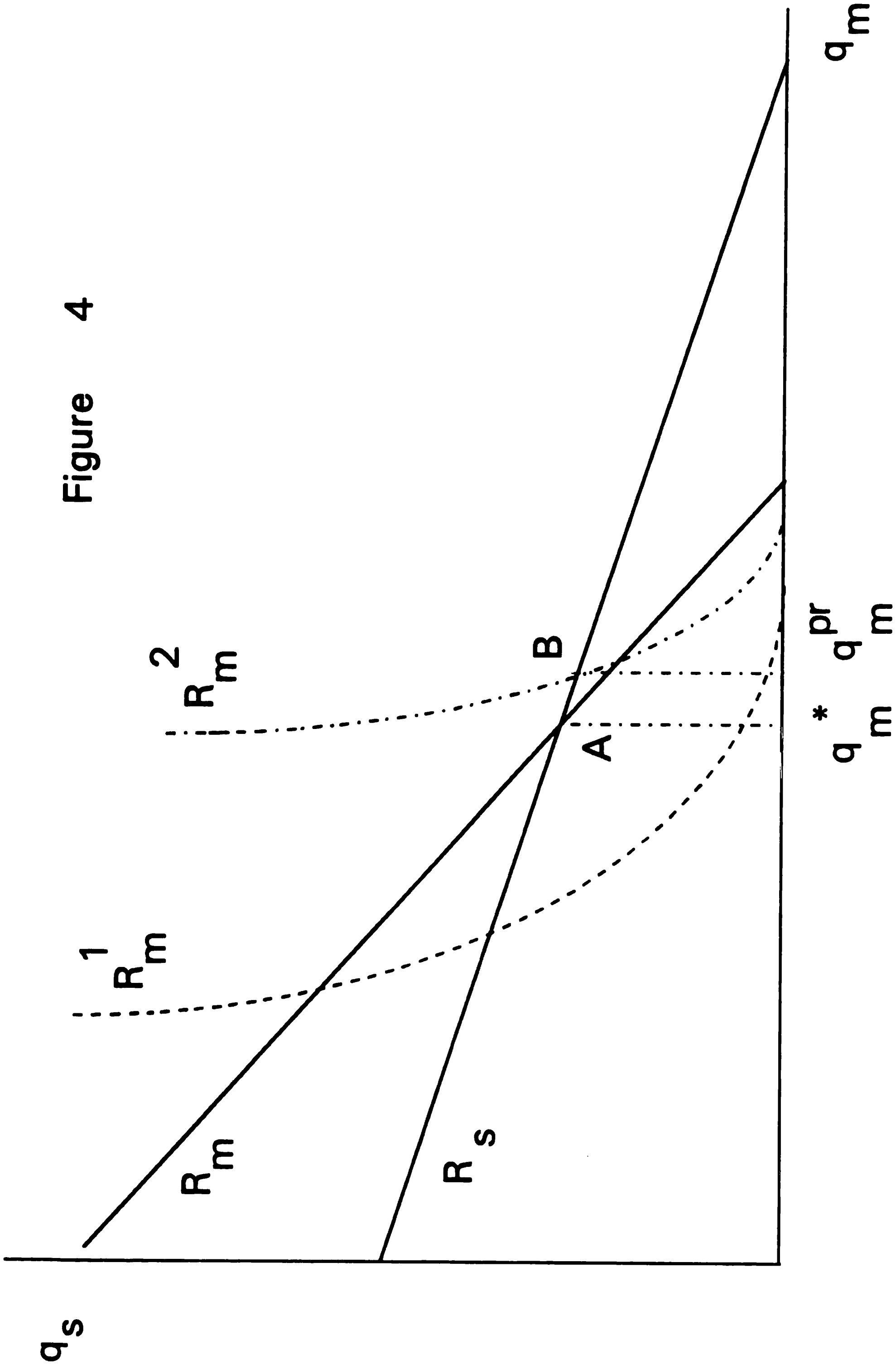

Figure 4

This model of partial regulation under Cournot duopoly fits into the class of two-period strategic models, where some 'investment' (with commitment value) is taken in period 1 to affect the second-period competition[26]. This 'investment' need not be an action taken by either firm, but rather is any action which affects the following competition. In this case the 'investment' or first-period action is the imposition of partial regulation. This action is observed by the rival duopolist, and makes the multiproduct firm 'tough' ('soft') in the second-period competition when the level of common cost is high (low). Partial regulation makes the multiproduct firm tough in the sense that the imposition of regulation in a related market makes the firm more aggressive (noncore output is higher), which in turn hurts the rival (rival profit is lower). The multiproduct firm gains market share at the expense of its rival. Partial regulation can make the regulated firm a 'top dog' in the noncore market, to its advantage.

Partial regulation has commitment value in this context because it is a decision outside the multiproduct firm's control[27]. Also, because of the allocation of common costs, there is no incentive for the multiproduct firms to lower noncore output, which would result in a net loss: lower noncore profit while maintaining zero core profit.

As in the case of a perfectly competitive noncore market, when there are high common costs, core market consumer surplus is less under partial regulation than when the firm is unconstrained in both markets. In this 'overproduction equilibrium,' total noncore market output is greater than in the unconstrained case (stability conditions guarantee that the increase in q_m more than offsets the decrease in q_s). Market output is closer to the monopoly output level. Note however that the partially-regulated firm, being able to 'commit' to a different best response (than if it were unregulated) extracts all gains from the increased noncore market profits. In this sense the result under partial regulation mimics a first-mover advantage. Consumer surplus in the noncore market has increased (total market output is greater, price is lower). The rival is made worse off (i.e. profit is lower because price and output are less) at the expense of its multiproduct competitor, whose profit are higher under partial regulation (partial regulation puts the firm closer to its monopoly equilibrium output). The effect of partial regulation on total welfare will depend on the relative size of each change.

Unlike the perfect competition case, we can relax the assumption on noncore attributable cost to allow for decreasing marginal cost in the noncore market. Comparing the level of fixed common costs needed to get the 'knife-edge' case where constrained noncore output equals the unconstrained level, that level of common cost is generally lower when there are decreasing marginal production costs in the core than when they are constant or increasing.

5. Effects of Market Structure

While the results given in Propositions 1 and 2 are qualitatively the same, there is a strategic effect to partial regulation: constrained noncore output above unconstrained levels occurs at lower levels of common cost under duopoly competition in the noncore market than under perfect competition, ceteris paribus. The multiproduct firm producing in a Cournot duopoly noncore market takes into account the reactions of its rival in determining noncore output, and so produces less output than would a perfectly competitive firm given the same attributable costs. The firm will therefore produce in a more elastic portion of the regulatory constraint when it is a duopolist in the noncore market than when it is a price taker in that market. The level of common costs under which the indirect effect will dominate the direct effect will therefore be less under imperfect competition than perfect competition.

Another way to see this effect is to notice that the average allocated costs in the core market will be greater under Cournot competition in the noncore market (e.g. for the relative output allocation rule, $ARC_r = F/(q_r+q_m)$). Equilibrium noncore output therefore affects effective average cost in the core market (given by the sum of average attributable cost and average allocated cost). For any given level of core output, for the same level of common cost and the same attributable cost function, the multiproduct firm knows that effective average cost in the core market will be higher when the firm competes in an imperfectly competitive noncore market than when it is a price taker in that market (because ARC_r is less under perfect competition in the noncore market). So core output that satisfies the regulatory constraint (i.e. output where price equals effective average cost) will be lower when the firm has market power in the unregulated market. As the level of common cost increases, core output decreases more when the firm is a duopolist in the noncore market (i.e. effective average cost rises faster). This leads to the following proposition:

> **Proposition 3**: There is a strategic effect to partial regulation. For identical cost functions in the core and noncore markets respectively, constrained noncore output greater than the unconstrained level occurs at a lower level of common cost when the multiproduct firm is a Cournot duopolist in the noncore market than under perfect competition.

Partial regulation therefore has a differential impact on the behavior of the regulated firm and its rival in their respective markets depending on the type of noncore market structure. This outcome implies that there is an additional informational burden on a regulator concerned with the effects of a move to partially regulate or partially deregulate a multiproduct firm.

6. Summary and Extensions

Partial regulation has been shown to have a non-negligible effect on the strategic positions of duopolists in an unregulated market. With high fixed common cost of production and FDC regulation in the core market, the partially-regulated firm will produce more than it would in the absence of any regulation. Its rival is disadvantaged when its multiproduct competitor is regulated in another product market under these conditions: profit for the rival is lower while its competitor's is higher, compared to the unconstrained levels. Partial regulation could potentially forestall entry by more cost-efficient potential entrants facing a multiproduct competitor. Regulators have certainly been concerned about such effects when regulating multiproduct firms. For example, the MFJ included restrictions on diversification: any line-of-business waiver allowed would require a showing "...that there is no substantial possibility that [a local exchange carrier] could use its monopoly power to impede competition in the market it seeks to enter" (Winston, 1993).

Simulation results show that even when the rival has a cost advantage (i.e. the rival has decreasing marginal cost, while the partially-regulated firm has constant or increasing marginal cost in the noncore market) the level of noncore output under partial regulation exceeds the unconstrained level. The fact that the multiproduct firm has economies of scope account for this.

On the consumer side, surplus is actually lower for consumers in the core market under partial regulation compared with the unconstrained case when the regulated firm has substantial common costs of production. Surplus is higher for consumers of the unregulated service. If the goal of partial regulation is to avoid cross subsidization of one product at the expense of the customers of another product, these results indicate that regulators need to consider the cost structure of the multiproduct firm it is regulating not only in terms of how a given level of common cost is *allocated*, but also what is the *level* of common cost.

The resulting difference in total welfare depends on the relative size of these markets; simulation results show that under a range of cost specifications, total welfare is less under partial regulation than in the unconstrained case.

Even though the above results occur at 'high' levels of common costs, this does not necessarily mean that the firm is using inefficiently high levels of common factors, or is inefficiently capital intensive or padding costs. However, the cases where profits for these high levels of common cost under the unconstrained output are negative (i.e. the firm would not produce if unconstrained) indicate that partial regulation is subsidizing production at levels of common cost that the firm in the absence of regulation would not operate under, indicating that it is the inefficient level. The optimal choice of technology under partial regulation is an extension to this basic model that is being examined.

In addition I have generalized the results obtained in earlier studies under perfect competition and market power (but no strategic interaction) to include cases with substantial common cost of production. Unlike these previous studies, overproduction (compared with the case of no regulation) in the unregulated market can result when common costs are substantial. The results for the case of nonstrategic market power were also obtained under these general conditions.

Several extensions of this basic model are being examined. In the next chapter, the role the nature of market competition has on the effects of partial regulation is explored in more detail. The noncore market is modeled to allow for simple dynamics, i.e., either the multiproduct firm or its rival act as Stackelberg leader. Under certain cost structures, partial regulation induces a less aggressive action by the unregulated rival, and in a dynamic setting this can be to the advantage of both duopolists. Competition in prices with differentiated products is also examined in the context of partial regulation. Rules for calculating the level of common costs in which the overproduction equilibrium occur are derived.

ENDNOTES

1. As opposed to environmental, safety or social regulation or antitrust enforcement. It is difficult if not impossible to find firms operating under absolutely no regulation -- firms face many legal institutions outside of the regulatory arena. In this paper, 'no regulation' or 'unregulated' refer to the absence of economic regulation as described here.

2. See Weiss and Klass (1986) and Winston (1993) for discussion of these and other examples of partial regulation and partial deregulation.

3.'Predatory' in the sense that partial regulation may provide strategic opportunities that the multiproduct firm may exploit using variables under its control, e.g. quantity or price in the unregulated market.

4.The historical emphasis in regulatory ratemaking in practice has been on the 'fairness' of rates (i.e. equity considerations rather that economic efficiency). 'Fair' rates have generally been considered those that avoid interservice subsidies. No service can generate revenues that more than cover its costs while another service's revenues fall short of covering costs. The debate on how to determine 'fair' shares when there are common costs of production between services, and how to test for cross subsidies when costs cannot be explicitly calculated, has been extensive. Equity concerns constitute only one of a number of observed motives for regulator behavior. General discussion of these issues is contained in Braeutigam (1989) and Joskow and Rose (1989).

5.Allocation rules need not be formulistic. Other allocation rules used have been based on 'subjective social evaluation' and 'value of service.' See Braeutigam (1980) for further examples and discussion of allocation rules.

6.Cost-of-service regulation has been shown to be equivalent to rate-of-return regulation (where revenues are constrained to be no greater than production costs plus a return on investment), when the allowed return is equal to the actual cost of capital (Joskow (1974) and BP).

7.It is assumed they meant that revenues (and not profits) are gained in the regulated markets, since technically profits can be constrained to be zero under FDC regulation.

8.His model is generalized to include multiple regulated and unregulated markets.

9.Using the taxonomy of business strategies of Fudenberg and Tirole (1984) and Bulow, et al. (1985), as described in Section 4.2 below.

10.This assumption is made for computational ease only; all that is needed is that the rival is not also producing the core service or a complementary good, and that any other goods it produces are not demand-related to the noncore service.

11.c_r,c_m and c_s are general enough to allow for fixed costs directly attributable to production of those goods. These arguments are dropped from the specification to simplify notation. Firms are assumed to be price takers in factor markets, and to choose factor inputs to minimize total cost of production.

12.F is assumed to be a 'common' cost (outputs can be produced in variable proportions) as opposed to 'joint' cost (in which the ratio of the level of one output to another is fixed).

13.The firm is a monopolist in the core market either because it is a natural monopoly with the inherent cost advantages implied, because demand is such to support only one firm, or because entry is proscribed by government action. Because these imply that different cost structures are possible in the core market, no further restrictions will be placed on the attributable core cost function $c_r(q_r)$.

14.As long as MR_r intersects MC_r from above, and given the condition assumed for $c_m(q_m)$, the sufficient conditions for maximization hold when the necessary conditions are satisfied.

15.f_i refers to the partial derivative of f(.) with respect to q_i.

16.Braeutigam (1980) compares the results of FDC regulation under different cost allocation rules for a fully-regulated multiproduct firm, and finds that the results are equivalent under the relative costs and relative revenue rules. Since attributable costs and revenues are functions of output, it is assumed that the specific form of allocation function used does not qualitatively affect the results of the model. When this is violated, the regulator's choice of allocation function would need to be modeled. This however introduces questions of incentive regulation, which are beyond the scope of this paper.

17.Including only the revenues from the regulated market matches common regulatory practice, and avoids one of the problems in Averch and Johnson (1962).

18.These properties hold under conditions which put minimal restrictions on the relationship between the marginal revenue and marginal cost curves. The conditions are given in Appendix A.1.

19.Sufficient conditions for maximization are given in Appendix A.3.

20.The slope of the isoprofit curve is given by

$$\frac{dq_m}{dq_r} = - [\frac{\partial \pi}{\partial q_r} \div \frac{\partial \pi}{\partial q_m}]$$

21. BP and Sweeney both modeled the problem as a multiproduct firm maximizing total (all markets) profit subject to the regulatory constraint. Technically, their results depend on the signing of the lagrange multiplier (the shadow price of the constraint), which, as shown in Appendix A.4, depends in fact on the level of common costs, and is not, as BP and Sweeney assumed, uniquely signed.

22.See footnote 10.

23.A sufficient condition for existence of a Cournot equilibrium is that each firm's marginal revenue is decreasing in the other firm's output (Novshek (1985)). This condition is more general than that usually assumed for Cournot competition, i.e. that the payoff function be concave (which is implied by downward-sloping demand and convex costs) (Szidarovsky and Yakowitz (1977)). This more general condition allows us to consider the case of decreasing marginal cost in the unregulated market. The sufficient condition for uniqueness

$$\left| \frac{\partial^2 \pi_m}{\partial q_m^2} \right| > \left| \frac{\partial^2 \pi_m}{\partial q_m \partial q_s} \right|$$

is satisfied for the case of homogeneous goods as long as dc_m/dq_m is nondecreasing, or is decreasing at less than twice the rate that MR_m is.

24.The sufficient condition for existence is the same as in the unconstrained case. The equilibrium outcome is unique if effective marginal cost for the multiproduct firm is nondecreasing, or if it is decreasing at less than twice the rate that MR_m is.

25.Qualitatively similar results arise when alternative cost structures are imposed.

26.This taxonomy of strategic behavior in a two-period game is due to Fudenberg and Tirole (1984) and Bulow et al. (1985).

27.The regulatory incentives literature addresses extensively the commitment value of regulation. A particular regulatory mechanism has commitment value when the regulator has the ability to commit credibly to the mechanism over some duration. In the context of this model, partial regulation would have commitment value if the rival believed that cost-based regulation would continue in the core market, and the noncore market would continue to be unregulated, for some horizon.

APPENDIX

A.1 -- Regulatory Constraint Conditions

In this section the conditions under which the regulatory constraint is upward sloping and convex in equilibrium are derived.

$$q_r P_1(q_r) - c_r(q_r) - f(q_r, q_m)F = 0 \tag{1a}$$

Totally differentiating the regulatory constraint:

$$\frac{dq_m}{dq_r} = \frac{q_r P_1' + P_1 - c_r' - f_r F}{f_m F} = \frac{MR_r - MC_r - MRC_r}{f_m F} \tag{2a}$$

we get that (where primes indicate derivatives)
and where RC refers to the 'regulated cost', i.e., $f(q_r, q_m)F$. We know that $dq_m/dq_r > 0$ when $MR_r \leq MC_r$, since $f_r > 0$ and $f_m < 0$. Also, $dq_m/dq_r > 0$ when $MR_r > MC_r$ and $MR_r < MC_r + MRC_r = EMC_r$ (i.e., core marginal revenue is less than core 'effective' marginal cost). If the multiproduct firm acted as a profit-maximizing monopolist who allocated costs using $f(q_r, q_m)$, it would choose q_r where $MR_r = MC_r + MRC_r$. Let the value of q_r that satisfies this be given by $\overline{q_r}$ Given that this firm is regulated, the constrained level of output will be greater than $\overline{q_r}$, and so $MR_r < MC_r + MRC_r$.

$$\frac{d^2 q_m}{dq_r^2} = \frac{MR_r' - MC_r' - MRC_r'}{f_m F} - \frac{dq_m}{dq_r}\frac{f_{mr}}{f_m F} \tag{3a}$$

Differentiating (2a) with respect to core output we get
If MR_r cuts EMC_r from above (i.e., $|MR_r'| > |EMC_r'|$) then the first term on the right-hand side of (3a) is positive (since f_m is negative). $dq_m/dq_r > 0$

$$f_{mr} = \frac{q_r - q_m}{(q_r + q_m)^3}$$

(see above). f_{mr} can be positive or negative: for example, given the relative output allocation rule,

$$\frac{MR_r' - MC_r' - MRC_r'}{f_m F} > \frac{dq_m}{dq_r}\frac{f_{mr}}{f_m F}$$

For $f_{mr}>0$, (3a)>0 and therefore the regulatory constraint is convex (at equilibrium). If $f_{mr}<0$, then the constraint is convex when

$$MR_r' - MC_r' - MRC_r' < \frac{dq_m}{dq_r} f_{mr} < 0$$

i.e., when
Not only must the marginal revenue curve intersect the marginal cost curve from above, but the difference in the slopes of the two curves is bounded above by a limit that relates the difference in the absolute output levels for the multiproduct firm and the slope of the regulatory constraint.

$$\frac{\partial \varepsilon_{rm}}{\partial q_r} = -\frac{q_m}{q_r}\frac{\partial q_r}{\partial q_m} + \frac{q_m}{q_r}\frac{\partial^2 q_r}{\partial q_m^2} < 0$$

Note: the elasticity of the regulatory constraint is decreasing in q_r:

$$\varepsilon_{rm} = \frac{\partial q_r}{\partial q_m}\frac{q_m}{q_r} = \frac{-f_m F}{MR_r - MC_r - f_r F}\frac{q_m}{q_r}$$

A.2 -- The level of common cost and MRC_m

when the implicit function rule is applied to the regulatory constraint (6).

$$\varepsilon_{rm} = \frac{-f_r F}{MR_r - MC_r - f_r F}$$

Using the relative output allocation rule, ε_{rm} reduces to

Given that $0 < f_r < 1$, a sufficient condition for $\varepsilon_{rm} > 1$ is that at equilibrium $MR_r - MC_r > 0$, i.e., constrained core output is less than unconstrained core output.

For higher levels of common cost, $q_r^*(q_m)$ decreases (because effective average cost in the core market increases), and therefore the multiproduct firm operates in increasingly lower sections of the regulatory constraint (more elastic sections). Therefore MRC_m becomes smaller, and q_m increases.

A.3 -- Sufficient Conditions for Maximization

Given that noncore marginal attributable cost is assumed to be nondecreasing in q_m, the sufficient condition for maximization is satisfied

$$\left|\frac{\partial MC_m}{\partial q_m}\right| > \left|\frac{\partial MRC_m}{\partial q_m}\right|$$

when MRC_m is also nondecreasing in q_m, or when

i.e., any change in q_m affects the marginal attributable cost to a greater degree than it affects the marginal regulated cost. Taking the derivative of

$$\frac{\partial MRC_m}{\partial q_m} = -F\left[\frac{q_r}{(q_r+q_m)^2}\frac{\partial \varepsilon_{rm}}{\partial q_m} + (1-\varepsilon_{rm})\frac{2q_r}{(q_r+q_m)^3}\right]$$

MRC_m (from equation (10) in the text) with respect to q_m, we get

When $\varepsilon_{rm} \geq 1$, MRC_m will be nondecreasing in q_m. When $\varepsilon_{rm} < 1$, a

$$\left|\frac{\partial(\text{direct effect})}{\partial q_m}\right| > \left|\frac{\partial(\text{indirect effect})}{\partial q_m}\right|$$

sufficient condition for MRC_m to be nondecreasing in q_m is that

i.e., any change in q_m has a bigger impact directly on the multiproduct firm than indirectly through the feedback effect between the firm's two markets.

A.4 -- Signing the lagrangian

The lagrangian in BP (their eq. 3, but using my notation) is:

$$H = q_r P_1(q_r) + q_m P_2^* - F - c_r(q_r) - c_m(q_m) + \lambda[f(q_r, q_m)F + c_r(q_r) - q_r P_1(q_r)] \tag{4a}$$

BP determine, in an analysis of 'waste' variables, that $0 < \lambda < 1$. Sweeney (in a similar model) assumes that $\lambda > 0$. From (4a), the first order conditions are:

$$\frac{\partial H}{\partial q_r} = MR_1 - MC_r + \lambda[f_r F + MC_r - MR_1] = 0 \tag{4b}$$

$$\frac{\partial H}{\partial q_m} = P_2^* - MC_m + \lambda f_m F = 0 \tag{4c}$$

$$\frac{\partial H}{\partial \lambda} = f(q_r, q_m)F + c_r(q_r) - q_r P_1(q_r) = 0 \tag{4d}$$

Solving the above for the lagrangian multiplier we get:

$$\lambda = \frac{MC_r - MR_1}{f_r F + MC_r - MR_1}$$

In equilibrium, if $MC_r > MR_1$, then $0 < \lambda < 1$. This is the same condition assumed by BP, and indicates that they were considering only cases where the core market price under partial regulation is less than the monopoly price (i.e., they exclude the case of high common costs). λ is also positive if $MC_r < MR_1$ and $|MC_r - MR_1| > |f_r F|$. But $\lambda < 0$ when $MC_r < MR_1$ and $|MC_r - MR_1| < |f_r F|$, which is the case when common costs are substantial.

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CHAPTER 2

TURNING TOP DOGS INTO FAT CATS -- IS PARTIAL REGULATION A FORM OF GENETIC ENGINEERING?

1. Introduction

In this paper I demonstrate that the spillover effects of cost-of-service regulation of a multiproduct firm with common costs of production onto an unregulated market where the firm has market power depend on the type of competition in that unregulated market, the level of common costs, and the type of allocation function chosen by the regulator. Results indicate the importance regulators should place on examining these conditions when considering partial deregulation of a multiproduct monopolist, or allowing a regulated firm to enter product markets outside its jurisdiction, when the firm has economies of scope.

Under some conditions, partial regulation in a related market forces the multiproduct firm away from its otherwise optimal business strategies in an imperfectly competitive unregulated market; the degree to which this occurs depends on the level of common costs of production. But under other conditions, regulation in one market can provide the commitment necessary to move duopolists in unregulated markets toward the monopoly outcome. Both the multiproduct firm and its unregulated rival can be better off (higher profit) when the multiproduct firm is subject to cost-based regulation in another related market, and these higher profits will come at the expense of consumers in the regulated markets, who are in effect subsidizing output in the unregulated market. Any decision by a regulator that takes into account the welfare effects of partial regulation must include the spillover effects onto unregulated but cost-related markets. Information requirements for the regulator include the level of common cost of production of the partially-regulated firm, and the nature of competition it faces in the unregulated but related markets, and how different cost allocation rules affect the firm's tradeoff between output in its regulated and unregulated markets.

Partial regulation of a multiproduct firm can result when a regulated firm is allowed to enter unregulated markets in which it did not previously compete. Line of business waivers granted to local telephone operating companies to enter the real estate business after the AT&T divestiture are examples of this form of partial regulation. A firm can also be partially regulated when regulation is lifted in a subset of the firm's product markets previously under regulatory control. For example, pricing and entry restrictions have been gradually lifted in the large business product market of local telephone operating companies, while rates for residential dial-up service continue to be regulated by most state public service commissions.

The spillover effects of partial cost-of-service regulation have previously been examined by Braeutigam and Panzar (1989) with the unregulated market modeled as perfectly competitive, and Sweeney (1982), who assumed the regulated firm had market power in its unregulated markets, but did not explicitly model interaction with rival competitors in that market. In an earlier paper (Schenk, 1995) I found that Sweeney's and Braeutigam and Panzar's results were special cases of a more general result: whether the multiproduct firm over- or under-produces in the unregulated market (compared with the equilibrium output level when it is under no regulation in either market) is dependent on the level of common cost of production. When the firm has high levels of common costs, the firm will overproduce in the unregulated market; the firm produces less in its unregulated market when partially-regulated only when it has low levels of common production costs. These results depend on the elasticity of the regulatory constraint, which captures the relationship between allowed levels of output in each market, and which therefore affects the opportunity cost of producing in the unregulated market.

This 'over-production' equilibrium has special implications when competition in the unregulated market is characterized as Cournot duopoly -- regulation in one market 'helps' the multiproduct firm in a related unregulated market gain market share at the expense of its unregulated rival. Production in the regulated market is 'subsidizing' production in the unregulated market, in the sense that effective marginal cost is lower in this market than it would be if the multiproduct firm only operated in that market, when common cost of production is 'high.' While the 'overproduction equilibrium' occurs in both the perfect competition and Cournot duopoly cases, the level of common costs at which this equilibrium occurs is lower for the case of Cournot duopoly -- the ability of the regulated firm to act strategically affects the results of partial regulation.

It is restrictive however to consider only the case where the firms in the unregulated market act simultaneously. Partial deregulation can be a regulatory agency's reaction to potential competition by entrants with new technology (e.g., the case of MCI's entry into one of AT&T's business markets in Illinois in the 1960's). In such cases the rival could be considered a first mover in that market competition. The regulated firm can also be the follower when it is an entrant into an established market (e.g., AT&T and computers). In other circumstances, the multiproduct firm, because it is the incumbent firm with an established service reputation and a captured customer base, could be the first mover/dominant firm.

Another consideration not fully explored is the difference when competition in the unregulated market is in prices and not in quantities. In telecommunications, for example, firms competing for the large business customers ('cream') often compete in rates, and then supply all calls at the given price.

As shown below, the effects of partial regulation depend not only on the cost structure of the multiproduct firm, but also on the type of competition in the unregulated market. As elsewhere in the study of imperfectly competitive competition, no one general rule can be derived. A regulator imposing partial regulation on a multiproduct firm operating in an unregulated market where it and its rivals have market power must look at each case to determine what the true effect of partial regulation will be on total welfare and possible cross-subsidization. In the case of no regulation, behavior differs whether rivals are competing in prices or quantities, and this continues under partial regulation. When one duopolist has a first-mover advantage, no general rule results because partial regulation makes it more 'expensive' for the partially-regulated firm to produce 'high' levels of output in the unregulated market, but less 'expensive' to produce 'low' levels. Therefore the effect of partial regulation on the multiproduct firm depends on who leads, since that determines how much the partially-regulated firm will produce in equilibrium. The next section outlines the taxonomy of business strategies in the baseline (no regulation) case. The results of competition in strategic complements when one duopolist is partially regulated in a cost-related market is presented in Section 3, and the effects on the firm's behavior is compared with optimal business strategies. The results for competition in strategic substitutes (derived in Schenk (1995)) are presented so that the effects under both types of competition can be summarized. A rule for what distinguishes 'high' and 'low' levels of common cost is derived in Section 4, and the effects of using different allocation rules is examined in the following section. In Section 6 the effects of partial regulation under dynamic competition are investigated. Results are summarized in the last section.

2. Taxonomy of Business Strategies

In the general model of two-stage duopolistic competition, the taxonomy of business strategies as formalized by Fudenberg and Tirole (1984) and Bulow et al. (1985) are in common usage. The taxonomy shows the optimal strategies for firms that can make a first-period 'investment' (e.g., choice of capacity level, level of R&D expenditure, advertising expenditures) that will affect the subsequent choices of its rival and therefore deter entry, or increase its own profits while accommodating entry. Optimal strategies depend on whether choice variables are strategic complements or substitutes (i.e. whether own marginal profit is decreasing or increasing in the other firm's choice variable) and whether the first-period 'investment' makes the firm 'tough' or 'soft' in second-period competition (rival's profit is decreasing or increasing in 'investment'). In the baseline case (no regulation in any market), the optimal strategies are as given in Table 1.

First-period 'investment' by an 'incumbent' that decreases its marginal cost in second-period competition makes the incumbent 'tough,' and so if second-period competition is in strategic substitutes (complements) the incumbent should over- (under-) invest in the entry accommodation case. In the Fudenberg and Tirole animal taxonomy the incumbent in this case should be a 'top dog' ('puppy dog'), i.e., the incumbent should 'overinvest' to look tough, and therefore elicit a soft response (reduced output) by the rival (underinvest to appear friendly, to elicit a soft response from the rival).

Table 1 -- Optimal Business Strategies

Type of Second-Period Competition	Investment Makes the "Incumbent":	
	Tough	Soft
Strategic Complements	A: Puppy Dog D: Top Dog	A: Fat Cat D: Lean&Hungry
Strategic Substitutes	A&D: Top Dog	A&D: Lean&Hungry

First-period 'investment' is generally taken to be any choice (e.g. capacity, advertising) taken by the incumbent firm that affects the actions of its rival in second-period play. But 'investment' can be extended to mean any choice (even out of the control of the competing duopolists) that affects second-period competition. For example[1], a domestic government can affect the behavior of foreign importers by subsidizing the production of domestic producers.

In the situation examined here, first-period 'investment' is the imposition of partial regulation by the regulator. Under partial cost-of-service regulation the firm cannot earn revenues in the regulated market that exceed the direct cost of producing in that market plus some 'fair' share of common cost. The firm is required to allocate common cost of production between the relevant markets, and the allocation rule is typically some function of relative outputs.

This regulatory constraint links equilibrium output levels in the regulated and unregulated markets.

Partially regulating the multiproduct firm affects the second-period competition in the noncore market by making the firm consider the 'effective marginal cost' of producing in that market, rather than just the marginal cost directly attributable to production in that market. The effective marginal cost incorporates the 'cost' to production in the regulation market of additional production in the unregulated market, i.e., each additional unit produced in the unregulated market reduces allowable revenues in the regulated market. The partially-regulated firm's best response function in the unregulated market differs from the best response function it would have if it were under no regulation in any of its markets, and therefore the actions of the rival are affected as well by partial regulation. As shown below, whether 'investment' (i.e. partial regulation) makes the regulated firm 'tough' or 'soft' will depend on the level of common costs.

3. Competition in Strategic Complements

The multiproduct firm serves two markets. It is a monopolist in the core (regulated) service and duopolist in the noncore (unregulated) market. The competing duopolist (the 'rival') produces only the noncore service[2]. Let p_i, $i=r,m,s$ denote the multiproduct firm's choice variable in the regulated and unregulated markets, and the choice variable of the single-product rival duopolist, respectively. Given that the multiproduct firm is a monopolist in the core market, without loss of generality let its choice variable in the core market be quantity, even if it considers the strategic variable to be price. The duopolists produce a differentiated good, and competition is in prices. Duopolists choose prices simultaneously. Total revenue in the duopoly market is given by $TR_m(p_m, p_s)$; marginal profit for each duopolist is assumed to be increasing in the other firm's choice variable, i.e. the actions (choice variables) of the duopolists are strategic complements[3].

The cost function for the multiproduct firm has the form

$$C(q_r, q_m(p_m, p_s)) = F + c_r(q_r) + c_m(q_m(p_m, p_s)) \qquad (1)$$

where $c_r(q_r)$ and $c_m(q_m(p_m, p_s))$ are the costs of production that can unambiguously be associated with the production of the core and noncore services[4]. F is a fixed common[5] cost that results from production of both services but which cannot be accurately assigned between the two services. Let $c_r(q_r)$, $c_m(q_m(p_m, p_s))$ and $c_s(q_s(p_m, p_s))$ be continuously differentiable in quantities over the interval $[0, \infty)$, with positive first derivatives.

The model is one of full information: cost functions and demand conditions are assumed to be known by all agents before competition begins.

3.1 Partial Regulation

Common cost F plays a central role in the behavior of the multiproduct firm under cost-based regulation. FDC pricing is assumed. Unattributable costs enter production decisions because the multiproduct firm is required by the regulator to allocate a portion of the common costs to each service, according to a formula chosen by the regulator, in an attempt to assign a 'fair' share of common costs to each service. Let the allocation function

$$0 \leq f(q_r, q_m(p_m, p_s)) \leq 1$$

represent the portion of F allocated to the core market; $f(q_r, q_m)$ is assumed to be monotonically increasing in core output $(f_r > 0)$[6] and monotonically decreasing in noncore output $(f_m < 0)$. Common costs are fully allocated between the two services. The actual form of the allocation function is chosen by the regulator. For example, one frequently used allocation rule is based on relative outputs (i.e., $f = q_r/(q_r + q_m)$).

The regulator's goal is to maximize core consumer surplus subject to the regulated firm earning nonnegative profits in the core market. To achieve this goal it allows the regulated firm to choose quantity (price) so that the multiproduct firm's revenue from the core service[7] is no more than the total of the costs directly attributable to that service and the allocated share of common costs of production. Under cost-based regulation, and assuming a binding regulatory constraint, the partially-regulated firm's output level in the regulated market is implicitly given by

$$q_r P_1(q_r) - c_r(q_r) - f(q_r, q_m(p_m, p_s))F = 0 \qquad (2)$$

Under general conditions the regulatory constraint has the following properties[8] at equilibrium: $dq_m/dq_r > 0$, $d^2q_m/dq_r^2 > 0$. Intuitively, the first condition holds because, for a given level of common cost, as noncore output increases, allocated costs in the core market decrease, and so allowed 'operating profit' (revenue less attributable cost) must fall to maintain the constraint, i.e., core output must rise. In (q_r, q_m) space, these conditions imply a regulatory constraint which is upward sloping and convex. These conditions imply that the point elasticity of the constraint, $e_{rm} = (\partial q_r/\partial q_m)(q_m/q_r)$ is decreasing in q_r.

3.2 Competition Under Partial Regulation

The duopolists choose p_m and p_s simultaneously. Given that the regulatory constraint is satisfied at a level of core output given by $q_r^*(q_m(p_m, p_s))$, the multiproduct firm's objective function in the noncore market is to choose p_m to maximize

$$\pi_m = TR_m(p_m, p_s) - c_m(q_m(p_m)) - F[1 - f(q_r^*(q_m(p_m, p_s)), q_m(p_m, p_s))] \qquad (3)$$

where the last term represents the portion of common costs not allocated to the core market by the regulator. Let these 'regulated' costs be represented by RC_m. Given stability and existence conditions are satisfied (endnote), the first order condition for the partially-regulated firm is given by

$$\frac{\partial \pi_m}{\partial p_m} = 0 = MR_m - MC_m - F \frac{\partial q_m}{\partial p_m} \left[\frac{\partial(1-f)}{\partial q_m} + \frac{\partial(1-f)}{\partial q_r} \frac{dq_r}{dq_m}\right] \tag{4}$$

where MR_m refers to noncore marginal revenue and MC_m refers to the marginal attributable cost. Let the third term on the right-hand side be referred to as the 'marginal regulated' cost (MRC_m):

$$MRC_m = F \frac{\partial q_m}{\partial p_m} \left[\frac{\partial(1-f)}{\partial q_m} + \frac{\partial(1-f)}{\partial q_r} \frac{dq_r}{dq_m}\right] \tag{5}$$

Any increase (decrease) in p_m will lower (raise) noncore output level, therefore $(\partial q_m)/(\partial p_m) < 0$. But any change in noncore output has an effect on the portion of common costs allocated to this market, and this secondary effect can be broken down into two parts.

The first term in MRC_m represents the direct effect of a change in noncore output on the allocated costs. The direct effect is positive: any increase (decrease) in noncore output will increase (decrease) the portion of common costs allocated to the noncore market. But there is an indirect effect which captures the relationship between production in the regulated and unregulated markets for the multiproduct firm: any change in noncore output affects the level of core output that satisfies the regulatory constraint, which in turn affects the level of allocated costs to the noncore market. The indirect effect is negative: any increase (decrease) in q_m results in an increase (decrease) in q_r^*, because q_m and q_r are positively related along the regulatory constraint, but an increase in q_r will decrease the amount of allocated costs to the noncore market.

Whether the direct or indirect effect dominates depends on the level of common costs. In the range where the regulatory constraint is elastic, the indirect effect will dominate the direct effect, and MRC_m will be positive. This results from the fact that in this range, any increase in q_m will result in an even greater increase in q_r. Using the relative output allocation rule,

$$MRC_m = F \frac{\partial q_m}{\partial p_m} \left[\frac{q_r}{(q_r + q_m)^2} - \frac{q_m}{(q_r + q_m)^2} \frac{dq_r}{dq_m}\right] \tag{6}$$

Multiplying the right-hand side by q_r/q_r,

$$MRC_m = F q_r \frac{\partial q_m}{\partial p_m} \left[\frac{1}{(q_r + q_m)^2} - \frac{1}{(q_r + q_m)^2} \frac{q_m}{q_r} \frac{dq_r}{dq_m}\right] \tag{7}$$

Therefore $MRC_m > 0$ when $\varepsilon_{rm} > 1$. A sufficient condition for $\varepsilon_{rm} > 1$ is that the level of core output under cost-of-service regulation is lower than the unconstrained (no regulation) level, i.e., when F is sufficiently. When F is sufficiently high, $MRC_m < 0$. Let F* be the level of common costs when $MRC_m = 0$.

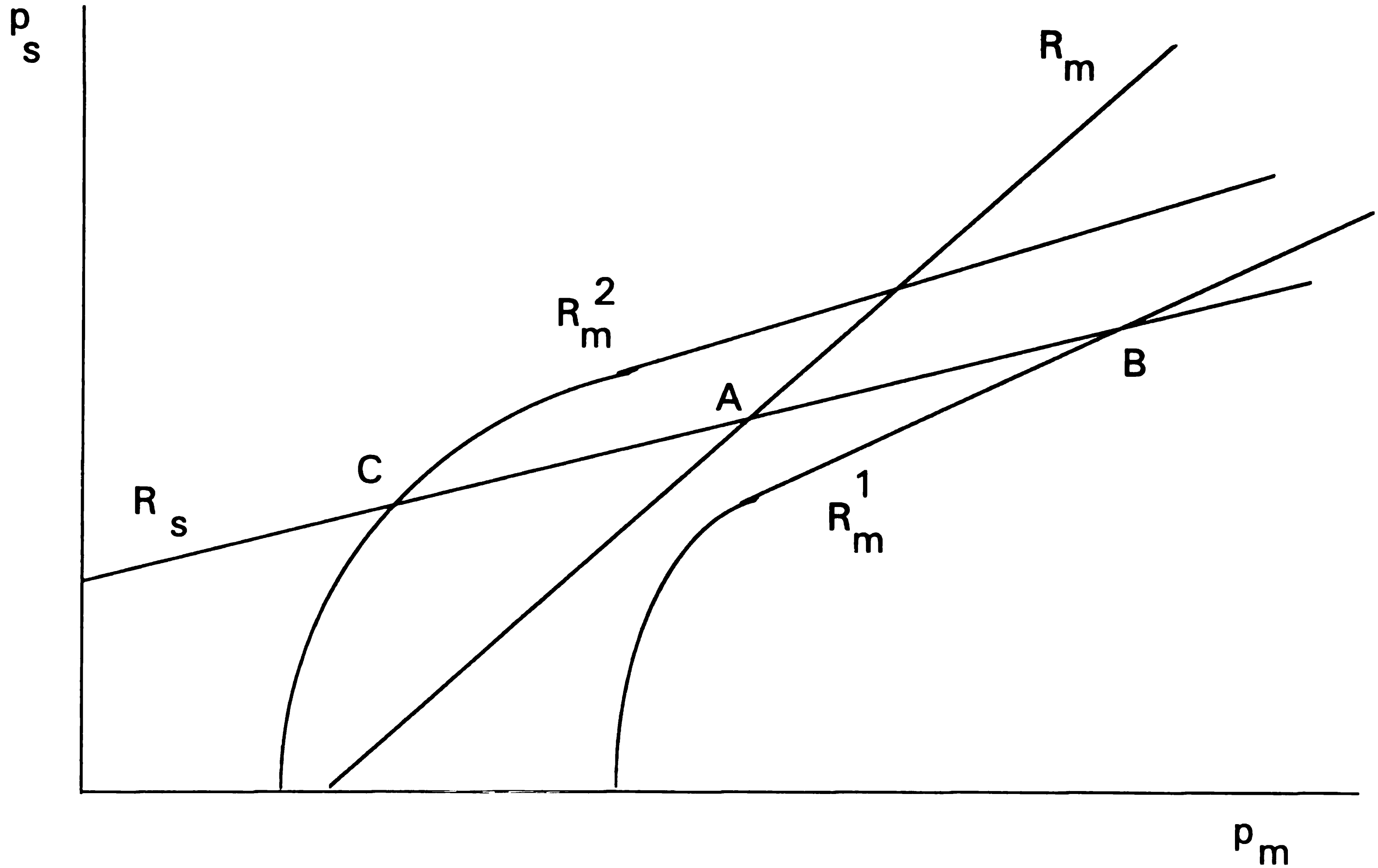
Since the marginal regulated cost is negative for the values of q_m in the range where the regulatory constraint is elastic, the effective marginal cost (where effective includes both attributable and allocated marginal costs) is less than the marginal (attributable) costs. For (q_r, q_m) in the inelastic portion of the regulatory constraint, MRC_m is positive, and the effective marginal cost in the noncore market, $EMC_m(q_r^*, q_m)$, is greater than the attributable marginal cost.

Figure 5 shows how noncore market equilibrium prices charged by the multiproduct firm and its rival are affected by partial regulation of the multiproduct firm. In (p_m, p_s) space, R_m and R_s represent the best response functions of the multiproduct firm and its rival, respectively, in the case of no regulation. These best response functions are solutions to the noncore first order conditions of each firm, as given above. Equilibrium in the case of no regulation is represented by point A on Figure 5.

When $F < F^*$, $EMC_m > MC_m$ at equilibrium. The multiproduct firm's best-response function under partial regulation when $F < F^*$ is to the right of that under no regulation in either market, and is represented by R_m^1 in Figure 5. Point B represents the Nash equilibrium for $F < F^*$. The price charged by the multiproduct firm in equilibrium in the noncore market will be greater than it would be in the no-regulation case.

In terms of optimal business strategies outlined in Section 2, when F is 'low', regulation ('investment') in the core market makes the firm 'soft' in noncore market competition, i.e. noncore price under partial regulation is higher than it would be if the firm were under no regulation in either market. The rival responds by raising its own price, with resulting higher noncore profits for both firms than if the multiproduct firm were not regulated in any market.

Figure 5



In the case of 'low' common costs of production, partial regulation facilitates a move by the firms toward the monopoly outcome, because partial regulation helps the multiproduct firm 'signal' less aggressive behavior. This matches the optimal business strategy (as shown in Table 1) in the case of second-period competition in strategic complements where 'investment' makes the firm 'soft.' When put in terms of the animal taxonomy, in the entry accommodation[9] case, partial regulation encourage the rival to be less aggressive, i.e., a 'fat cat' strategy results in higher noncore profits for the multiproduct firm.

While noncore profits for the regulated firm are higher when partially-regulated, whether the firm prefers to be partially regulated depends on whether lower core profits under regulation are at least offset by the increase in noncore operating profits.

When $F > F^*$ in equilibrium, $EMC_m < MC_m$, and the multiproduct firm's best-response function under partial regulation is to the left of that under no regulation. The best response function for the multiproduct firm in this case is represented by R_m^2 in Figure 5, and equilibrium under partial regulation is at point C. Equilibrium price charged by the partially-regulated firm in the noncore market will be less than it would be if the firm were unregulated in both markets. Partial regulation when the firm has a high level of common costs makes that firm more aggressive, to both firms' detriment. Partial regulation in this case makes the multiproduct firm 'tough': since $p_m^{cos} < p_m^*$, the rival's best response is to lower its own price, with resulting lower profits.

In the baseline (no regulation) accommodation case the optimal strategy when competition is in strategic complements and investment makes the incumbent tough is to 'underinvest.' The analogous situation under partial regulation is that the firm would 'choose' not to be partially-regulated, so as not to have lower effective production costs (and therefore not to have lower total profits[10]). That is, the regulated firm would prefer to appear friendly and therefore not toughen the competition, a 'puppy-dog' strategy. Instead, partial regulation forces the firm into behaving like a 'top dog,' which is the optimal strategy only if it wants to deter entry[11]. For a multiproduct firm with substantial common costs competing in strategic complements, partial regulation facilitates entry deterrence, but toughens the competition between accommodating duopolists. From society's view, partial regulation in this case moves the duopolists toward the preferable competitive (social optimal) equilibrium. This can, ironically, lead to a situation in which the partially-regulated firm should be put under regulatory protection in the unregulated market, since producing at $P_m = MC_m$ in the noncore market could lead to negative overall profits for the firm (as it would not be covering the cost of common production facilities).

The case of second-period competition in strategic substitutes (quantity competition in homogenous goods) was examined in detail in Schenk (1995). In equilibrium the multiproduct firm will over- (under-) produce compared with the no-regulation equilibrium when, in equilibrium, $F > (<) F^*$, respectively [$MRC_m < 0$ (> 0) when $\varepsilon_{m} > 1$ (< 1)]. Applying the optimal business strategy taxonomy in this case, when F is 'low' ('high'), core market regulation makes the multiproduct firm 'soft' ('tough') in noncore market. When F is 'high,' partial regulation makes the multiproduct firm a 'top dog,' which is the optimal[12] strategy. But when F is 'low,' partial regulation makes the multiproduct firm 'soft' and with strategic substitutes the firm would 'choose' not to be partially-regulated[13], if it could, to stay 'lean & hungry.' In the case of a 'low' level of common costs, core market regulation makes the firm a 'fat cat' in the noncore market, to its disadvantage.

The results of partial regulation of a multiproduct firm in noncore market competition are summarized in Table 2. Partial regulation 'commits' the multiproduct firm to what are the same strategies as the 'optimal' baseline strategies in two cases: when the level of common costs is low and the duopolists compete in prices, and when common costs are substantial and duopolists compete in prices.

Under quantity competition the firm should stay 'lean & hungry', in order not to force a fight with the rival, but when common costs are low partial

Table 2 -- Strategies in Second-Period Competition under Partial Regulation

		Partial Regulation Makes the Regulated Firm	
Cost Level:	Competition in:	Tough	Soft
F low	Price		fat cat
	Quantity		fat cat*
F high	Price	top dog*	
	Quantity	top dog	

* differs from the optimal baseline strategy

regulation makes the firm a 'fat cat,' to its detriment. That is, the firm does not want to be partially-regulated and have to incorporate the opportunity costs of noncore production on core revenues, but rather would like to keep costs low to look tough. In the price competition case with high common costs, partial regulation hurts the multiproduct firm because it commits the firm to a lower price response than it would in the no-regulation case: the firm would prefer not to be partially regulated, but is forced to be a 'top dog,' incorporating the cost noncore production has on allowable revenues in the core market.

What level common costs are at effects what happens in each of the multiproduct firm's markets. Regulators are usually concerned with what happens to consumers in the core (regulated) market. In determining the critical level of common costs (F^*), we can also see that consumer surplus in the core market can be lower under partial regulation than in the no regulation case, for high levels of common costs in both quantity and price competition.

4. Determination of F^*

F^* has been defined as the level of common cost at which equilibrium noncore output under partial regulation is equal to equilibrium output under no regulation. For any F below F^*, $q_m^{cos} < q_m^*$, and for any F above F^*, the 'overproduction equilibrium' occurs -- $q_m^{cos} > q_m^*$. Because the conditions under which $q_m^{cos} = q_m^*$ are clearly defined, an explicit functional form for F^* is obtainable; the value of F^* for given cost and demand conditions in the two markets can therefore be determined. Assuming complete information, regulators would be able to tell whether common costs were 'low' or 'high,' and therefore what the full effects of partial regulation would be.

In order for $q_m^{cos} = q_m^*$, the first-order condition under partial regulation $MR_m - MC_m - MRC_m = 0$ must be equivalent to $MR_m - MC_m = 0$. For positive values of F, q_m, and q_r, the only way to obtain this condition is if $MRC_m = 0$. This occurs when the best-response function for the multiproduct firm under partial regulation intersects the unregulated best-response function at the equilibrium output vector under no regulation, i.e., (q_m^*, q_s^*). For the relative output allocation rule,

$$MRC_m = \frac{Fq_r}{(q_r + q_m)^2}[1 - \varepsilon_{rm}]$$

$MRC_m = 0$ only when $\varepsilon_{rm} = 1$, where ε_{rm} is given by (for the relative output allocation rule),

$$\varepsilon_{rm} = \frac{q_m}{q_r}\frac{dq_r}{dq_m} = \frac{-q_m F}{(MR_1 - MC_r)(q_r + q_m)^2 - q_m F} \quad (8)$$

For interior solutions, $\varepsilon_{rm} = 1$ iff $q_r^{cos} = q_r^*$ (where q_r^{cos} is the solution when $MR_1 = MC_r$). Therefore, when $F = F^*$, $q_r^{cos} = q_r^*$. These output levels are given by the solution to the equilibrium conditions:

$$q_r \frac{dP_1}{dq_r} + P_1 = c_{r'} - q_r^*$$

$$P_1 = \frac{c_r + f(q_r, q_m)F}{q_r} - q_r^{cos}$$

$q_r^{cos} = q_r^*$ implies that when $F = F^*$, the same price will be charged in the core market under partial regulation as would be charged by the firm acting as an unregulated monopolist. Therefore the $F = F^*$ for which $q_r^{cos} = q_r^*$ is given by (with all terms evaluated at (q_r^*, q_m^*)):

$$q_r \frac{dP_1}{dq_r} + \frac{c_r}{q_r} + \frac{fF^*}{q_r} = c_{r'} \quad (9)$$

This condition reduces to

$$F^* = \left[\frac{MC_r - AC_r}{P_1} - \frac{1}{\varepsilon_D}\right](q_r + q_m) \qquad (10)$$

where ε_D is the elasticity of core product demand. For given demand and cost functions in the core and noncore markets, the resulting no-regulation equilibrium output levels q_r^* and q_m^* substituted into equation (10) yield F^*. With this information the regulator can determine how any given level of common costs will affect noncore market activity, and therefore the true welfare effects of partial regulation.

Similar analysis holds for the simultaneous price competition case, since $p_m^{cos} = p_m^*$ when $F = F^*$ (i.e., $MRC_m = 0$), and this occurs at $(p_m^{cos}, p_s^{cos}) = (p_m^*, p_s^*)$.

The condition that $F = F^*$ when $q_r^{cos} = q_r^*$ shows that the effect partial regulation has on core market consumer surplus is dependent on the level of common costs. In quantity competition, if $F > F^*$, $q_r^{cos} < q_r^*$, and therefore core price is higher under partial regulation than under no regulation. Consumer surplus is lower when the firm is partially-regulated than when it is an unregulated monopolist!

5. Alternate Allocation Functions

Much of the above results relied, at least in part, on using the relative output allocation rule. While this allocation function has been used often in practice (e.g., by the Interstate Commerce Commission in allocating the cost of railroad track between freight and passenger service based on relative ton-miles), other allocation rules have also been used. How widely applicable the results obtained above are depends on their sensitivity to alternate specifications of the allocation rule.

In his model of a fully regulated multiproduct firm, Braeutigam (1980) showed that under zero profit FDC pricing the relative output rule resulted in different tariff rules than did the relative attributable cost and relative gross revenue rules. Under the latter two rules, the ratio of price to average attributable cost had to be equal for all services. Under the relative output rule, the difference between price and average attributable cost had to be equal for all services.

Sweeney (1982) found that the results of partial regulation do not depend on which of two 'classes' of allocation functions were used. The 'monotonic cost allocation method' included allocation functions based on relative output or on relative attributable cost. An allocation function $f(q_r, q_m)$ based on either of these rules is monotonically increasing in regulated output, decreasing in unregulated output. Using the 'revenue method,' the portion of common costs allocated to the regulated market is the percent of total revenues earned in the regulated market. Braeutigam and Panzar's (1989) results also do not depend on the type of allocation method employed. They point out that, although the relative revenue rule is not necessarily globally increasing in core output (as are the relative output and relative attributable cost rules), it is sufficient that the allocation function is increasing in core output at the optimum for equivalence of the results. Since more general results have been derived here in this context, a reexamination of the sensitivity of results to the choice of allocation function is needed.

The aspects of the model which capture the interrelationship between output decisions in the two markets are the MRC_m and the elasticity of the regulatory constraint. The following represent the salient points of comparison for the effects of partial regulation under the different cost allocation rules (remembering that the portion of common cost allocated to the noncore market is given by $RC_m = [1 - f(q_r^*, q_m)]F$, and that $\varepsilon_{rm} = (q_m/q_r)(dq_r/dq_m)$ represents the elasticity of the regulatory constraint).

For the relative output rule, as has been previously derived,

$$MRC_m^q = \frac{F}{q_r(q_r + q_m)^2}[1 - \varepsilon_{rm}]$$

$$\left(\frac{dq_r}{dq_m}\right)^q = \frac{-q_r F}{(MR_1 - MC_r)(q_r + q_m)^2 - q_m F}$$

For the relative attributable cost rule, where $f(q_r, q_m) = c_r/(c_r + c_m)$,

$$RC_m^c = \frac{c_m F}{(c_r(q_r^*) + c_m)}$$

$$MRC_m^c = \frac{q_r F}{q_m (c_r + c_m)^2}\left[\frac{q_m}{q_r} c_{m'} c_r - c_m c_{r'} \varepsilon_{rm}\right]$$

$$\left(\frac{dq_r}{dq_m}\right)^c = \frac{-c_r c_{m'} F}{(MR_1 - MC_r)(c_r + c_m)^2 - F c_m c_{r'}}$$

When the relative gross revenue method is used, $f(q_r, q_m) = R_1/(R_1 + R_2)$, and

$$RC_m^r = \frac{R_2}{R_1(\dot{q_r}) + R_2}$$

$$MRC_m^r = \frac{q_r F_r}{q_m (R_1 + R_2)^2}\left[\frac{q_m}{q_r} R_1 MR_2 - R_2 MR_1 e_{rm}\right]$$

$$\left(\frac{dq_r}{dq_m}\right)^r = \frac{-R_1 MR_2 F}{(MR_1 - MC_r)(R_1 + R_2)^2 - R_2 MR_1 F}$$

Several general results are obtained by comparing these conditions:

1. As in the case of the relative output rule, $q_m^{cos} > (=, <)\ q_m^*$ when $\varepsilon_{rm} > (=, <)\ 1$ for each of the other two allocation rules, and this will occur when $q_r^{cos} < (=, >)\ q_r^*$.

2. $F = F^*$ (i.e., the level of common costs for which $q_m^{cos} = q_m^*$) will differ (for the same cost and demand functions), depending on which allocation rule is used. This follows directly from the fact that $F=F^*$ when $q_r^{cos} = q^{r*}$, and so the condition for F^* obtained above still holds, i.e.,

$$F^* = \frac{c_{r'} q_r - c_r + q_r^2 \dfrac{dP_1}{dq_r}}{f(q_r, q_m)}$$

For the case where the marginal attributable costs in the core and noncore markets are constant, f(.) under the relative output and relative attributable cost rules will be the same, and so F^* will be the same in these two cases. With P_1, $P_2 > 0$ and all terms evaluated at (q_r^*, q_m^*),

$$\frac{R_1}{R_1 + R_2} = \frac{q_r P_1}{q_r P_1 + q_m P_2} = \frac{q_r}{q_r + q_m} \text{ only when } P_1 = P_2$$

When $P_1 > P_2$ at the no regulation equilibrium levels, the portion of common costs allocated to the core market will be greater using the relative revenue rule than the relative output rule, and when $P_1 < P_2$, the opposite is true. For any given core attributable cost and demand functions, when the relative revenue rule is used F^* will be less than when the relative output rule is employed.

While other results can be found under specific assumptions on cost functions or types of noncore competition, no general rules are readily obtainable. In contrast to previous work, these results clearly indicate that the effects of partial regulation depend on what cost allocation rule is used.

6. Dynamic Noncore Competition

In this section, the basic model of partial regulation of a firm that has market power in an unregulated market is extended to examine a case of simple dynamic interaction in the unregulated market. The duopolists are assumed to move sequentially rather than simultaneously. If one of the duopolists assumes a leadership position (i.e. one firm acts before the other duopolist), is the equilibrium outcome affected differently under partial regulation than it is when the firms act simultaneously, and how does this differ from the change that occurs under the no-regulation case? In the baseline (no regulation) case, equilibrium outcomes are affected when duopolists move sequentially, because the leader takes the follower's reactions (as opposed to actions) as given. The follower maintains Cournot conjectures, and the leader, realizing this, is able to profit from the follower's behavior. Leader profits are higher than those for a Cournot duopolist.

Partial regulation in the core market affects the multiproduct firm's best response function in the noncore market, and therefore its rival's expectation of how the firm will react to its own choices. This expectation will change how the rival behaves as a leader. The effect partial regulation has on the multiproduct firm's best response function will directly change how the multiproduct firm acts as a leader, by affecting its own marginal profit over the range of feasible output. As shown below, the driving force behind the results is that the effect partial regulation has on production incentives depends on the level of production in the noncore market, because these levels directly affect the allowable level of core market revenues through the regulatory constraint. Given that, in general, the firm produces more as a quantity leader than as a Cournot duopolist, and less as a follower than as a Cournot duopolist, the effects of partial regulation will differ depending on when the multiproduct firm moves in noncore competition.

6.1 Multiproduct Firm as Stackelberg Leader

Assume that under cost-of-service regulation, core output is given by $q_r^*(q_m)$, as shown above, and assume competition in the noncore market is in strategic substitutes (quantities). The partially-regulated firm as Stackelberg leader will choose noncore market output q_m^{cos} that maximizes $p_m = q_m P_2(q_m, q_s(q_m)) - c_m(q_m) - [1 - f(q_r^*(q_m), q_m)] F$, where $q_r^*(q_m)$ is given by the regulatory constraint, and $q_s(q_m)$ is the rival's (follower's) best response function. The first order condition for the partially-regulated firm is then

$$\begin{aligned} \frac{d\pi_m}{dq_m} &= 0 \\ &= q_m \frac{\partial P_2}{\partial q_s} + q_m \frac{\partial P_2}{\partial q_m} + P_2 - c_{m'} - F\left[\frac{\partial(1-f)}{\partial q_m} + \frac{\partial(1-f)}{\partial q_r}\frac{dq_r}{dq_m}\right] \end{aligned} \qquad (11)$$

[Note that the first order condition when there is no regulation in either market would be the same, except for the exclusion of the last term on the right-hand side, F[.], which is the MRC_m.] When $MRC_m = 0$, that is when $\varepsilon_m = 1$ (i.e., $q_r^{cos} = q_r^*$), noncore output for the partially-regulated firm is equal to the level that would be produced by a leader under no regulation in either market. As in the simultaneous move case, 'overproduction' will occur for the partially-regulated leader for 'high' levels of F. However, under partial regulation the level of common costs under which this overproduction equilibrium occurs is higher than in the simultaneous move case.

Let q_m^{**} be the level of noncore output for which $MRC_m = 0$. For any given F, $MRC_m < 0$ for any level of noncore output less than q_m^{**}, but $MRC_m > 0$ for $q_m > q_m^{**}$. Partial regulation makes it more costly to produce 'high' levels of noncore output and less costly to produce 'low' levels, for any given level of common costs. Because of this, it is more expensive (on the margin) for the multiproduct firm to be the Stackelberg leader, since a firm produces more as a leader than a Cournot duopolist for any given cost and demand functions.

The determination of F* in the case in which the partially-regulated firm is a Stackelberg leader follows from the derivation when noncore competition is Cournot duopoly. The unconstrained (no-regulation) equilibrium (q_m^*, q_s^*) when the partially-regulated firm is the Stackelberg leader is determined by the point at which the firm's noncore iso-profit (i.e. operating profits) curve π_m is tangent to the rival's best-response function, i.e. the point at which the slopes of these two curves are the same. For linear demand the slope of the rival's reaction function will be a constant (let this be given by K). (q_m^*, q_s^*) will therefore be given by the condition:

$$\frac{dq_s}{dq_m} = -\frac{\frac{\partial \pi_m}{\partial q_m}}{\frac{\partial \pi_m}{\partial q_s}} = -\frac{q_m \frac{\partial P_2}{\partial q_m} + P_2 - c_{m'}}{q_m \frac{\partial P_2}{\partial q_s}} = K \qquad (12)$$

Under partial regulation the rival's best response function is the same as in the no-regulation case, and so its slope is still equal to the constant K. Equilibrium under partial regulation is therefore obtained at

$$\frac{q_m \frac{\partial P_2}{\partial q_m} + P_2 - c_{m'} + MRC_m}{q_m \frac{\partial P_2}{\partial q_s}} = K \qquad (13)$$

This will result for $(q_m^{cos}, q_s^{cos}) = (q_m^*, q_s^*)$ only when $MRC_m = 0$ (assuming an interior solution). But, as shown above, $MRC_m = 0$ only when $\varepsilon_{rm} = 1$, which is the case iff $q_r^{cos} = q_r^*$. Therefore $F = F^*$ when (q_r^*, q_m^*, q_s^*) is the equilibrium result under partial regulation. F^* is therefore as given for the case of Cournot duopoly:

$$F^* = P_1 \left[\frac{MC_r - AC_r}{P_1} - \frac{1}{\varepsilon_D}\right](q_r + q_m)$$

Since equilibrium noncore output when the firm is a leader is greater than when it is a Cournot duopolist, F* will be greater in the former case than in the latter, for the same cost and demand functions. Intuitively, since equilibrium output is greater when the firm is a leader that when the duopolists choose simultaneously, the partially-regulated firm is operating on a more inelastic portion of the regulatory constraint for any given level of common costs, so to get to the point where it is operating in the elastic portion, the firm would have to be producing on a higher regulatory locus if it were a leader, i.e., F* would have to be greater than in the case of Cournot duopoly.

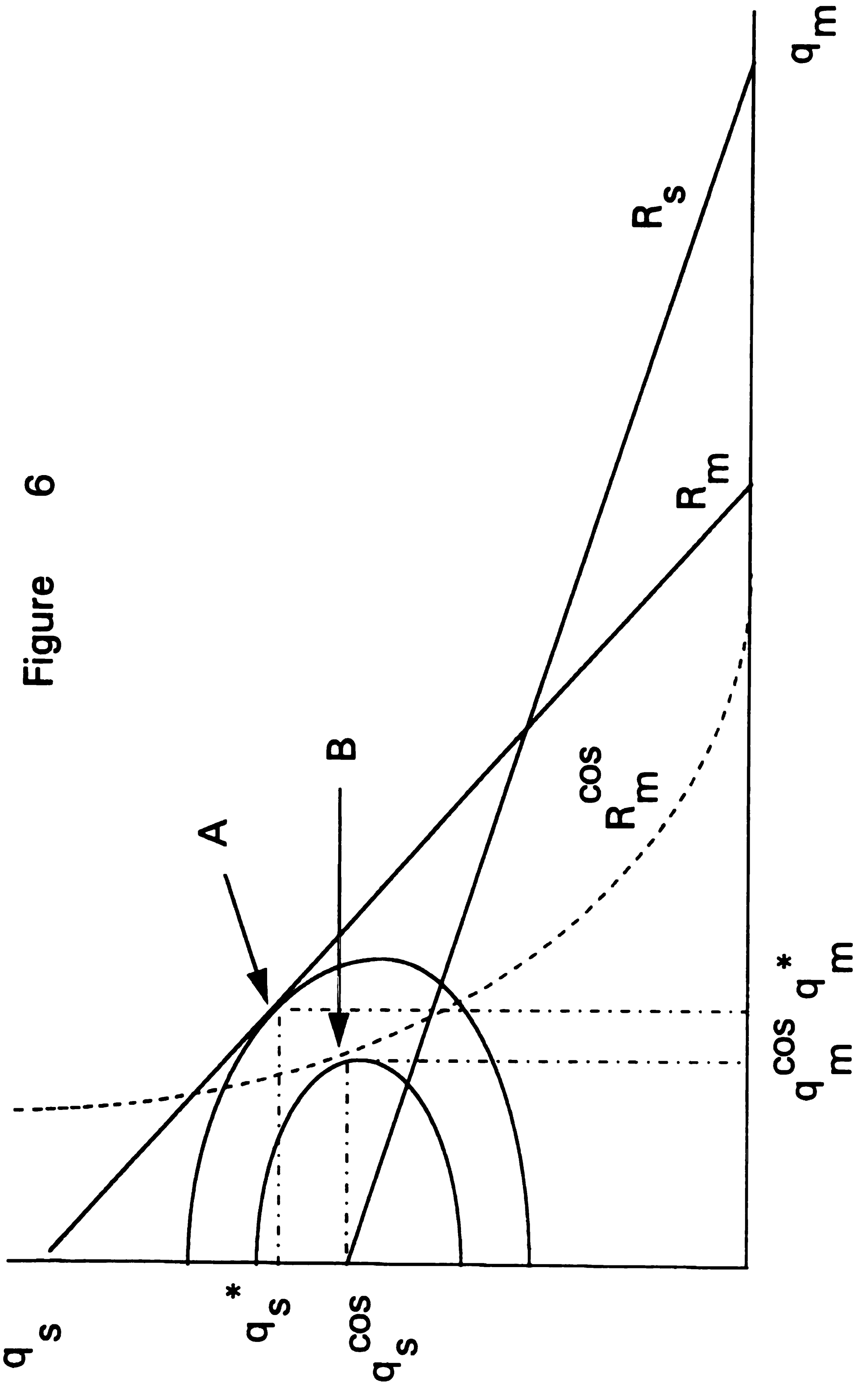
This difference in F* reinforces the idea that knowledge of the type of market competition in the unregulated market aids in determining the true welfare effect of partial regulation. When the firm has an established reputation, captive customer base, or other conditions which give it a first mover advantage, it can get an overproduction equilibrium at lower level of common cost than if it and its rival moved simultaneously -- the partially regulated firm can gain market share at the expense of its rival more readily (at lower cost).

6.2 Rival as Stackelberg Leader

When the multiproduct follower is partially-regulated, the rival as first mover incorporates not only how the follower will respond to its noncore output level choice (as it would if both markets were unregulated), but also how its own choice affects how the partially-regulated firm responds, and therefore the tradeoff the partially-regulated firm has between production levels allowed in its two markets by the regulatory constraint. These tradeoffs are incorporated into the best-response function for the follower under partial cost-of-service regulation, $R_m^{cos}(q_s, q_r^*(q_m))$ as derived in the simultaneous competition case. A surprising result is obtained: if the regulated firm is a follower, the firm may prefer to be under partial regulation than to be totally unregulated, and its rival may also prefer this.

When F is 'low', $MRC_m > 0$ over the range of q_m containing the no-regulation follower equilibrium. The rival leader knows the partially-regulated follower has higher costs than it would if it were unregulated in both markets -- for any given level of rival output, the rival knows that the partially-regulated follower will produce less than it would were it under no regulation. The rival anticipates a softer response to any action it takes, and so can choose to produce at a lower level of output. In this case total market output is closer to the collusive (monopoly) level under partial regulation than it is when both of the follower's markets are unregulated. The rival (and under certain circumstances both firms) can be earning higher profits when the follower is partially regulated. The multiproduct firm with a low level of common costs, if it has to be a follower, may prefer to be partially-regulated than to be completely free of regulation (and its rival would prefer this too).

Figure 6



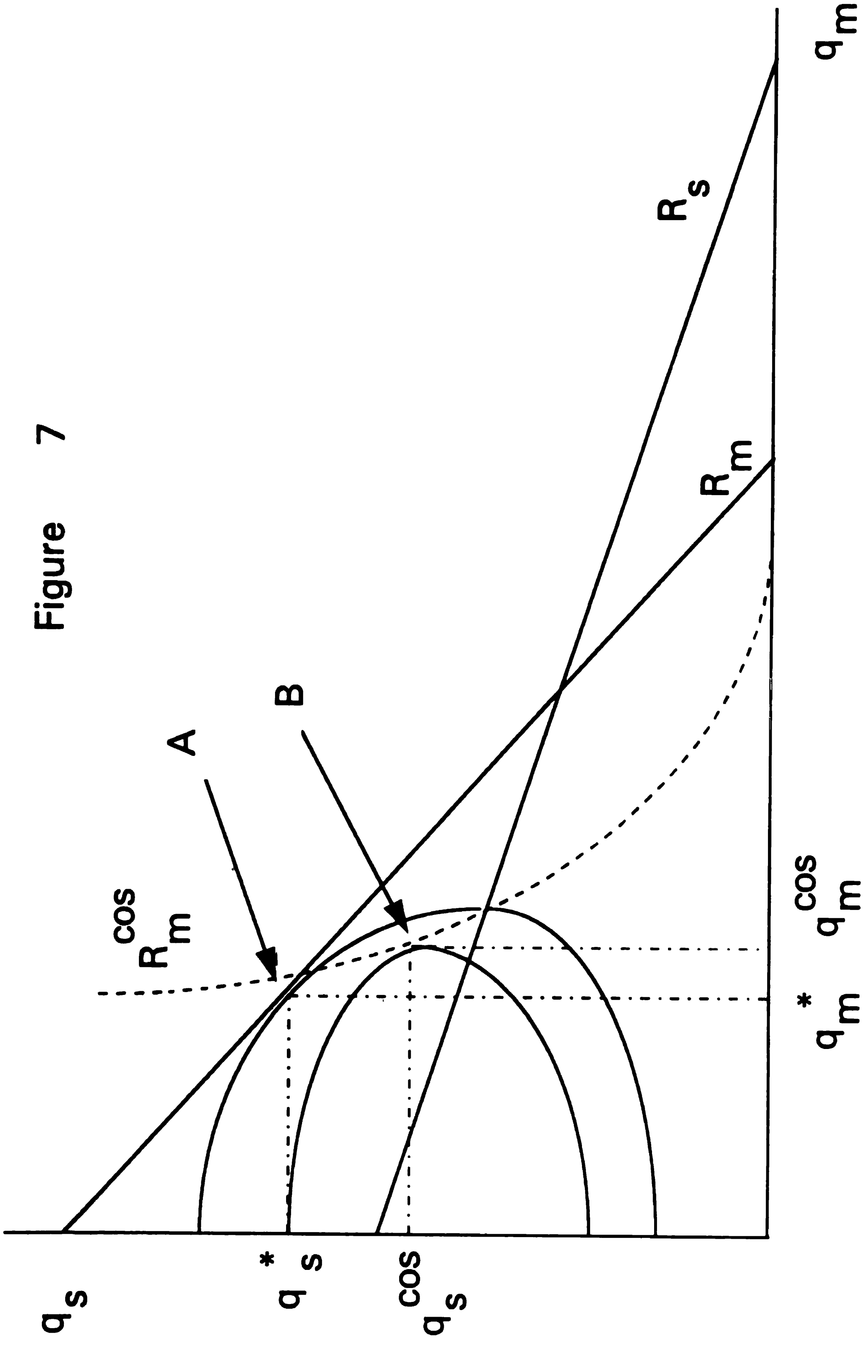
This case is illustrated in Figure 6. In (q_m, q_s) space, R_m and R_s represent the best response functions of the (unregulated) multiproduct firm and its rival, respectively. π_i, i = 1, 2 are the isoprofit loci for the rival, representing increasing levels of profit. Let point A represent equilibrium when the rival is the leader and the multiproduct firm is not regulated in its core market, given demand and cost conditions. Equilibrium output for the multiproduct firm and its rival are q_m* and q_s* respectively. Let R_m^{cos} represent the multiproduct firm's best response function when its common cost of production is low and it is partially regulated. In this case, equilibrium when its rival is the leader is now represented by point B, with resulting equilibrium outputs q_m^{cos} ($<q_m$*) and q_s^{cos} ($<q_s$*).

For 'high' F, even though the multiproduct firm is the second mover (follower), partial regulation 'precommits' the firm to produce a higher level of noncore output (than it would as a totally-unregulated follower) over a range of rival output levels. This is because $MRC_m < 0$, so effective marginal cost is less when partially regulated. The follower can take away some of the rival's first-mover advantage (although the rival's profit is still higher than it would be as a Cournot duopolist, so still prefers to be the first mover). Both firms may be better off when the multiproduct follower is partially-regulated when F is 'high' : under partial regulation noncore output is higher than would be under no-regulation for 'low' levels of noncore output. The rival, taking this reaction as given, produces less than it would if it were leader and the follower were under no regulation, with resulting noncore market price greater than would be under no regulation (since the decrease in rival output offsets the increase in follower output).

Figure 7 depicts this case. As in Figure 6, point A represents equilibrium with the rival as leader when the multiproduct firm is not regulated in its core market. R_m^{cos} in Figure 7 represent the best response function of the multiproduct firm when it is partially regulated and has a high level of common cost (note that it would be to the right of its counterpart when the firm has "low" common costs). Equilibrium with the rival as leader and the multiproduct firm partially regulated is represented by point B. Equilibrium output in this case for the multiproduct firm would be q_m^{cos} ($>q_m$*) and for the rival would be q_s^{cos} ($<q_s$*).

An explicit formula for F* (the level at which follower output under partial regulation is equal to that under no regulation), similar to that found above for the cases where the partially-regulated firm is a Cournot duopolist or Stackelberg leader, cannot be obtained for the case where the firm is a follower (the rival duopolist is the Stackelberg leader). In the no regulation case, (q_m*, q_s*) is obtained where the slope of the follower's best-response function is equal to the slope of the rival's isoprofit curve. As shown on the figure below, the only F for which equilibrium (q_m, q_s) under partial regulation could be equal to (q_m*, q_s*) is that which gives R_m^{cos} as the best-response function for the partially-regulated follower. But for this F, the slope of the follower's reaction

Figure 7



function is not equal to the slope of the rival's isoprofit curve which goes through this point, therefore (q_m*, q_s*) cannot be the equilibrium result under partial regulation. In fact, no (q_m, q_s) where R_m^{cos} intersects R_m (i.e. where MRC_m = 0) will be the equilibrium result under partial regulation where the rival is the leader. There will be an F = F* such that $q_m^{cos} = q_m^*$, but at this point $MRC_m > 0$, therefore $\varepsilon_m < 1$ and $q_r^{cos} > q_r^*$. Finding an explicit formula for F* depends on the condition that $q_r^{cos} = q_r^*$, but q_r^{cos} ¹ q_r^* when $q_m^{cos} = q_m^*$. Therefore we cannot determine exactly what level of common costs are 'high' enough to get and 'overproduction equilibrium' in the case where the rival is the first mover,.

In general however, we know that F* will be lower when the rival is the leader than under Cournot duopoly (and so less than when the partially-regulated firm is leader). Equilibrium noncore output is lower when the firm is a follower than when the duopolists move simultaneously, therefore the follower is operating on a more elastic portion of the regulatory constraint than as a Cournot duopolist. Therefore the level of common costs needed to shift regulatory constraint to point where equilibrium (q_r, q_m) is in the section where $\varepsilon_m > 1$ is less.

7. Summary

Regulation of a firm in one market will affect the behavior of that firm and its rival in an unregulated, but cost-related imperfectly competitive market.

Partial cost-of-service regulation can facilitate entry deterrence by the partially-regulated firm, help the regulated firm gain market share at the expense of its rival, or facilitate collusive behavior between the duopolists, depending on the type of competition in the unregulated market and the level of common cost of production for the regulated firm.

The effect partial regulation has on the firms' behavior in the unregulated market also depends on the allocation rule used. The one generalization that results is that the level of common costs that determine whether over- or underproduction in the noncore market will occur depends on which allocation rule the regulator orders the firm to use. When noncore market competition is that of Cournot duopoly or when the partially-regulated firm is a Stackelberg leader, an explicit functional form defining what the critical level of common cost is, i.e., that which determines whether there is over- or underproduction under partial regulation, can be found. This critical level F^* is a function of cost and demand conditions in each market, and can be obtained because of the relationship between the unconstrained levels of output, q_r^* and q_m^*, on the regulatory constraint. The relationship between critical F values under the different types of market competition can be obtained. This relationship is of importance to examining the welfare effects of partial regulation. A value for F^* cannot be calculated however when the (unregulated) rival is a

Stackelberg leader; F* will be lower when the partially-regulated firm is a follower than in the other two cases examined.

ENDNOTES

1. Brander and Spencer (1984) and Dixit and Grossman (1986). For a description of other examples of first-period actions by those other than the duopolists, see Tirole (1988).

2. See footnote 10.

3. This terminology was formalized by Bulow et al. (1985). Formally, actions are strategic complements if the marginal profits of a duopolist are increasing in its rival's actions.

4. c_r, c_m and c_s are general enough to allow for fixed costs directly attributable to production of those goods. These arguments are dropped from the specification to simplify notation. Firms are assumed to be price takers in factor markets, and to choose factor inputs to minimize total cost of production.

5. F is assumed to be a 'common' cost (outputs can be produced in variable proportions) as opposed to 'joint' cost (in which the ratio of the level of one output to another is fixed).

6. f_i refers to the partial derivative of f(.) with respect to q_i.

7. Including only the revenues from the regulated market matches common regulatory practice, and avoids one of the problems in Averch and Johnson (1962).

8. These properties hold under conditions which put minimal restrictions on the relationship between the marginal revenue and marginal cost curves. The conditions are similar to those given in the Appendix to chapter 1 of this volume.

9. Discussion here is limited to the entry accommodation case. The entry deterrence case is not considered since, in the case of deregulation, entry deterrence could trigger a strong reaction by regulators (e.g. markets could be reregulated) therefore it is assumed that the partially-regulated firm takes the existence of a rival for granted.

10. Both core and noncore profits are lower under partial regulation than under no regulation, so total profits for the multiproduct firm are unambiguously lower under partial regulation.

11. And is willing to forego profits to do so.

12. In the case where any difference in core profits due to the imposition of the regulatory constraint is more than offset by the increased noncore profits.

13. No regulation would be optimal for the firm, since total profits are unambiguously higher under no regulation than under partial regulation.

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CHAPTER 3

SPILLOVER EFFECTS OF PARTIAL PRICE-CAP REGULATION

1. Introduction

The inefficiency of cost-of-service regulation of a multiproduct firm with common costs of production has been much discussed and analyzed. Under fully-distributed cost (FDC) pricing, the firm has no incentive to be cost efficient, or to report costs accurately. Informational requirements are substantial and cross-subsidization incentives exist. Price-cap regulation is increasingly being used as an alternative to profit-level[1] regulation schemes such as FDC pricing. Regulation by capping price is considered an incentive-enhancing mechanism: by no longer directly relating costs and allowed revenues, firms have an incentive for cost reduction. Under a price-cap plan the benefits of cost reductions (as well as the risks of cost increases) accrue to the firm, rather than to the consumers as in profit level regulatory regimes.

The inefficiencies resulting under FDC pricing also exist when the firm is only partially regulated, in which case cost-of-service regulation is applied to only a subset of the firm's output vector. Sweeney (1982), Braeutigam and Panzar (1989) and Schenk (1995) all examine partial regulation under FDC pricing, showing that prices and output decisions are affected in an unregulated market when the firm is under cost-of-service regulation in a cost-related market.

Price-cap regulation is often seen in conjunction with partial deregulation of a subset of a multiproduct firm's product markets subject to competitive entry. It is generally believed[2] that a firm under partial price-cap regulation will not make the inefficient pricing and production decisions in unregulated product markets that it does when the firm is subject to partial profit-level regulation. Under price-cap regulation there is no artificial link between the markets in the form of a rule allocating common costs of production. Braeutigam and Panzar (1989) (hereafter BP), is one of the few analyses that explicitly examined partial regulation under price-cap regulation[3]. BP found that a partially price-regulated firm is Pareto efficient in a cost-related unregulated market: the firm will produce in the unregulated (perfectly competitive) market up to the point where marginal cost and price are equated, since at that output level profits will be maximized. The choice of output in the unregulated market has no effect on the price cap. This is in contrast to their results for partial regulation under FDC pricing. In that case, the firm is Pareto inefficient compared with the no-regulation equilibrium because each additional unit of output in the unregulated market affects the level of allowable revenue in the regulated market, as the share of common costs allocated to that market changes. Under FDC pricing, the partially-regulated firm's effective marginal cost in the unregulated market includes the effect that its production in that market has on costs (and therefore allowed revenues) in the regulated market. Their analysis in the case of price regulation does not however adequately address the effect of the choice of price cap level[4].

Using BP's framework, I will show that there are spillover effects of partial price-cap regulation on the firm's behavior in unregulated markets. These effects arise from two sources. Diversification must be profitable: any common costs not covered by the constrained revenues in the regulated market must be covered by revenues in the unregulated market. A second factor is that output in the unregulated market still affects allowable revenues in the regulated market for some forms of price capping. The firm must take into account the opportunity cost production in the unregulated market has on the level of allowable revenues in the regulated market. This internalization of marginal costs occurs without the artificial allocation mechanism used under FDC pricing. How price-cap regulation in a cost-related market will affect equilibrium output in the firm's unregulated markets will depend on the regulator's choice of price cap level, the cost structure of the firm, the type of market competition[5] in the unregulated market, as well as on the level of common costs of production. This latter result mirrors the results found in Schenk (1995) for partial regulation under an FDC regime. Partial price regulation can lead to misallocation of resources, and so the true welfare effects of partial regulation must incorporate more than just welfare in the regulated market.

Institutional aspects of price-cap regulation are discussed in Section 2. In Section 3 the model is developed and results when the unregulated market is perfectly competitive are discussed. Section 4 examines the case where the partially-regulated firm has market power in the unregulated market. The case where common costs are variable, as opposed to fixed, is addressed in Section 5. Results are summarized and extensions discussed in the final section.

2. Price-Level Regulation in Theory and Practice

Price-cap regulation is increasingly being used by regulatory agencies as an alternative to profit-level regulation (e.g., FDC or cost-of-service regulation). In general, the goal of profit-level regulation is to replicate, as closely as possible without subjecting the firm to undue restrictions, the results of competition by equating the firm's total costs and revenues. Although tying allowed revenues to actual internal costs protects consumers from monopoly power, it also gives the firm the incentive to inflate those costs and the disincentive to be more productively efficient. Price-level regulation attempts to correct for this cost efficiency disincentives, while still protecting consumers in certain markets. The firm's objective is to maximize profit, but in price-level regulation this translated to minimizing costs in the face of constrained revenues; in this way efficiency and competitive behavior are encouraged. By placing a limit on what price can be charged in certain markets while giving firms freedom to make economic decisions in other markets, regulators protect certain consumer groups from market power while providing incentives for the firms to be efficient, and encouraging competitive behavior while reducing managerial and regulatory administrative burdens.

Most incentive-enhancing mechanisms designed under price regulation regimes take the basic form of a 'PI-X' plan. Under this type of plan, the regulated firm is constrained so that in any period a weighted average of its prices in its regulated markets increases by no more than the rate of increase in its input costs (usually measured by some price index, such as the CPI or PPI) less X percent for expected productivity improvement. The price cap (the initial price level or weighted average) and offset components are chosen by the regulator[6]. The price cap plan imposed on the British telecommunications industry in the early 1980's is often cited as the standard (see Beesley and Littlechild (1989)).

Partial price-cap regulation has been increasingly used as monopoly markets have been opened to competitive activity. In the 1976 and 1980 Interstate Commerce Act amendments, the Interstate Commerce Commission's authority to establish maximum reasonable rates was eliminated, except in product markets for which carriers are found to possess "market dominance." The Federal Communications Commission (FCC) adopted price-cap regulation for AT&T in 1989; although originally separate price caps were set for three service baskets, pricing restrictions have since been lifted from most of the services in two of the baskets, while residential and small business services continue to be regulated. In many states, price cap regimes similar to the FCC plan have been adopted by state regulatory agencies in regulating local exchange carriers. In most of these cases it has evolved that price-cap regulation has remained on basic local exchange service while other services (such as large business services, or enhanced calling features) have been deregulated when competitive markets have been shown to (or are suspected to) exist. Implementation of price-cap regulation on the state level has mostly been in the form of sliding scale price cap plans (Braeutigam and Panzar, 1993).

In a 'PI-X' plan, the adjustment factor for price increases protects the regulated firm from losses during inflationary periods due to having static output prices while input prices are increasing. Debate continues as to whether the correct price index in the mechanism is an index on final goods (such as the CPI) or an input price index (to reflect changes in inputs used by the regulated firm, which has potential incentive implications especially for energy utilities). While the CPI does not reflect changing input costs facing the firm, it has the advantage that it is not affected by the behavior of the firm (as could an input price index).

The technology offset (the 'X' component) accounts for (recent and assumed continuing) gains in technological efficiency. Consumers gain from the 'usual' productivity growth, and the firm gains from increases in efficiency beyond the projected productivity increase. Optimally, the offset level is chosen by the regulator so that it cannot be affected by any strategic behavior by the firm. In price cap regimes in the regulation of railroad rates, industry-specific productivity indices are used, as firms are relatively homogenous in production technology. In telecommunications, where technology is more heterogeneous across firms, firm-specific productivity offsets are used (although in practice what is used is some combination of national productivity measure and firm-specific adjustment factor, to limit endogeneity).

The important consideration for regulators when determining which indices to use in any price-cap mechanism is that the index be exogenous to the decision-making of the firm being regulated to avoid any strategic incentives to manipulate output or price to affect (ultimately) the allowable price limit. The exogenous nature of the price cap gives the firm the incentive to be cost efficient and to adopt cost-reducing investments and innovations, as any gains from such reductions are captured by the firm (at least in part, depending on whether some 'sharing rule' is imposed).

This paper represents a departure from most of the current literature on price-cap regulation by turning the focus away from the adjustment components of the price cap. Instead, the focus of this paper is the effect the regulator's choice of price cap level has on the firm's behavior in all related markets. The price-cap mechanism modeled below therefore abstracts from these individual terms and is modeled as a single, regulator-chosen price ceiling. Whether the price cap is set at historical cost-of-service level, adjusted from that level to correct for historical cross-subsidization, or set at some other, perhaps arbitrary, level, is shown to affect how the firm behaves in unregulated but cost-related markets.

The model considered here is a static one-period model. Price-cap plans in practice may include specific rules for recontracting (i.e., regulatory review, where the price cap is adjusted for the next period depending on realized profits/losses in the regulated markets in previous periods), rules for how previous cost (profit) history is used in the determination of the initial price-cap at the onset of price regulation, or rules that include restrictions on allowed rates of return (i.e., sliding scale price cap plans). Studying the impact of these price-cap schemes would involve examining behavior over time, and therefore would need to be examined in a multiperiod setting. Most dynamic issues dealing with price-cap regulation in a partial regulation setting with common cost of production would require some form of arbitrary cost allocation (usually in the determination of how profitable the firm is in the regulated market, or in what is considered to be the cost of producing in the regulated market). Whether for this reason the results of price-cap regulation in a dynamic setting would follow to some degree those under FDC pricing is a subject of future research.

3. The Model

First consider a baseline model of an unregulated firm serving two markets[7]. This firm is a monopolist in market 1 (the 'core' service), producing a level of output given by q_r (as this will be the regulated market below). Inverse demand in this market is given by $P_1(q_r)$ and is assumed to be downward sloping. The multiproduct firm is a price taker in market 2, with output denoted by q_m (the 'noncore' service, where the subscript refers to output in this market by the multiproduct firm). In this market the multiproduct firm faces many competitors, each producing a single[8] output q_s, with total cost function given by $c_s(q_s)$. Price in the noncore market is determined by the condition that all competitors (other than the multiproduct firm) are in long-run equilibrium, i.e., by the condition $P_2^* = c_s' = c_s/q_s$ (with the prime denoting the first derivative). The core and noncore services considered here are not demand-related[9].

The cost function for the multiproduct firm has the form

$$C(q_r\,,\; q_m) = F + c_r(q_r) + c_m(q_m) \qquad (1)$$

where $c_r(q_r)$ and $c_m(q_m)$ are the costs of production that can unambiguously be associated with the production of the core and noncore services[10]. F is a fixed common[11] cost that results from production of both services but which cannot be accurately assigned between the two services[12]. Let $c_r(q_r)$, $c_m(q_m)$ and $c_s(q_s)$ be continuously differentiable over the interval $[0, \infty)$, with positive first derivatives. To ensure that the regulated firm is 'small' in the noncore market and therefore unable to influence the equilibrium price P_2^*, let $d^2c_m/dq_m^2 \geq 0$ at the optimum

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the optimum (i.e. the regulated firm has nondecreasing marginal costs in the noncore market)[13].

The model is one of full information: cost functions and demand conditions are assumed to be known by all agents before competition begins.

3.1 The Unregulated Benchmark Case

When the multiproduct firm is unconstrained by regulation in either market, it chooses output levels q_r and q_m to maximize profits

$$\pi(q_r, q_m) = q_r P_1(q_r) + q_m P_2^* - F - c_r(q_r) - c_m(q_m) \qquad (2)$$

The first-order conditions for the multiproduct firm are given by (with arguments omitted for brevity)[14]:

$$P_1 + q_r \frac{\partial P_1}{\partial q_r} - \frac{\partial c_r}{\partial q_r} = 0 \qquad (3)$$

$$P_2^* - \frac{\partial c_m}{\partial q_m} = 0 \qquad (4)$$

The firm will choose the output levels in each market at which marginal revenue is equal to marginal cost. Let the equilibrium output level in the noncore market be given by q_m^*. Although production in the two product markets is linked for the multiproduct firm because of the common factors of production, the output decision

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decision rules for the two markets are unrelated. The common cost affects only the level of total profit for the multiproduct firm, not the level of marginal profit, and therefore does not affect its production level decisions (assuming an interior solution).

3.2 Partial Regulation Under A Price-Cap Regime

Under a price-cap regulatory regime, the regulator gives the multiproduct firm freedom to choose quantity (price) in the core market, as long as price in that market does not exceed[15] some given level $P = \overline{P_1}$. $\overline{P_1}$ is assumed to be chosen[16] (as it was in BP) by the regulator so that the multiproduct firm 'breaks even' in the core market. This rule for choosing the price cap implicitly incorporates some allowed rate of return, and therefore is not a 'pure' price cap. This case is examined first to allow comparison with previous results. In effect, the regime modeled here represents the case in which the firm is required to return any 'excess' profits earned over the allowable revenues. Modeling the price cap as a function of current output also follows Baron (1991), where the optimal price cap is set prospectively based on costs anticipated for that period, but here in the case of complete information. Partial price-cap regulation under a rule closer to pure price caps (where the price cap is exogenously determined (i.e. without respect to realized output)) will be examined in Section 4 below.

What constitutes 'breaking even,' which BP did not explicitly address, affects the price cap level chosen, and therefore affects equilibrium output in both markets. $\overline{P_1}$ could be set so that common cost F is covered by revenues in the regulated market (i.e., a 'stand-alone' criterion is used), or set so that only attributable core costs are covered (i.e., the cost of common factors of production are considered 'incremental costs' of noncore production), or set somewhere between these two extremes, where an equity criterion may be used so that some 'fair share' of common costs are covered in each market. Different criteria are used in practice, depending on institutional factors and political considerations.

A number of cases must therefore be considered. The maximum allowed price in the core market can be represented by

$$\overline{P_1} = \frac{c_r(q_r) + f(q_r, q_m)F}{q_r}, \qquad 0 \leq f(q_r, q_m) \leq 1,$$

where q_r and q_m are output levels realized by the firm in each market. Different rules for what constitutes 'breaking even' are represented by what level $f(q_r, q_m)$ is chosen by the regulator (e.g., a 'stand-alone' criterion is analogous to $f(.) = 1$).

Case 1: The incremental cost of noncore output is zero, i.e., all common costs are covered by revenues in the core market. To 'break even' in the core market, total revenue must be equal to the sum of attributable core costs and total common costs. In this case,

$$\overline{P_1} = \frac{c_r(q_r) + F}{q_r}$$

In order to be profitable to diversify (i.e., profitable to produce in the noncore market) it must be true that, at the equilibrium level of noncore output,

$$P_2^* \geq AC_m(q_m) = \frac{c_m(q_m)}{q_m}$$

With constant noncore (attributable) marginal cost, equilibrium under partial price regulation can be obtained at the unconstrained output level (i.e., where $P_2^* = MC_m^*$, where * indicates levels at the no-regulation equilibrium output). Price regulation in the core market has no effect on the equilibrium output level in the noncore market, the level of noncore output under partial regulation (q_m^{pr}) will be the same as that under no regulation in either market (q_m^*). This result matches that found by BP, under the same assumptions, except they did not specify what constituted 'breaking even' when a firm had common costs of production.

With increasing attributable marginal cost in the noncore market, in every case in which a (completely) unregulated firm would produce (i.e., where the solution is not a corner solution), the firm will also produce (and at the same level) under partial price regulation. Noncore marginal cost and average cost are unaffected by partial regulation in this case, and so there is no reason to deviate from the no-regulation equilibrium: either the firm will produce the efficient level of noncore output, or a corner solution will result.

This price cap choice is unlikely to be seen in practice, however. Regulators in general have a bias against 'harming' captive (core) customers; expecting core customers to shoulder the full burden of paying for common production facilities, especially when these facilities are used to produce services in unregulated markets, has equity implications. Abnormal profits can be realized by the firm, where productive facilities are used to produce both monopoly and competitive products, but the full cost is covered by revenues in the monopoly market. The price cap in this case is greater than the price resulting under cost-of-service regulation[17], and although price caps higher than cost-of-service prices may be necessary under partial deregulation to offset historical (or perceived historical) cross-subsidies, regulators may be reluctant for political reasons to set price caps above prices resulting under cost-of-service regulation. Under this scenario a move to price-cap regulation would leave consumers in the regulated market worse off than under profit-level regulation. Because there may be reluctance on the part of regulators to set a price cap at this level, the effects of price caps set at other levels need to be considered.

Case 2: The price cap is set so that maximum allowable core revenues cover only attributable costs, i.e., the price cap is set to cover only costs specific to the production of core product:

$$\overline{P_1} = \frac{c_r(q_r)}{q_r}, \quad [< P^{cos} = \frac{c_r(q_r) + fF}{q_r}, \ 0 < f < 1]$$

In this case all common costs of production are associated with the noncore market, that is, common costs are treated as incremental costs of going from a single product producer to a multiproduct firm. While this certainly does not include the typical examples of partially-regulated utilities where core products/services cannot be produced without certain common facilities (e.g. local telephone company providing both (regulated) residential local plain-old-telephone (POT) service and (unregulated) large business POT service), price cap plans like this are considered by regulatory agencies in cases where it is desired that core consumers not be made to bear the costs of risky ventures by the firm.

As in the previous case, marginal production cost in the noncore market is unaffected by the regulatory rule in effect in the core market. In the (perfectly competitive) noncore market the firm produces where $P_2^* = MC_m$, i.e.,

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i.e., equilibrium output will be the same as the no-regulation case, so long as resulting noncore profits $\pi_m = q_m^* P_2^* - c_m(q_m^*) \geq F$. Only the decision to enter/exit the unregulated market is affected by partial regulation in this case; if it is profitable to enter/stay in the market, the equilibrium output level is the same as it would be if the firm were completely unregulated.

It may not be profitable to diversify for all levels of common cost of production, given that the core market price cap is set to cover attributable costs only. This condition is the same as for an entrant (single product) with entry costs or investment equal to F. Price regulation in one market in the form of a price cap that covers only attributable costs can lead to inefficient entry into an unregulated market, because the multiproduct firm is not allowed to take advantage of economies of scope. The partially-regulated firm operates with common facilities, but there may be inefficient entry by that firm into unregulated markets because the cost of the common facilities has to be covered by revenue in the unregulated market only, and not by total revenue. From a social standpoint, too tough a condition may be placed on diversification in this case, depending on the production technology of the regulated firm relative to its competitors in the unregulated markets.

Basing price caps on attributable costs only is seen as a theoretical alternative (to rates under cost-of-service regulation) for subsidy-free pricing (Hillman and Braeutigam, 1989). But the determination of what constitutes 'subsidy-free' pricing when there are common costs of production is contentious. The subsidy-free criterion does not necessarily preclude prices based on average costs (e.g. cost-of-service pricing)[18], which are considered in the following case.

Case 3: $\overline{P_1}$ is set at the level that would result under cost-of-service regulation, i.e.,

$$\overline{P_1} = \frac{c_r(q_r) + f(q_r, q_m)F}{q_r} = P_1^{cos}, \quad 0 < f(q_r, q_m) < 1$$

Total allowable revenues in the noncore market are no more than the sum of attributable noncore costs plus some portion of common costs. In cases where regulators are setting initial price caps at a transition from cost-of-service to price-based regulation, or when price regulation is being considered as an intermediate step to full deregulation, $\overline{P_1} = P_1^{cos}$ is often a focal point for setting an initial price cap, especially in cases where cross-subsidization is not suspected or difficult to determine. This type of price cap rule could result under bargaining between the firm and regulator, when the firm agrees to deregulation of one of its product markets in return for a guarantee that they will obtain a reasonable rate of return in their remaining regulated markets.

In this case, total core market revenues are constrained to be no more than total core attributable cost plus a portion ('fair' share) of common costs, i.e., $q_r \overline{P_1} - c_r(q_r) - f(q_r, q_m)F = 0$. But this condition is the same as the regulatory constraint the firm is required to operate under in cost-of-service (FDC) regulation. Given that this constraint is satisfied, the firm's objective function in the noncore market is to choose q_m to maximize

$\pi_m = q_m P_2^* - c_m(q_m) - [1 - f(q_r^{pc}(q_m), q_m)] F$, where $q_r^{pc}(q_m)$ is the level of core output which satisfies the regulatory constraint under this price-cap rule. $q_m^{pc}(q_r^{pc})$ is given by first-order condition:

$$0 = P_2^* - \frac{\partial c_m}{\partial q_m} - F[\frac{\partial(1-f)}{\partial q_m} + \frac{\partial(1-f)}{\partial q_r}\frac{dq_r}{dq_m}]$$

The firm will produce where price equals effective marginal cost, effective marginal cost incorporates the opportunity cost of an additional unit of noncore output on the allowable price-cap (i.e., the allowable core revenues). As shown in Schenk (1995), this opportunity cost is represented by

$$MRC_m = F\left[\frac{\partial(1-f)}{\partial q_m} + \frac{\partial(1-f)}{\partial q_r}\frac{dq_r}{dq_m}\right]$$

which is the change in the amount of common costs not allocated by the regulator to the core market.

MRC_m is > (<) 0 when F < (>) F^*, with F^* determined by the cost and demand structures in the two markets. When F > (<) F^*, effective marginal cost is less than (more than) it would be under no regulation (i.e. less than attribu

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attributable marginal cost), and so noncore market output will be higher than (lower than) it would be under no regulation. Price regulation in one market, where the price cap is set so that some portion of common costs of production are incorporated (and this portion is some function of relative outputs), will therefore affect the equilibrium output level in the unregulated market: any unit produced in the noncore market affects the price cap level (i.e., the level of allowable revenues) in the regulated market.

To summarize the results obtained so far, the only case where price regulation has no effect on production decisions in cost-related unregulated markets is the case where the price cap is set so that all common costs are covered by revenues in the regulated market. When allowable revenues are set so that only attributable costs in the core market are covered, diversification decisions may be affected depending on the level of common cost of production. In the case where the price cap is set to cover some portion of the common cost of production, the firm in effect operates in the regulated and unregulated markets as if it were operating under cost-of-service regulation. The spillover effects of price regulation unto unregulated markets, in addition to being dependent on the level of common costs (as was previously shown for cost-of-service regulation) are also dependent on the rule determining the price cap level. Contrary to what is generally believed, partial price regulation (as implemented in this way) may not improve upon the results under partial cost-of-service regulation.

To make the analysis complete, one more case needs to be considered.

Case 4: The price cap is set so that a portion of common costs are covered by core revenues, but this portion is some arbitrary level (chosen[19] by the regulator):

$$\overline{P}_1 = \frac{c_r + \alpha F}{q_r} \quad 0 < \alpha < 1$$

The effects of partial price regulation under this type of price cap rule will be dependent on what level the price cap (i.e. α) is set at, as well as whether resulting core operating profits are greater than common costs. The effects under this case mirror those when the price cap is exogenously set, which are fully discussed in the next section, so the reader is referred there for analysis of this case.

3.3 Alternative Price Cap Determination

In the first three cases discussed above, the equilibrium levels of output in the regulated and unregulated markets directly affected the allowable price cap because of the condition that the firm 'break even' in the regulated market. Pure price caps are not a function of current output. Price caps are set for a period of time (e.g. five or ten years) and, provided the firm does not exceed the cap, the firm is free to choose any output level in the core market.

Assuming the firm is a protected monopolist in the core market, the price cap is binding: a one-period model is considered here, so absent strategic behavior, there is no reason for the firm to charge less than the price cap, as long as that price cap is no higher than the monopoly price. The firm effectively acts as a price taker in the core market, with the price set by the regulator rather than by the market. The marginal cost of production in the noncore market is no longer a function of the level of core output. Under the price caps considered in the three cases above, every additional unit of noncore output affected the allowable revenues in the core market. Under the exogenous price cap however, core market price is not a function of noncore output and therefore neither is allowable revenue. The firm will produce in the noncore market up to the level where marginal revenue and marginal attributable cost are equated.

However, price regulation of this type will still affect whether diversification by the firm into the noncore market is viable. Assuming that the price cap is set below the monopoly price, the firm will produce in the core market where $MR_1 = \overline{P_1} = MC_r$, so $q_r^{pc} > q_r^*$, and $\pi_r^{pc} < \pi_r^*$ (where π_i represents operating profits, i.e. total revenue less total attributable costs).

If $F < \pi_r^{pc}$, diversification is 'free' -- the firm can take advantage of economies of scope so long as its noncore operating profits are non-negative, yet noncore market production does not have to 'pay for' any portion of common costs.

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If $F > \pi_r^{pc}$, some portion of common costs must be covered by noncore revenue. For a given price cap, a higher portion of common costs must be covered by noncore revenues than in the case where the multiproduct firm is under no regulation in either market. There will be price cap levels under which it would have been profitable to diversify when there is no regulation, but under which it is no longer profitable to diversify when there is partial price cap regulation. It is important to note that in the case where diversification is unprofitable, the firm is also not viable in the core market in the long run, since revenues are less than average cost under this price cap.

Partial price level regulation, where the price cap is an exogenously set level, does not affect the noncore output level decision rule, but does affect entry decisions. The portion of common costs that has to be covered by noncore revenues, and therefore how profitable it will be to diversify, depends on the (exogenous) price cap level chosen by the regulator.

4. Partial Price Regulation with an Imperfectly Competitive Noncore Market

The previous results are readily extended to the case where the multiproduct firm had market power in the noncore market. Assume now that the multiproduct firm is a monopolist in the core service and duopolist in the noncore service. The competing duopolist (the 'rival') produces only the noncore service[20]. Firms compete in outputs, levels of which are given by q_i, $i=r, m, s$ denoting the multiproduct firm's output in the regulated and unregulated markets and the output of the single-product rival duopolist, respectively. The duopolists produce a homogeneous good. Inverse demand in the duopoly market is given by $P_2(q_m, q_s)$, and marginal revenue for each duopolist is assumed to be decreasing in the other firm's output. Marginal cost in the noncore market can be decreasing now, as long as marginal cost is such that the marginal revenue curve intersects the marginal cost curve from above. All other notation and assumptions are as given in Section 3.

4.1 The Unregulated Baseline Case with Cournot Duopoly

When the multiproduct firm is unconstrained by regulation in either market, it chooses output levels q_r and q_m to maximize profits

$$\pi(q_r, q_m, q_s) = q_r\, P_1(q_r) + q_m P_2(q_m, q_s) - F - c_r(q_r) - c_m(q_m) \tag{5}$$

Its rival in the unregulated market chooses output level q_s to maximize own profits: $\pi_s = q_s\, P_2(q_m, q_s) - c_s(q_s)$. The noncore market structure is Cournot duopoly, i.e. the firms choose output levels simultaneously, taking as given the actions of the other firm. The first-order conditions for the multiproduct firm are given by (with arguments omitted for brevity):

$$P_1 + q_r \frac{\partial P_1}{\partial q_r} - \frac{\partial c_r}{\partial q_r} = 0 \tag{6}$$

$$P_2 + q_m \frac{\partial P_2}{\partial q_m} - \frac{\partial c_m}{\partial q_m} = 0 \tag{7}$$

and for the rival duopolist by:

$$P_2 + q_s \frac{\partial P_2}{\partial q_s} - \frac{\partial c_s}{\partial q_s} = 0 \tag{8}$$

Each firm will choose output levels in their respective markets where marginal revenue is equal to marginal cost;[21] the simultaneous solution of (7) and (8) is a Nash equilibrium. Although production in the two product markets is linked for the multiproduct firm, the output decision rules for the two markets are separate. The common fixed costs affect only the level of total profit for the multiproduct firm, not the level of marginal profit, and therefore do not affect its production level decisions (given an interior solution).

4.2 Partial Price-Cap Regulation

As in the case where the multiproduct firm was a price taker in the noncore market, for profitably diversification into a noncore market which is imperfectly competitive, it must be the case that operating[22] profits be sufficient to cover at least the portion of common cost of production not covered by revenues in the core market, i.e.,

$$\pi_2 = q_m P_2(q_m, q_s) - c_m \geq [1 - f(q_r^*, q_m)] F$$

with $0 \leq f(q_r^*, q_m) \leq 1$. In the case where the price cap is set so that all common costs are covered by revenues in the regulated market (i.e. as in Case 1 above), operating profits must be greater than or equal to zero, which is the same as it would be if the firm were under no regulation in either market. In this case, price level regulation in one market has no effect of the behavior of the firm in a cost-related unregulated market. The multiproduct Cournot duopolist produces the same level of equilibrium output in the noncore market as if it were under no regulation in either market.

When $f(.) = 0$ (i.e., the price cap in the core market is set so that core revenues cover none of the common costs of production), the feasible range of production (i.e., the possible (q_m, q_s) equilibrium combination) is limited for a given level of F, and is binding when $F > \pi_2^* (q_m^*, q_s^*)$, where * indicates the no-regulation equilibrium output levels. Only if $F < \pi_2^*$ is it profitable to diversify at (q_m^*, q_s^*). Therefore profitable diversification will depend on the attributable cost function and demand conditions in the noncore market. In general, since demand facing the firm is more inelastic when the firm has market power, operating profits will be higher when the firm is a Cournot duopolist than when it is a price taker (for the same attributable cost function). Cases (i.e. for certain levels of common costs) where it was not profitable to diversify under price level regulation when the firm was a price taker present profitable diversification opportunities when the noncore market is imperfectly competitive.

When $0 < f(.) < 1$, the price cap in the core market is set so that only a portion of common costs need to be covered by noncore revenues, with this portion a function of the firm's outputs in the two markets. The multiproduct firm's objective function in the noncore market, assuming that the firm is producing $q_r^*(q_m)$ in the core market, is

$$q_m P_2(q_m, q_s) - c_m(q_m) - [1 - f(q_r^*(q_m), q_m)] F$$

The rival duopolist knows that the partially-regulated firm takes into account the opportunity cost of noncore production on the allowable core revenues. For low levels of common costs, the opportunity cost of noncore production on the core market production is negative: an additional unit of noncore market output reduces allowable revenues in the core market, therefore the multiproduct firm will not produce up to q_m^*. When the firm has high levels of common cost of production, production in the core market in effect subsidizes production in the noncore market: each additional unit of noncore output cost less to produce than it would have cost if the firm were unregulated in both markets, and so the firm produces the noncore service at a higher level than it would if it were a completely unregulated duopolist. These results depend on how the amount of common cost that must be covered by noncore revenues changes as output changes, and are analogous to those found under cost-of-service regulation as modeled in Schenk (1995).

5. Partial Price-Cap Regulation with Variable Common Costs of Production

The output markets of a multiproduct firm can also be cost-related when the marginal cost of production in one market is a function of the level of output in another product market. For example, a local telephone company may use the same employees to install both business and residential services. The more business systems a person installs, the quicker they can install residential services (a type of learning by doing), and therefore increasing the number of business systems installed will lower the marginal cost of installing residential service. The cost function of the multiproduct firm when there are complementarities in production can be represented by:

$$C(q_r,\ q_m) = c_r(q_r) + c_m(q_m) - \nu(q_r, q_m)$$

where the marginal cost of producing either service is given by

$$MC_i = \frac{dc_i}{dq_i} + \frac{\partial v}{\partial q_i} \quad i = r, m$$

When partial price-cap regulation is imposed on this firm, the effect of partial regulation on unregulated markets is readily seen, and are present regardless of what rule is used to determine the price cap. The level at which the price cap is set affects the level of core output chosen by the firm, which in turn affects the marginal cost of production in the noncore market. In addition the firm has to be concerned with the feasibility of production in the unregulated market.

A firm producing in the core market with no regulation would produce level q_r^* and charge P_1^*. If the price cap $\overline{P_1}$ is set so that $\overline{P_1} < P_1*$, the firm produces $q_r^{\,p}$, where $q_r^* < q_r^{\,p}$. With $q_r^{\,p} > q_r^*$, noncore marginal cost is lower for any given level of noncore output is lower under price cap regulation than if the firm were under no regulation in either market, and therefore equilibrium noncore output level is greater under partial regulation than under no regulation. When $\overline{P_1} > P_1*$, noncore output will be lower under price cap regulation than in the no regulation case, since noncore marginal cost will be higher with $q_r^p < q_r*$.

The price cap, by affecting marginal revenue in the core market, affects equilibrium output in that market and therefore marginal costs in the noncore market. The welfare effects of partial regulation are therefore not limited to the effects on profit and consumer surplus in the core (regulated) market, and so the true 'costs' of regulation are misrepresented when only welfare for the core market participants is considered.

6. Summary and Extensions

Price-cap regulation is appealing to regulators because (theoretically) under pure price caps the regulated firm's behavior is determined by market conditions more so than under profit-level regulation. Price-cap regulation is often coupled with partial deregulation by regulators. As shown above, however, the degree to which price caps will affect behavior of a partially-regulated firm in cost-related unregulated markets will depend on what level the price cap is set at.

Partial price-cap regulation has no effect on the equilibrium output of a multiproduct firm with common cost of production when the price cap is set so that all common costs are recovered by revenues in the core market. However, partial price-cap regulation does have spillover effect on cost-related unregulated markets when the cap is set at or below the price level that exists under cost-of-service regulation. The degree to which production decisions are affected in the unregulated market depends on the cost structure of the firm and the type of competition in the noncore (unregulated) market. Unlike previous work, these results demonstrate that partial price-level regulation affects production decisions in noncore market, as was the case under cost-of-service regulation.

There is no one general rule for when this spillover effect will result; regulators must examine each case separately, since results of partial price-level regulation are dependent on what level the price cap is set at, the cost structure of the multiproduct firm, and the type of competition in the noncore (unregulated) market. Information requirements for regulators are still high even under price regulation. In some cases partial price-cap regulation leads to a misallocation of resources, as the optimal combination of outputs for the firm is affected. In others inefficient entry into unregulated markets results: demand conditions in the unregulated market are insufficient to generate revenues that cover both attributable costs and the portion of common costs not covered by the (constrained) revenues in the regulated market. The welfare effects of partial price regulation therefore include what effects the choice of price cap level have on competition in unregulated markets.

The results in this model were obtained using a simple static model. Three aspects of price-level regulation in practice cannot be captured in a static model. Since regulators in general cannot commit to a given regulatory regime, firms under partial price regulation must worry about recontracting, and therefore about how decisions today and in a given market will affect what are considered core profits, and therefore what level price caps will be set at in future periods. Secondly, in a transition from cost-of-service regulation to price capping, costs incurred under profit level regulation often determine in part future price caps. Price regulation as adopted in actual regulatory regimes (as opposed to optimal price regulation) comes in many forms, and under most of these there are aspects of rate-of-return calculations or cost revelation. Sliding scale price cap regulation, in use in the telecommunications industry in the regulation of local exchange carriers, adjusts price caps based on earned rates-of-return in the previous period. Under this type of regulation, when there are common costs of production cost allocation rules are needed to determine the profitability of the core (regulated) market separately. In the model presented above a first cut was taken at incorporating rate-of-return considerations within a price cap, albeit in a static setting, by embedding price ceilings and 'break even' conditions. Dynamic aspects of price cap setting have been explored in the context of a fully regulated multiproduct firm. Little work has been done on the strategic behavior of a *partially* price-regulated firm in a dynamic setting, although such work is needed given that price level regulation is often coupled with partial deregulation, especially in cases where a firm remains a protected monopolist in some core services.

ENDNOTES

1. Under "profit-level" regulation price levels are restricted as well, but the focus is on what profit level results under such prices. Under the general category of "price-level" regulation there are included incentive mechanisms such as price caps. In (pure) price-cap regulation, maximum prices are fixed with resulting profits unrestricted. Sliding scale price caps are an intermediate form of regulation: prices are restricted, but are periodically reevaluated based on rates of return earned by the regulated firm.

2. See Hillman and Braeutigam (1989) for discussion.

3. Hillman and Braeutigam (1989) also address this issue, stating that it is not possible for a firm to use competitive markets which require lower rates to justify price increases in more inelastic markets when the competitive markets are deregulated.

4. What effect setting the price cap at different levels has on the firm's behavior is addressed by Hillman and Braeutigam, but only in the case of a diversified firm whose markets are all under price level regulation. In that analysis they are only concerned with price ceilings that are too low to ensure viability of the firm, or just sufficient to maintain viability but not high enough to promote new investment by the firm.

5. BP only examine price-taking behavior in the unregulated market.

6. Although ultimately the cap and adjustment levels are chosen by the regulator, there is generally a bargaining process between the regulator, the firm, and intervenors involved. Bargaining may be done over both the initial levels and any changes over time. Here it is simply assumed that the choice is the regulator's alone, since a single-period model is used.

7. Or a firm currently serving one market, and considering diversification into another product market. BP examine the incentives for profitable diversification under partial regulation -- what determines whether a regulated monopolist branches off and starts producing in a new (to them) unregulated market, and if they do diversify, what level of output will they produce in that market. The decision mechanisms for the firm is essentially the same whether we considering diversification incentives as in BP, or determining the level of output in a market after that market is deregulated.

8. This assumption is made for computational ease only; all that is needed is that the rival is not also producing the core service or a complementary good,

and that any other goods it produces are not demand-related to the noncore service.

9. Demand-related products add another layer of complexity to the problem. Price restrictions on basic residential telephone service would affect the level of service provision, and therefore the demand for complementary services such as optional calling features (e.g., call waiting), which are in many jurisdictions unregulated.

10. c_r,c_m and c_s are general enough to allow for fixed costs directly attributable to production of those goods. These arguments are dropped from the specification to simplify notation. Firms are assumed to be price takers in factor markets, and to choose factor inputs to minimize total cost of production.

11. F is assumed to be a 'common' cost (outputs can be produced in variable proportions) as opposed to 'joint' cost (in which the ratio of the level of one output to another is fixed).

12. This is a short-run model, therefore it is assumed that the firm cannot change its technology to use production methods with only attributable costs. If the firm wants to continue to serve both markets, it must use technology involving common costs (e.g., to offer both residential and business telephone service, the local telephone company must use the same switching equipment). The level of common costs is taken as given.

13. The firm is a monopolist in the core market either because it is a natural monopoly with the inherent cost advantages implied, because demand is such to support only one firm, or because entry is proscribed by government action. Because these imply that different cost structures are possible in the core market, no further restrictions will be placed on the attributable core cost function $c_r(q_r)$.

14. As long as MR_r intersects MC_r from above, and given the condition assumed for $c_m(q_m)$, the sufficient conditions for maximization hold when the necessary conditions are satisfied.

15. In fact, the only circumstance under which it is not profit maximizing for the firm to charge a price equal to the price cap is when $\overline{P_1} > P_1{*}$, where $P_1{*}$ is determined by $MR_1 = MC_r$. Only in this case would the firm charge less than the price cap. However, it is not likely that the price cap would be set this high.

16. While choosing the price cap at the Ramsey price may be second-best efficient, it does not preclude cross-subsidization and is in practice impossible for the regulator to implement due to information asymmetries.

17. Where $P_1^{cos} = \dfrac{c_r + fF}{q_r}$, $0 < f < 1$

18. See Berg and Tschirhart, 1988.

19. In this case it must be assumed that the regulator does not choose a according to some objective function (e.g., to maximize consumer welfare), since that objective function would then have to enter the maximization problem. In establishing price cap regimes, regulators are generally looking at such regimes as a way for them to get out of the process, i.e., for the market (rather than themselves) to determine firm decisions. Assuming this motivation to be the case, it follows that one should model the problem as one where the regulator chooses the price cap incorporating some common cost sharing (for equity considerations) but does not otherwise enter the decision process.

20. See footnote 8.

21. A sufficient condition for existence of a Cournot equilibrium is that each firm's marginal revenue is decreasing in the other firm's output (Novshek (1985)). This condition is more general than that usually assumed for Cournot competition, i.e. that the payoff function be concave (which is implied by downward-sloping demand and convex costs) (Szidarovsky and Yakowitz (1977)). This more general condition allows us to consider the case of decreasing marginal cost in the unregulated market. The sufficient condition for uniqueness

$$\left| \frac{\partial^2 \pi_m}{\partial q_m^{\,2}} \right| > \left| \frac{\partial^2 \pi_m}{\partial q_m \partial q_s} \right|$$

is satisfied for the case of homogeneous goods as long as dc_m/dq_m is nondecreasing, or is decreasing at less than twice the rate that MR_m is.

22. Where operating profits are defined as total revenue less total attributable cost.