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ON THE EFFECTS OF ENTRY

BY JESUS SEADE[1]

The effects of entry into an oligopolistic industry are studied, generalizing the usual Cournot model to allow for the possibility of collusion by firms and deriving stronger results than had previously been obtained. Necessary and sufficient conditions for output per firm y to rise or fall as entry occurs are given and discussed, and the "perverse" effect (entry increasing y) is shown to be consistent with stable equilibria and not empirically implausible. In contrast, it is shown that industry output unambiguously expands and profits per firm fall as entry into *stable* equilibria takes place. Total industry profits are also considered and some results obtained.

1. INTRODUCTION

THE PROBLEM OF ENTRY receives a great deal of attention in present-day Industrial Economics. The main question typically asked in this connection, ever since the work of Bain and Sylos–Labini, is what the best strategies are for oligopolists facing the threat of entry into their industry, that is, the implications of potential entry on their optimal policies regarding pricing, investment, research and development, advertising, and so on. Were entry to occur, conventional wisdom says, the effects would be unambiguous: profits per firm, and perhaps also output per firm would fall, while the industry as a whole would become "more competitive" in some sense, in particular expanding output. These effects are commonly taken for granted in discussions on entry, as obvious truths or, at best, as underlying assumptions. The natural question arises of whether this deep-rooted piece of conventional wisdom is in fact correct for the general case, as the behavior of oligopoloy is, alas, complex enough to keep many surprises in store.

Of course, these remarks are not meant to apply to the limit case where barriers to entry are removed altogether, thus breaking entirely the oligopolistic set-up. The effect on profits, in particular, would in this extreme case be necessarily unambiguous, as they would need to be zero in the new equilibrium, be it perfect or monopolistic competition. This is no more than a definition of equilibrium, but perhaps our intuition draws too heavily on this trivial consideration.[2]

Some of the effects of entry we shall be examining, in particular those on output, have been studied before, albeit in a rather limited form. Frank [**1**], Okuguchi [**3**], and Ruffin [**4**] found that certain "reasonable" conditions were sufficient for aggregate output to rise and firm-output to fall as entry occurs in the simple Cournot model of oligopoly.[3] However, these authors do not examine what

[1] I should like to thank Keith Cowling, Avinash Dixit, Paul Stoneman, a referee of this journal, and participants at the 1977 Warwick Summer Economics Workshop (on Oligopoly) for helpful comments.

[2] Even then, however, the limit behavior of output and price is not obvious [**1, 4**].

[3] Otherwise, [**1**] and [**4**] mainly discuss limit behavior as unrestricted entry is introduced. Other contributions are by McManus [**2**], who derives similar results diagrammatically, assuming linear demands and costs; Telser [**6**], who wrongly derives a result on aggregate output (p. 136); and Okuguchi [**3**], who extends the results of [**1, 4**] on limited entry to the case where industry heterogeneity of a special form is allowed (see fn. 5, below). All these authors consider only the Cournot model.

happens when these nontrivial requirements are not imposed, nor do they look into the behavior of other related variables. We shall see, for example, that much stronger sufficient conditions for "normal" behavior of aggregate output can be given than those they assume—in fact we shall find that output *always* expands with entry, given only observability of equilibrium, but we shall argue too that it is not quite safe to disregard the cases they exclude.

Our aim here is to look at the effects of entry systematically, (i) discussing movements in profits as well as in outputs, at the firm and industry levels; (ii) allowing the conditions for alternative comparative-statics forms of behavior to emerge from the analysis, with no a priori requirement other than profit maximization, and (iii) relaxing the strong Cournot assumption into a somewhat more general "quasi-Cournot" world, where firms may have a certain degree of "collusion," that is, awareness of their interdependence via the equilibrium effects of their individual actions, provided these effects are well defined and well predicted by producers. We shall identify certain demand (and cost) conditions under which entry (or exit) would cause the equilibrium values of some of the variables studied to move in the opposite direction to conventional wisdom. Some such "perverse" effects of entry, however, will be ruled out on the grounds that they correspond to unstable (hence in practice unobservable) equilibria identified in [**5**], while others remain real possibilities previously ignored by assumption.

2. FRAMEWORK

Let homogeneous output Y be produced by n firms, producing y^f each, with price p determined by the inverse demand function $p = p(Y)$. Profits for a firm are

$$\Pi^f = y^f p(Y) - c^f(y^f),$$

where $c^f(\cdot)$ is the cost function. Profit maximization requires

$$\frac{d\Pi^f}{dy^f} = p + y^f p' \frac{dY}{dy^f} - c^{f\prime} = 0$$

for all f, where dY/dy^f is the conjectural change in total output Y for firm f, relative to a given small change in its own output y^f. This conjectural change can take on any value in general, which renders the whole exercise in principle indeterminate. It is this game-theoretic indeterminateness of the conjectural variations that make oligopoly theory difficult to handle.

In order to make things manageable, I shall assume each firm conjectures others would follow, perhaps only partially, its own expansions or contractions of output around a given joint optimum, a reflection of their common desire to protect their market shares, in such a way that the value of dY/dy^f is some factor λ^f which would probably be taken by the firm to be, and shall be treated here as a constant in the relevant ranges. Nothing crucial hinges on this assumed constancy of λ^f, and we shall later allow this parameter to vary as entry occurs. What matters is the assumed *existence* of the function dY/dy^f, i.e. that each firm be able to predict correctly the effects of its actions on the industry. This way of modelling interactions within an industry is a convenient standard practice which might naturally be called "quasi-Cournot" behavior. An extreme instance of it is the Cournot assumption, by which each firm conjectures the rest of the industry would not follow it at all were it to expand its own output, hence $dY/dy^f = 1$ then. At the other end, if all firms were fully aware of their interactions, any "profitable" move by a given firm would be exactly matched by similar measures by the rest, all of them reacting to the same environment. We would then get, in an industry of equal-sized firms, $dY/dy^f = n$. This is tantamount to having full collusion of all firms concerned, as if they had an explicit monopolistic agreement to choose the level of aggregate output that maximizes joint profits, subject only to the condition that these profits be equally generated and distributed amongst them. This provides an intuitively plausible upper bound on the change in Y that would follow a firm's changing its own output. In sum, we shall treat the reaction factor λ^f as a constant, whose interesting values probably lie between 1 and n.[4] The larger λ is, the more "collusive" the behavior it captures.

Finally, we shall assume, for great convenience and at low cost in terms of interpretation, that firms are identical and equilibria symmetric. The reason for doing this is that, with a non-homogeneous industry, it is not clear anymore what "entry" means, as it becomes necessary to specify the *kind* of firm that enters the industry. This would complicate notation and expressions considerably and weaken possible results, while providing no interesting new insight into the problem.[5] Thus, eliminating differences across firms, first and second order conditions for an equilibrium become

(1) $$p + \lambda y p' - c' = 0,$$

and

(2) $$\lambda^2 y p'' + 2\lambda p' - c'' < 0.$$

For convenience, I use strict concavity of profits as a function of own-output (hence (2) at the equilibrium point), which with (1) is sufficient for an equilibrium, instead of the customary necessary condition, with a weak inequality in (2).

[4] These bounds on possible forms of industry behavior, between Cournot and full collusion, are only suggested to fix ideas, and assumed in the paper for convenience. One might perhaps want to allow for λ's in $[0, 1)$, a regime of "struggle," rather than "collusion" as in $(1, n]$. The story would go that, were I to reduce my output trying to move up along my perceived demand curve, others would jump in, expanding output and taking part of my market share. Or one might even argue for lower values of λ for reductions than for increases in y^f, a general kinked-demand-curve-type phenomenon.

[5] An alternative way to circumvent these difficulties is used by Okuguchi [**3**], who allows for differences across firms but requires entry to be in effect *replication* of the industry, so that the whole range of existing firms "enter," in the given prevailing proportions. This seems a natural tack for discussions of limit cases, as in the well-known analogue of this replication in the context of general equilibrium and the core. But as an assumption on the nature of (limited) entry it seems somewhat artificial.

3. MODELLING ENTRY

Let us now let a new producer enter (or leave) the industry. It would be of great help to be able to treat the number of firms n as a continuous variable and differentiate all relevant variables with respect to it. This in fact is common practice, usually with an apology rather than a justification. But this expedient can easily be made rigorous. We simply allow the number of firms n to be an actual continuous variable on which everything depends differentiably according to the given relations, but we restrict attention to integer realizations of this variable. Then, if ξ is any dependent variable defined on the number of firms n, its change when one firm enters is $\Delta\xi = \int_n^{n+1} \xi'(\nu)\, d\nu$. It is clear that (sign $\Delta\xi$) = (sign $\xi'(\nu)$) whenever the latter sign does not change in the relevant range $(n, n+1)$; otherwise the sign of $\Delta\xi$ is ambiguous. I shall assume away cases where this ambiguity arises and hence work with sign $\xi'(n)$ directly. It is essentially this single-signedness assumption, which one can check, that underlies the common continuous treatment of discrete variables in problems of the present sort.

4. OUTPUT PER FIRM

The "normal," or conventional-wisdom result whose robustness we want to examine is that output per firm declines as entry occurs: $dy/dn < 0$. Differentiating (1) with respect to n,

$$p'\left(n\frac{dy}{dn}+y\right)+\lambda y p''\left(n\frac{dy}{dn}+y\right)+\lambda p'\frac{dy}{dn}=c''\frac{dy}{dn}$$

which, assuming $p' < 0$, yields

$$\eta_{yn} = -(E+m)/(E+m+k) \tag{3}$$

(if $E+m+k \neq 0$), where $\eta_{yn} \equiv (n\, dy/dn)/y$ is the elasticity of y with respect to n, whose sign interests us, and

$$m \equiv n/\lambda;$$

$$E \equiv Yp''/p'; \quad \text{and}$$

$$k \equiv 1 - c''/\lambda p'.$$

The use of these variables will considerably simplify our notation and be an aid to intuition. It will be seen that, in fact, m and E are the key explanatory variables in most of what follows. The former, $m \equiv n/\lambda$, can be regarded as the *number of "effective" firms* in the industry, i.e. the inverse of a measure of *effective* concentration quite distinct from the standard measure of *observed* concentration n, which is here adjusted by the degree of collusion λ.[6] When $\lambda = 1$ (no collusion, the Cournot case), the market has n "effective" (and actual) firms, whereas when $\lambda = n$, the market behaves in a fully collusive manner, with $m = 1$ (as a monopolist,

[6] The unequal-firms counterpart of this m would be $1/H\lambda$, where $H \equiv \Sigma\, w_i^2$ is the Herfindahl index of *observed* concentration, the w_i's being the market shares of individual firms.

subject only to symmetry).[7] To avoid unnecessary taxonomy of results, I shall assume $1 \leqslant m \leqslant n$ throughout.

Apart from m, which in the Cournot model reduces to n and has no special interest in itself, the central variable to examine turns out to be $E \equiv Yp''/p'$, the *elasticity of the slope* of demand, negative (positive) for convex (concave) curves. This will be discussed in some detail in the following section.

Finally, the variable $k \equiv 1 - c''/\lambda p'$ will usually have a value not far from 1 and at any rate will normally be positive, since $k < 0$ is equivalent to $c'' < \lambda p'$, i.e. marginal costs not only falling but doing so faster than perceived demand, a rather uninteresting possibility which we shall in fact presently rule out altogether.

With this notation, we can rewrite the second-order condition (2) as

$$(4) \qquad E + m + mk > 0.$$

On the other hand, it is shown in [**5**] that (i) given $k > 0$, as one would normally assume, equilibrium is unstable (a saddle point) for $E < -(m+k)$ and stable for $E > -(m+k)$, which includes in particular the case assumed in [**1**, **3**, **4**], $E > -m$;[8] and that (ii) $k < 0$ by itself yields instability. It is natural to disregard unstable equilibria as being *unobservable*, in particular in the context of a comparative-statics exercise, where any possible initial unstable equilibrium would be lost when perturbed and would not be regained subsequently. We therefore impose

$$(5) \qquad k > 0,$$

and more importantly

$$(6) \qquad E + m + k > 0,$$

which given (5) is a stronger requirement than (4). These conditions are necessary and sufficient for stability of the present model (under industry homogeneity; [**5**]); if either of them is reversed the equilibrium turns into a saddle point, of a different kind for each of the two cases, while not both conditions can fail to hold at the same time in any (stable or unstable) equilibrium, by (4), given $m \geqslant 1$.

Most results we shall derive below will be instances of Samuelson's correspondence principle, depending critically on these stability conditions. But the first result follows directly:

RESULT R1 (Ruffin): *$E > -m$ is sufficient for $\eta_{yn} < 0$.*

PROOF: Given $E + m > 0$, $E + m + k \leqslant 0$ implies $k < 0$, which in turn implies $E + m + mk \leqslant 0$ given $m \geqslant 1$, thus contradicting (4). It follows that (6) must hold and, by (3), that $\eta_{yn} < 0$. *Q.E.D.*

[7] Similarly, when $\lambda = 0$ (cf. note 4) the number of effective firms is $m = \infty$, just as in perfect competition. Here, no individual firm can change aggregate output (hence price), because of the voracious practices of its competitors.

[8] Assumptions A', $B1'$, and $B2'$ in [**5**] are equivalent to $k > 0$, $E > -m$, and $E < -(m+k)$, respectively.

The next result gives the sign of dy/dn ($=$ sign η_{yn}) for the general case.

RESULT R2: *Output per firm behaves in a "perverse" form as entry occurs* ($\eta_{yn} > 0$), *given only stability of equilibrium, if and only if* $-(m+k) < E < -m$; *otherwise,* $\eta_{yn} \leq 0$ (*with strict inequality for* $E > -m$).

"Otherwise" here, given only the second-order condition (4), would in principle mean E's in either of two disjoint intervals, $-(m+mk) < E < -(m+k)$ or $-m < E$, which would be surprising, but the first of these possibilities is excluded by (6).

5. INTERPRETATION

The *elasticity of the slope* of demand $E \equiv Yp''/p'$, is (inversely) related to the curvature of $p = p(Y)$, taking its sign from whether the latter is concave or convex. When E is negative and large, e.g. $E < -m$, or more so $E < -(m+k)$, the slope is falling in absolute value "too" quickly, i.e. we have a "very" convex curve. Let us see what ruling out either of these possibilities means, as one needs to do to ensure "normal" behavior in R2 or at least stability (equation (6)), respectively.

The condition $E > -m$ can be transformed into

$$2\lambda p' + \lambda^2 yp'' < \lambda p'. \tag{7}$$

Now, each firm conjectures that $dY/dy = \lambda$ and so $Y = \lambda y + Q$ (for some constants λ, Q), locally. Hence *perceived* demand for the firm, relating price to its own output, can be written as $p = p(\lambda y + Q) \equiv D(y; \lambda, Q)$, which as a function of y has slope $\lambda p'$ and whose marginal revenue curve is $p + \lambda yp'$. The slope of the latter, finally, is $2\lambda p' + \lambda^2 yp''$. Hence (7) (and so $E > -m$) requires *marginal revenue* to be *steeper than perceived demand*, which in the Cournot case reduces simply to market demand.

The relation between these relative slopes and the interpretation of E in terms of the curvature of demand is easily shown diagrammatically. In Figure 1 perceived demand D meets the price axis at p^0 and becomes perfectly elastic at p^1. Clearly, $MR < D$ whenever D_y (i.e. $\lambda p'$) < 0, while $MR = D$ both when D is flat *and* at p^0. It obviously follows that MR must be flatter than D for some values of y, say at y^0, before merging with D at y^1. Hence an equilibrium at y^0 does not satisfy $E > -m$.

Yet another interpretation of the condition $E > -m$ is helpful. We know marginal revenue for the producer is given by $MR = p + \lambda yp'$, where the argument of $p(\cdot)$ is $\lambda y + Q$. Let us now perform the thought exercise of increasing everyone else's output while keeping "our" producer's output y constant, hence increasing total output $Y = \lambda y + Q$ via Q alone. From the expression for MR we get that $MR_Q = p' + \lambda yp''$, which is negative if and only if (7) holds. That is, the sufficient condition for "normality" of results $E > -m$, can be re-read as saying that $MR_Q < 0$, that MR for a firm should fall as other firms expand output. Viewed in this light, the perverse result in R2 is not so surprising: suppose a new firm enters

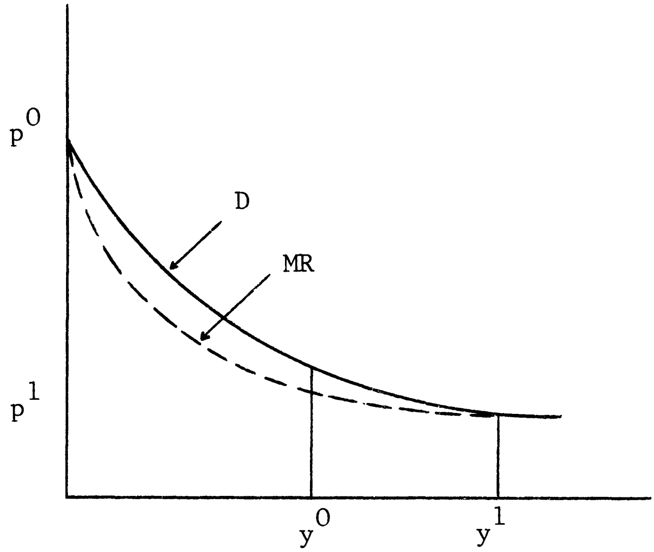

FIGURE 1

an industry producing initially the same output the typical firm was producing before entry. This extra output increases Q ("output by all others") for each of the previous firms. But if $E < -m$, this expansion by others *increases MR* for each individual firm, which obviously induces all previously established firms to expand.

A similar interpretation (see [**5**]) can be shown to apply to the bottom boundary of the "perverse" interval in R2, where (6) stops holding and instability starts. $E > -(m+k)$ requires the producer's perceived profits function to be "concave enough," so that a "forced" increase in output away from equilibrium by all firms renders each firm's own perceived marginal profit negative (it was zero in equilibrium), thus inviting them to pull back to equilibrium, despite the positive effect on marginal revenue of the others' expansion when $E < -m$, as explained above.

A simple example as shown in Table I will suggest that perverse possibilities should generally *not* be ruled out a priori. Suppose demand has constant elasticity

TABLE I

PRICE ELASTICITIES FOR THE FLOOR ON SECOND ORDER CONDITIONS (LINE 2) AND FOR THE "PERVERSE" INTERVAL IN R2 TO APPLY (LINES 3, 4).

m	1	1.5	2	2.5	3	5
$1/(2m-1)$	1	1/2	1/3	1/4	1/5	1/9
$1/m$	1	2/3	1/2	2/5	1/3	1/5
$1/(m-1)$	∞	2	1	2/3	1/2	1/4

ε, $p = AY^{-1/\varepsilon}$, and that $c'' = 0$. In this case $E \equiv Yp''/p'$ is also a constant: $E = -((1/\varepsilon)+1)$. Hence, the second order condition reads $\varepsilon > 1/(2m-1)$, while the critical interval for E indicated in R2 corresponds to $1/m < \varepsilon < 1/(m-1)$; the lower of these limits is also the lower boundary for equilibria to be stable. Remember that the number of effective firms $m = n/\lambda$ will usually be lower, perhaps considerably so, than n, the crude number of oligopolists in the given industry.

For values of m beyond 4 or 5, say, one can be fairly confident that conventional wisdom is correct, but for m close to 1 practically *every* value of ε consistent with stable equilibria yields $dy/dn > 0$. The example is not special on this, and entry of a new producer into a highly collusive or otherwise concentrated quasi-Cournot industry may rather easily result in increased output *per firm*! The explanation for this seemingly surprising result lies on the relatively serious blow that entry represents to existing firms' monopoly power when this power is high. This result or possibility will be reinforced if the collusion parameter λ itself falls as entry occurs, as one would expect it to do; this will be shown in the closing section.

6. AGGREGATE OUTPUT AND PROFITS PER FIRM

Conventional wisdom suggests $d\Pi^f/dn < 0$ and $dY/dn > 0$. From $Y = ny$, we immediately get $\eta_{Yn} = 1 + \eta_{yn}$. Hence, from (3),

$$\eta_{Yn} = k/(E+m+k). \tag{8}$$

It is clear that $k > 0$ and $(E+m) > 0$ are sufficient for $\eta_{Yn} > 0$; this, for the Cournot case, is the main result on limited entry of Frank [**1**], Okuguchi [**3**] (whose model is however more general in a different respect; see footnote 5) and Ruffin [**4**]. We have just argued that the second of these assumptions is not a good one to impose *a priori*, unlike the first one which is economically harmless and mathematically required for stability. But (8) tells us directly the necessary and sufficient conditions for "quasi-competitiveness" of equilibrium, $\eta_{Yn} > 0$, which turn out to be precisely the same as those for stability, equations (5) and (6).[9]

RESULT R3: *Total output always expands as entry into stable equilibria occurs.*

Similarly, differentiating $\Pi^f = yp(ny) - c(y)$ we obtain, after some manipulations,

$$\frac{d\Pi^f}{dn} = \frac{y^2 p'}{m}\left[\frac{E+m+mk}{E+m+k}\right], \tag{9}$$

which from $p' < 0$, second-order (4), and stability (6), gives again a definite answer.

RESULT R4: *Profits per firm always fall as entry into stable equilibria occurs.*

[9] Given that the numerator and denominator in (8) cannot *both* be negative, by (4).

I found these results stronger than I expected, as they apply to the general Cournot case and more, without any special conditions.

7. TOTAL PROFITS

The effect of entry on profits is less clear-cut than those on the variables we have discussed so far. This is what one would expect, however, as *levels* previously irrelevant, notably the fixed cost $c(0)$ which the entrant incurs, are now important. Some special cases can be considered, an interesting one being that when profits are negative before entry occurs (a short-run possibility, provided only running profits remain positive), with "entry" being now interpreted as of negative sign presumably, i.e. *exit*. For this case, since

$$\frac{d\Pi^T}{dn}=\frac{d(n\Pi^f)}{dn}=n\frac{d\Pi^f}{dn}+\Pi^f, \tag{10}$$

we immediately get (using R4):

RESULT R5: *$\Pi^f \leqslant 0$ is sufficient for $d\Pi^T/dn<0$, given only stability of equilibria.*

Hence "exit" from an ailing industry is always beneficial not only to the firms that remain (R4) but also to the industry as a whole. But, of course, if $\Pi^f>0$, the positive profits made by the entrant may compensate for the reduction in profits other firms will suffer, rendering the sign of $d\Pi^T/dn$ indeterminate. This is made clearer by the following alternative form of (10) (derived, e.g., using (9)):

$$\frac{d\Pi^T}{dn}=\frac{(n-\lambda)y^2p'k}{E+m+k}+(yc'-c). \tag{11}$$

The first term in (11) depends essentially on demand conditions, and can be thought of as representing the *change*, following entry, in the extent to which consumer's surplus is captured by producers. The second term, on the contrary, is purely related to cost conditions, and corresponds to the extent to which producers are collective cost minimizers for given total output: as entry occurs, total costs fall by yc', the total marginal cost saved by established firms as they reduce output by y units altogether, minus c, the total cost of production incurred by the new firm. Clearly, the two terms in (11) are rather independent of each other and the second one can take any sign.

Let us note two further special cases from (11).

(i) *Under full collusion, total profits increase (fall) with entry if average cost for the firm is an increasing (decreasing) function of output*: $c'\gtreqless c/y$. The reason is clear: under increasing costs, the total cost curve for the group is lowered by entry, as a more efficient scale is used per plant, while Y is simply adjusted collectively (in a fully collusive manner) so as to remain maximizing total profits. But this shows how easily one can have $d\Pi^T/dn>0$, merely by having increasing costs and a high degree of collusion in the industry, say, a pair of not too unlikely conditions.

(ii) *Decreasing-(or nonincreasing-) costs industries necessarily have their total profits lowered by entry.*

8. A VARIABLE DEGREE OF COLLUSION

The conjectural variation λ has been assumed not only to be (well defined and) constant at and around a given equilibrium but, what is probably more debatable, it has been treated as a constant across equilibria, as entry takes place. It might be argued, however, that λ does depend on the number of firms n, as the greater ease of communication amongst firms or of enforcement of (explicit or tacit) agreements when they are few may facilitate more collusive policies to be pursued. This could have easily been incorporated in the above analysis at great expense in terms of simplicity of the expressions obtained. However, we do not need full details of these new equations to obtain qualitative results. Writing $\xi=\xi(n, \lambda)$ for any of the variables considered above, we have $d\xi/dn = (\partial\xi/\partial n)+(\partial\xi/\partial\lambda)(d\lambda/dn)$, so that we need only look at $\partial\xi/\partial\lambda$ here, and briefly bring this effect together with the $\partial\xi/\partial n$ of previous sections. Proceedings as before, one easily finds:

$$\eta_{y\lambda}=-1/(E+m+k), \tag{12}$$

and

$$d\Pi^f/d\lambda=-y^2p'(m-1)/(E+m+k). \tag{13}$$

Also, $\eta_{Y\lambda}=\eta_{y\lambda}$ and $d\Pi^T/d\lambda=nd\Pi^f/d\lambda$. Hence, imposing $(E+m+k)>0$, the effect of increased collusion, by itself, turns out to be unambiguous in all cases: y and Y fall, while Π^f and Π^T rise with λ. Collusion works. And if $d\lambda/dn<0$, as one would presumably assume, the total effect of entry on Π^f and Y remains "normal" always, reinforcing R3 and R4, while the ambiguous effects on y and Π^T remain of course ambiguous, but the possibility of perverse movements in the former is *increased* when collusion is less after entry takes place, while for aggregate profits a "normal" behavior, if falling profits is what one expects, becomes more likely through this effect.

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