

"ENTRY GAME WITH RESALABLE CAPACITY"

by
Murugappa KRISHNAN*
Lars-Hendrik ROLLER**

N° 88 / 27

* Murugappa KRISHNAN, Purdue University

** Lars-Hendrik ROLLER, Assistant Professor of Economics
INSEAD, Fontainebleau, France

Director of Publication :

Charles WYPLOSZ, Associate Dean
for Research and Development

Printed at INSEAD,
Fontainebleau, France

ENTRY GAME WITH RESALABLE CAPACITY*

Murugappa Krishnan
525 Krannert Bldg.
Purdue University
West Lafayette, IN 47907
(317) 494-4497 (Office)
(317) 463-9802 (Home)
ARPANET: bip@j.cc.purdue.edu

Lars-Hendrik Röller
INSEAD
Boulevard de Constance
77305 Fontainebleau Cedex
France
33-1-6072 4000 (Ext. 4686)
Netmail: ROLLER%FREIBA51.Bitnet

April 1988

Preliminary
Please Don't Quote
Comments Welcome

ABSTRACT

ENTRY GAME WITH RESALABLE CAPACITY

Murugappa Krishnan (Purdue)

Lars-Hendrik Röller (INSEAD)

We study an entry game under perfect information, with the salient feature that capacity is resalable.

While entry itself is easier -- entry deterrence is never feasible -- it is the incumbent, not the entrant, who is better off: resalability increases the complexity of the incumbent's precommitment problem, but also furnishes her with an additional source of power -- in our model the price at which to resell capacity. The entrant is worse off, despite a larger share of a larger output.

While a capacity resale market enables capacity to be shared, and serves as a "collusion facilitating mechanism," the very existence of a resale market generates an incentive for a much larger initial level of investment, to the point where the overall equilibrium outcome is more competitive.

ENTRY GAME WITH RESALABLE CAPACITY

1. Introduction

Traditional analysis has emphasized the role of "sunk investments" in entry deterrence (see, e.g., Shapiro (1987)): they help make a threat or promise more credible. A complementary question — what happens when investment is not perfectly irrevocable — does not seem to have been examined. The central purpose of this paper is to consider one departure from the traditional assumption, in an entry game under perfect information. We make an assumption that has obvious empirical relevance: investment is "quasi-irrevocable" or resalable. It is not as liquid as cash (which would completely preclude any ability to precommit) but can be resold to another firm considering entry into the same industry.

Passing references (see, e.g., Shapiro (1987), Dixit (1980), Neven (1987) and Spence (1977)) to such investment have merely noted that it makes the incumbent's precommitment problem more complex. While our analysis does confirm this (indeed, for our parametric example entry deterrence is never even feasible when capacity is resalable), it shows, however, that despite this it is the incumbent who is always better off. This is because resalability inherently furnishes the incumbent with a second instrument -- in our model the price at which to resell capacity. The entrant is worse off, despite a larger share of a larger output.

Resale markets for capacity (or other "investment goods") are interesting for the same reason that Salop (1986) found a variety of buyer-seller agreements interesting: from the perspective of the Federal Trade Commission, the Department of Justice, etc., such mechanisms would not normally be considered collusive, yet they can be "collusion facilitating". Reselling capacity would

be regarded as an act of "divestiture", in which an incumbent sheds market power, but, as we demonstrate later, resale markets facilitate collusion by enabling capacity to be shared, even in a noncooperative setting in which binding commitments are not possible, and in which agreements can be consummated only if they are intrinsically self-enforcing. Resale markets emerge in our model because each party has an immediate incentive to participate in such markets.

Our main results are as follows. While entry deterrence is not even feasible with quasi-irrevocable investment, relative to perfectly-irrevocable investment, despite this, the entrant is worse off with resale markets than in a world where such markets are disallowed.

A surprising result holds for the incumbent. Resale markets strengthen the incumbent's hand, resulting in higher payoff than when there are no resale markets. Furthermore, the price the incumbent charges the entrant for a unit of capacity is higher than the external price (which is taken to be exogenous and constant). Both of these results suggest that the first-mover advantage is greater with quasi-irrevocable investment than with perfectly irrevocable investment.

Results bearing on welfare are more subtle. Each firm (incumbent as well as entrant) uses the resale market to restrict the other's output in the final stage. Thus, for any given initial choice of capacity by the incumbent, industry output in our model is strictly less than in a world where no resale markets exist.

However, this is not the end of the story. Given the existence of resale markets in later stages of the game, the incumbent finds it optimal to select a higher level of capacity in the first stage, and this causes the overall equilibrium industry output to be higher in our model. Note, however, that to

achieve the emergence of resale markets in equilibrium, it is necessary to create incentives for each firm to restrict the other firm's choice, i.e., we must explicitly allow for collusion in our model. Yet paradoxically, what we get in equilibrium is quite the opposite: the overall effect of resale markets is to promote competition, not collusion, as originally conjectured. So the consumer is at least as well off in our world as without resale markets. While there is a vast literature examining the role of precommitment in the face of entry, we are not aware of any precedence for this result, relating precommitment to an increase in the "competitive nature" of the equilibrium outcome. The increase in consumer surplus more than offsets a decrease in producer surplus, so that total surplus is higher when capacity is resalable.

The next section introduces our model. Section 3 defines equilibrium and provides some general remarks. Section 4 considers a parametric example which allows us to characterize the equilibrium in more detail. Section 5 outlines planned extensions to this research, while Section 6 provides some concluding remarks.

2. Model

We assume, as in Eaton and Ware (1987), that all capacity decisions are made in the earlier stages while in the final stage quantities are chosen, subject to capacity constraints.

While a variety of game trees are possible, the one we focus on (see Figure 1) not only seems most natural but is also the simplest in which to generate incentives for a resale market to emerge in equilibrium.¹ (We stress that our emphasis is not on the existence of resale markets, but rather on their surprising implications for entrant and incumbent, and on the effect of precommitment possibilities on the collusive nature of an overall equilibrium.)

It would be applicable to industries where even after capacity has been acquired from an upstream supplier, there is the possibility of intra-industry adjustments.

Time Structure

As can be seen from Figure 1, the incumbent has the privilege of moving first and chooses capacity (k). The entrant then considers buying capacity (e) from the external (competitive) capacity market. Then we have the "internal market subgame" in which the incumbent chooses a price (c) at which to resell capacity, to which the entrant responds with her demand for capacity (i) from the incumbent. In the final stage the incumbent and entrant choose (capacity-constrained) quantities, q_I and q_E , respectively.

Insert Figure 1 about here

Entry is deterred only if both "e" and "i" are zero. In this case, in the final stage the incumbent is a monopolist.

For purposes of comparison, we also consider the corresponding game tree for a world without resale markets, shown in Figure 2 below.

Insert Figure 2 about here

Assumptions

A1 - Cost functions are identical for incumbent and entrant:²

$$TC_j(q_j) = TC(q_j), \quad j = I \text{ (incumbent)}$$
$$E \text{ (entrant)}$$

$$TC'(q_j) > 0$$

$$TC''(q_j) > 0$$

A2 - Fixed costs are zero.

A1 and A2 imply that we wish to ignore explanations based on differences in costs, or on the existence of fixed costs.

A3 - The marginal cost of buying one unit of capacity externally is given by an exogenous constant P_b , $P_b > 0$.

This implies that as consumers in the upstream capacity (say, machinery) market, both incumbent and entrant have negligible influence.³

A4 - The market inverse demand curve is given by $P = f(Q)$, $f'(Q) < 0$ where P is the price; and Q , industry output.

It is well-known that this can be derived from more fundamental utility maximization considerations. (See, e.g., Dixit (1980).)

$f(0) > P_b$, or else prices will never be sufficient to recover even capacity costs.

A5 - The marginal gross profit (i.e., given capacities) of the entrant is increasing in the entrant's quantity, along the entrant's (unconstrained) reaction function:

$$\frac{d^2 \pi_E}{dq_E^2} = \left\{ \frac{\partial^2 \pi_E}{\partial q_E^2} \cdot \left(\frac{dq_E}{dq_I} \right)^2 + 2 \cdot \frac{\partial^2 \pi_E}{\partial q_E \partial q_I} \cdot \frac{dq_E}{dq_I} + \frac{\partial^2 \pi_E}{\partial q_I^2} \right\} \Big|_{q_E = q_E^*(q_I)} > 0$$

The exact role played by this assumption will be explained later: we use it to eliminate one particular possibility of excess-capacity equilibrium, in which the entrant wastes capacity bought from the incumbent.

At this stage it will be useful to consider Figure 3 below which maps final-stage capacities into equilibrium quantity choices.

Insert Figure 3 about here

As discussed in Eaton and Ware (1987), we have the following mapping from final-stage capacity vectors into quantity equilibria:

- Region I - (unconstrained) Cournot point
- Region II - quantities equal to capacities
- Region III - point on the entrant's reaction function directly below the capacity point
- Region IV - point on the incumbent's reaction function directly to the left of the capacity point.

It is straightforward to establish the following useful Lemmas.

Lemma 1: The incumbent can never have excess capacity.

Proof: Consider a "candidate equilibrium" with excess capacity for the incumbent. Denote it by the set $\{k^*, e^*, c^*, i^*, q_I^*, q_E^* | k^* - i^* > q_I^*\}$.

Consider another sub-game with 'k' reduced so that $k^* - i^* = q_I^*$.

It is straightforward to verify that subsequent choices $\{e^*, c^*, i^*, q_I^*, q_E^*\}$ will continue to be feasible and optimal in this modified sub-game, if they were feasible and optimal to begin with, but in the first-stage the incumbent will have higher profits by reducing 'k'. So the original equilibrium cannot be subgame perfect. #

This eliminates "candidate equilibria" in Regions 1 and 4. We are left with candidates in Region 3.

Lemma 2: The entrant can never have excess capacity with $e^* > 0$.

Proof: Denote candidate equilibria by

$$\{k^*, e^*, c^*, i^*, q_I^*, q_E^* | e^* > 0, e^* + i^* > q_E^*\}$$

and compare them with

$$\{k^*, e^*, c^*, i^*, q_I^*, q_E^* | e^* = \text{Max}(0, q_E^* - i^*)\}$$

Again, it is easy to show that by reducing 'e' to $\text{Max}(0, q_E^* - i^*)$, the entrant can increase her profits without disturbing subsequent choices. Hence we can eliminate this class of candidate equilibria as well. #

Lemma 3: The entrant can never have excess capacity with $i^* > 0$, and $e^* = 0$.

Proof: Let us note that such an equilibrium would imply that a "buy-and-waste" strategy is optimal for the entrant. From Figure 3, it is clear that a choice of 'i', given that the resulting capacity vector will be in Region 3, will affect the subsequent quantity equilibrium, so the strategy adopted in the proof of the previous two lemmas will not work. So must explicitly consider all possible ways in which such choices will change.

Denote the candidate equilibrium with

$$\{k^*, e^*, c^*, i^*, q_I^*, q_E^* | e^* = 0, i^* > q_E^*\}$$

and compare it with another in which 'c' is slightly higher than c^* (k^* and e^* are the same).

Case 1 - If i^* does not change, then we will be left with the same final-stage capacity vector as before, which will yield the same quantity equilibrium. But the incumbent will have higher profits (in Stage 3), so the candidate equilibrium is eliminated.#

Case 2 - If ' i ' increases to, say, $i^{**} > i^*$, then the entrant could not possibly have been optimizing in the original candidate equilibrium, since i^{**} would have been feasible, at lower cost. In other words, for the same $\{k^*, e^*\}$, if it is true that for $c > c^*$, $i = i^{**} > i^*$, then we can always construct an alternative sequence of choices, $\{k^*, e^*, c^*, i^{**} > i^*\}$ in which the entrant is better off (in Stage 4) than in the candidate equilibrium.#

Case 3 - If ' i ' decreases for a small increase in ' c ', then the effect on both entrant's and incumbent's profit is, in general, ambiguous.

To eliminate this case, we use the restriction in assumption A5. What it does is to ensure that the Stage 4 problem of the entrant (assuming that her choice of ' i ' will place the resulting capacity vector in Region 3) has a convex objective function,⁴ so that the maximum is either at $i^* = 0$ or at $i^* = k^*$.

If $i^* = 0$, the resulting capacity vector (since $e^* = 0$) will not be in Region 3. If $i^* = k^*$, the incumbent cannot possibly be optimizing in the original candidate equilibrium for, by setting $c^* \rightarrow \infty$, she can force $i^* = 0$, and capture all of the joint profits that would result from allowing $i^* = k^*$. Thus, we can eliminate all cases of Region 3 equilibria.#

Remark: It is not surprising that we have to use A5 to eliminate excess-capacity equilibria involving a "buy-and-waste" strategy of the entrant. Even in Eaton and Ware (1987), who use the traditional assumption about the nature of investment, the "strategic substitutability" restriction (see Bulow, Geanakoplos and Klemperer (1985)), that marginal profits of the i^{th} firm is decreasing in the output of another firm, plays a crucial role.⁵ While our assumption also imposes a restriction on marginal profits, it does not imply, and nor is it implied by, "strategic substitutability." Intuitively, what this restriction does is to ensure that the degree of convexity in costs is "small" relative to the degree of concavity in revenues. One should also note that our assumption about the nature of investment — that it is resalable — is weaker than the traditional assumption.

Finally, the reader should note that for the most popular parametric example considered in the literature (the linear-quadratic case), this restriction is automatically satisfied.

Collecting the above three lemmas, we get Proposition 1 below.

Proposition 1: A subgame-perfect equilibrium will not be characterized by excess capacity.#

This implies that the only possible equilibria involve capacities (and quantities) in Region 2 of Figure 3, i.e., the final-stage quantity equilibrium is completely determined by previous choices. It is now easy to see why the entrant might have an incentive to buy capacity from the incumbent, even at a price greater than the external market price: doing so would reduce the incumbent's output.

Proposition 1 also simplifies consideration of previous stages, in which we must solve the following problems.

Stage 4

$$\text{Max}_i \quad \pi_4^E = -c \cdot i + \pi_5^E(k-i, e+i; k, e, c)$$

Stage 3

$$\text{Max}_c \quad \pi_3^I = c \cdot i^*(k, e, c) + \pi_5^I(k-i^*(k, e, c), e+i^*(k, e, c))$$

Stage 2

$$\begin{aligned} \text{Max}_e \quad \pi_2^E = & -P_b \cdot e - c^*(k, e) \cdot i^*(k, e, c^*(k, e)) \\ & + \pi_5^E(k-i^*(k, e, c^*(k, e)), e+i^*(k, e, c^*(k, e))) \end{aligned}$$

Stage 1

$$\begin{aligned} \text{Max}_k \quad \pi_1^I = & -P_b \cdot k + c^*(\cdot) \cdot i^*(\cdot) \\ & + \pi_5^I(k-i^*(\cdot), e^*(\cdot) + i^*(\cdot)) \end{aligned}$$

where we omit arguments only to avoid notational clutter.

Assuming that second-order conditions are satisfied the first-order conditions characterizing an equilibrium can now be written.

f.o.c.

(In what follows, we omit the subscript for the final stage in all the RHS terms, letting subscripts denote only the appropriate partial derivative.)

$$\frac{d\pi_4^E}{di} = -c + \pi_i^E(k-i, e+i) \leq 0, \quad i \geq 0$$

$$\frac{d\pi_3^I}{dc} = i^*(k, e, c) + c \cdot i_c^*(k, e, c) + \pi_c^I(\cdot, \cdot) = 0,$$

$$\begin{aligned} \frac{d\pi_2^E}{de} = & -P_b - c_e^*(k, e) \cdot i^*(\cdot) - c^*(k, e) \cdot i_e^*(\cdot) \\ & + \pi_e^E(\cdot) \leq 0, \quad e \geq 0 \end{aligned}$$

$$\begin{aligned} \frac{d\pi_1^I}{dk} = & -P_b + c_k^*(\cdot) \cdot i^*(\cdot) + c^*(\cdot) \cdot i_k^*(\cdot) + \pi_k^I(\cdot, \cdot) \leq 0, \\ & k \geq i^*(k, e^*(k), c^*(k, e^*(k))) \end{aligned}$$

Proposition 2

The equilibrium internal demand function is (weakly) downward sloping:

$$\frac{di}{dc} \leq 0$$

(For c above a certain point, i will remain at zero.)

Proof: It follows from the first-order condition in Stage 4, that if a solution

exists with $i > 0$, then $i_c^* = \frac{-1}{TC''}$

where TC'' is the slope of the marginal cost function, assumed to be increasing. #

Remark: If we had constant marginal costs, $TC'' = 0$, and the Stage 4 choice of 'i' by the entrant would involve an "all-or-nothing" decision. This is

because total quantity, $(k + e)$, is independent of 'i', hence marginal revenue, as a function of 'i', is also constant.

4. Parametric Example

To characterize the equilibrium in more detail, in this section we consider a parametric case for which we can compute the explicit solution for all choices at each stage.

The case we consider is the familiar linear-quadratic example:

$$P(Q) = a - b \cdot Q, \quad a, b > 0$$

$$TC(q_j) = m \cdot q_j^2, \quad j = I, E \\ m > 0$$

Without loss of generality, we can set b , m , and p_b , the external market capacity price, all equal to unity.⁶ This simplifies the calculations, and enables us to describe all our results in terms of a single parameter, 'a'. For purposes of comparison, we use Model 2 — a world without resale market possibilities — as a benchmark.

Proposition 3 (No entry deterrence.)

With resalable capacity, entry deterrence is never even feasible.

Proof: To deter entry, the incumbent must be able to force both 'e' and 'i' to be zero.

Consider the values in Table 1. Since $e^*(k) = \frac{-11 \cdot k + 9(a-1)}{34}$ by choosing 'k' at least as large as $k = \frac{9(a-1)}{11}$, the incumbent could force 'e' to zero.

However, it turns out that it is never optimal for the incumbent to choose a large 'c' and force 'i' to zero.

$$c^*(k,e)|_{e=0} = - \frac{5 \cdot k - 3 \cdot a}{3}$$

which yields the optimal

$$i^*(k,e)|_{e=0} = \frac{k}{3}$$

which is always positive for positive 'k'.

Thus, no matter how large 'k' is, the incumbent cannot credibly indicate to the entrant that 'c' will be so large that she must stay out.⁷#

Proposition 4 (First-mover advantage magnified.)

The entrant is worse off in a world with resalable capacity, but the incumbent is better off, despite the entrant having a larger share of a larger output.

Proof: This follows from a comparison of profits in Tables 1 and 2.#

Insert Tables 1 & 2 about here

Proposition 4 implies that the first mover advantage is magnified by moving from a regime with perfectly irrevocable precommitment to a regime with quasi-irrevocable precommitment. Furthermore, a (qualitative) non-monotonicity property in markets with precommitment is identified, contrary to the accepted wisdom that the first mover advantage should disappear as precommitment becomes

more perfectly revocable. It is interesting to note that Proposition 4 holds despite the entrant having a larger proportion of a larger output.

From the calculations summarized in Tables 1 and 2, it is straightforward to establish the following propositions.

Proposition 5 ($c^* > P_b$)

The equilibrium price in the internal market exceeds the external market price for capacity.#

To see the intuition beneath this, one should note that in our model the incumbent would never be willing to sell at less than P_b , because this would mean losing not only in the output market (where she loses market share to the extent of 'i') but also in the capacity market (where she would actually be subsidizing entry).

The entrant is willing to pay more than P_b because this helps restrict the incumbent's output.

Proposition 6 (Resale markets facilitate collusion.)

For any given level of capacity investment 'k' by the incumbent, total output when capacity is resalable is less than when it is not.

Proof: Total output under both Models 1 and 2, for given 'k', would be $k + e(k)$, so we can simply compare $e(k)$ under both regimes. Model 1 output (given 'k') exceeds Model 2 output provided $k > \frac{a-1}{5}$, which is just the restriction needed to ensure the emergence of a resale market.#

However, given the possibility of resale, the incumbent no longer has the incentive to pick the same 'k' that she would have without resalability. In fact, she always chooses a higher 'k' to take advantage of opportunities in the resale market. This always offsets the collusive effect of resale markets.

Proposition 7 (The collusive effect is swamped.)

Resale markets (strictly) increase industry output.#

Insert Table 3 about here

Proposition 8 (Welfare)

A regime in which capacity is resalable yields greater consumer surplus, which more than offsets a decrease in producer surplus, so that total surplus is also higher, relative to a world where capacity is not resalable.

Proof: It follows from Table 3.#

5. Related Research

A. Further investigation into the relationship between precommitment and collusiveness.

In this paper, the most intriguing result (to us at least) is the relationship between precommitment and the collusive nature of the equilibrium outcome, and it is tempting to advance the following conjecture:

Let us embed models with collusion facilitating mechanisms in a world where there is the possibility of credible precommitment. It will still be the case that despite collusive possibilities in later stages, the very existence of such possibilities will induce a first-stage choice of the precommitment variable that will, as in this paper, "swamp" the collusive effect.

That this is not true in general can be seen from a simple counterexample.

Counterexample: Consider a game where firms are symmetric Bertrand players under classical assumptions. Assume that we have (as described in Salop (1986)) "matching competition clauses" which serve as a facilitating mechanism. It is well-known that with this mechanism, the equilibrium price is equal to the monopoly price (and not marginal cost as in traditional Bertrand), since no firm has an incentive to undercut.

Now let us add a precommitment stage. Assume that an incumbent firm can advertise a "maximum price", and, to make this credible, assume there is a large penalty for violating this implicit agreement with consumers.

It is clear that the incumbent has no incentive to advertise anything less than the monopoly price, so that exactly the same equilibrium will be realized when the subsequent Bertrand game is played, i.e., in this case precommitment possibilities do not mitigate the collusive nature of the final outcome.#

Currently, we are studying various mechanisms presented in Salop (1986) where players choose prices in the final stage (rather than quantities as we have done so far), to see if there is any general relationship between

precommitment possibilities and collusiveness, depending on either the final-stage choice variable or the type of precommitment.

B. Application to public policy with respect to international competition.

We have shown that when precommitment possibilities exist in a world with resale markets, consumers are better off (since total output is higher) but the entrant is worse off. This is consistent with some opinions about competition in the US sub-compact car industry where we may consider the overseas producers to be the incumbent, and home producers, the entrant. (The recent spate of joint ventures can also be interpreted as resale devices, if we are willing to abstract from other considerations, e.g., technology).

Public policy is typically concerned with both consumer as well as producer surplus. This suggests a natural question in the context of our model: can the government, via a system of tariffs and taxes and/or subsidies, preserve consumer surplus at at least the same level while improving the position of the entrant (home producer)? If so, what is the optimal policy? Or can an incumbent use the resale market to "foil" such policies? This may suggest the use of additional instruments.

6. Concluding Remarks

In this paper, we have tried to contribute towards an understanding of the implications of quasi-irrevocable investment and, in particular the role of a resale market in equilibrium.

We have seen that while resale markets facilitate sharing of capacity and thereby have a collusive effect, their very existence creates an incentive for the incumbent to precommit to a higher level of capacity, which leads to a higher level of industry output in equilibrium.

While entry is, as expected, easier with resale markets, despite this, the incumbent's payoff is higher with resale markets, whereas the entrant fares worse. Furthermore, the incumbent is able to sell capacity to the entrant at a price above the market price. Both of these observations suggest an increase in the first mover advantage by making precommitment quasi-irrevocable. The most important insight in this analysis is that while the incumbent's precommitment problem is more complex, because of resalability, she also acquires a new source of power from having an additional instrument, the price at which to resell capacity.

Finally, our work suggests that it may not always be meaningful to associate deterrence with exclusion from a market or even with threatening a decrease in output, rather than simply predation of profits. While "sunk investments" seem necessary for even feasibility of "exclusionary" strategies, they may be less important in considering more general predatory behavior. This point will become more important as the literature begins to pay more attention to non-traditional strategic variables.⁸

ENDNOTES

- * We have benefited from the comments and suggestions of several people, and are especially grateful to Jordi Caballe and Bill Novshek, who pointed out several errors and ambiguities in earlier versions of this paper. Of course, we alone are responsible for any remaining shortcomings.
- 1 - Some alternative sequences of choices — for the same set of choice variables — will never give rise to a resale market in a subgame-perfect equilibrium. Consider games where the amount of capacity resold is chosen (either by incumbent or entrant) before its price. If a positive value is selected by the entrant (incumbent) the incumbent (entrant) will then select an infinite (zero) price, so that in equilibrium no capacity will be resold. While this does not exhaust all possible alternatives, investigating robustness with respect to choice of game tree is beyond the scope of this paper.
- 2 - Most other papers (e.g., Eaton and Ware (1987)) assume constant marginal costs, rather than (strictly) convex costs. We need this — as will become apparent — only to prevent the potential entrant's choice in the resale market from becoming an "all-or-nothing" decision.
- 3 - This assumption is similar to that in Dixit (1980). Eaton and Ware (1987) use a different assumption: they assume decreasing average capacity costs. While we have not investigated the sensitivity of our results to this assumption, a priori, it would seem that it would be even easier for an incumbent to compete against an upstream capacity supplier with such costs, which would make the emergence of a resale market for capacity, if entry is allowed, even more likely.

4 - This objective function can be written as:

$$\pi_4^E = -c \cdot i + \pi_5^E(q_I, q_E)$$

$i \geq 0$

where $q_I = k-1$, and $q_E = q_E^*(k-1)$ (i.e., the unconstrained reaction function).

$$\frac{d^2 \pi_4^E}{di^2} = \pi_{11} + 2 \cdot \pi_{12} \cdot \frac{dq_E^*}{dq_I} + \pi_{22} \cdot \left(\frac{dq_E^*}{dq_I}\right)^2$$

$$+ \pi_2 \cdot \frac{d^2 q_E^*}{dq_I^2}$$

where ' π ' in the RHS denotes π_5^E , and subscripts are used only to denote partials.

Since the last term vanishes along the reaction function, the above expression is positive under assumption A5.

- 5 - They present it as an equivalent restriction on marginal revenues.
- 6 - We assert that there is no loss of generality because we have completed computations for the general case. For details please consult the authors directly.
- 7 - In contrast, under Model 2, entry deterrence is feasible for a ϵ (1,1.33), for $k = a-1$. However, it turns out that it can never be optimal even in this regime. In other words, for $k = a-1$, the incumbent can convince the entrant that she will produce upto capacity, and this will cause the entrant to stay out. But choosing $k < a-1$, and allowing entry, always yields higher profits.

8 - The authors will gladly make available additional notes and full details of all calculations, both for the special case with $m=b=P_b=1$, and for the general case, to anyone who is interested.

References

- Bulow, J.I., J.D. Geanakoplos, and P.D. Klemperer (1985), "Multimarket Oligopoly: Strategic Substitutes and Complements," Journal of Political Economy, Vol. 98, No. 3, 488-511.
- Dixit, A. (1980), The Role of Investment in Entry Deterrence, Economic Journal, 90, 95-106.
- Eaton, C.B. and R. Ware (1987), A Theory of Market Structure with Sequential Entry, RAND, Vol. 18, No. 1, Spring, 109-123.
- Neven, D. (1987), Strategic Entry Deterrence: Recent Developments in the Economics of Industry, INSEAD working paper.
- Salop, S.C. (1986), Practices (Credibly) Facilitate Oligopoly Co-ordination, in J.E. Stiglitz and G.F. Mathewson, eds., New Developments in the Theory of Market Structure, Cambridge: MIT Press, 90-123.
- Shapiro, Carl (1987), Theories of Oligopoly Behaviour, Discussion Paper #126, Woodrow Wilson School, Princeton University.
- Spence, M. (1977), Entry, Capacity, Investment and Oligopolistic Pricing, Bell Journal of Economics, 12, 49-70.

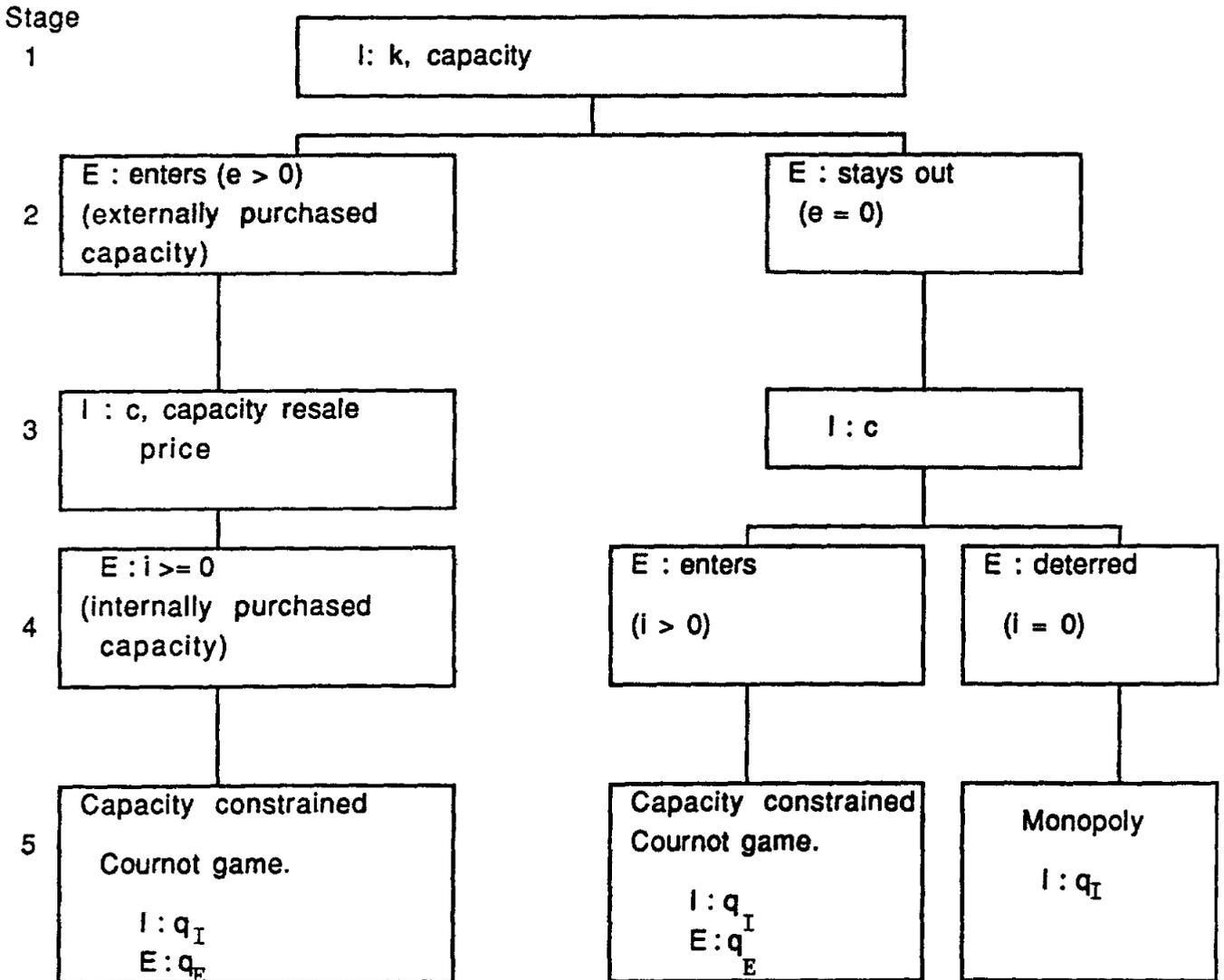


Fig. 1: Model with Resale Market.

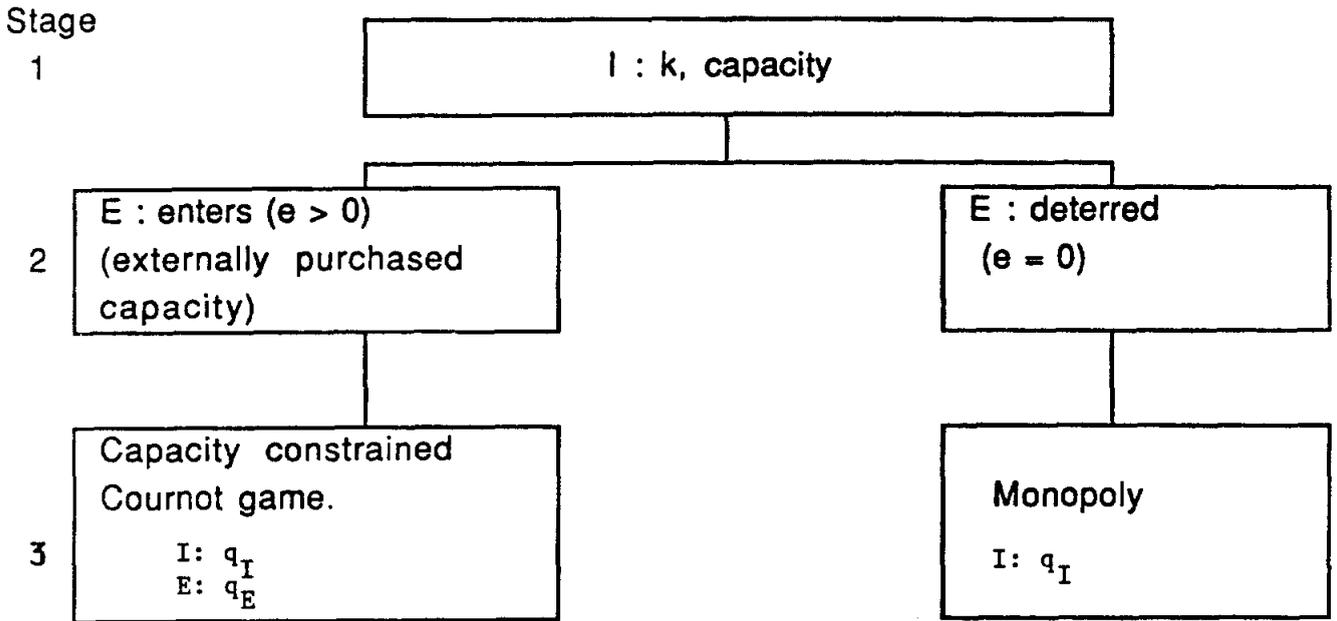


Fig. 2: Model without Resale Market

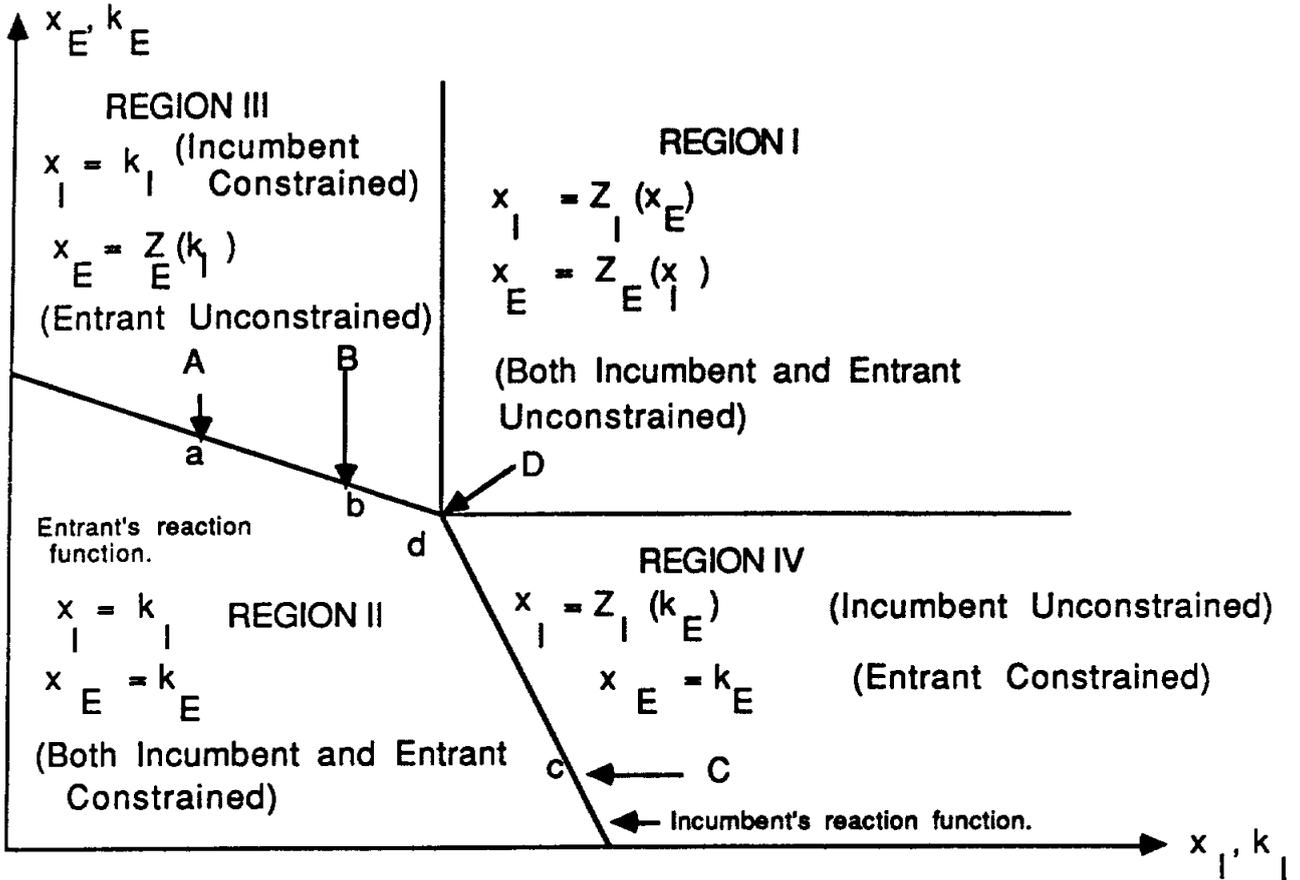


Fig: 3: Stage 5 - Mapping of Capacities into Quantity Equilibria.
 (This is similar to Eaton and Ware, 1987.)

x_j = final stage output of firm j , $j = I, E$.

k_j = final stage capacity of firm j , $j = I, E$.

$Z_j(.)$ = unconstrained reaction function of firm j , $j = I, E$

I = incumbent, E = entrant

A, B, C, D - typical capacity points

a, b, c, d - corresponding quantity equilibria.

TABLE 1

EQUILIBRIUM VALUES FOR MODEL 1

(Model with Resalable Capacity)

- o Stage 2 Optimal Values (given 'k', initial capacity investment)

$$e^*(k) = - \frac{11k-9a+9}{34}, \quad i^*(k) = \frac{3(5k-a+1)}{34}, \quad c^*(k) = \frac{31k-13a-21}{34}$$

- o Stage 3 Optimal Values (given (k,e))

$$i^*(k,e) = \frac{k-e}{3}, \quad c^*(k,e) = - \frac{5k+7e-3a}{3}$$

- o Stage 4 Optimal Values

$$i^*(k,e,c) = - \frac{k+3 \cdot e+c-a}{2}$$

- o Overall Equilibrium

$$k^* = \frac{290(a-1)}{1263}$$

$$e^* = \frac{481(a-1)}{2526}$$

$$c^* = \frac{437a+2089}{2526}$$

$$i^* = \frac{11(a-1)}{842}$$

- o Profits

$$\pi^* I^* = \frac{409(a-1)^2}{5052},$$

$$\pi^* E^* = \frac{158131(a-1)^2}{2126892}$$

Notes:

1. These values pertain to the special case of the linear-quadratic model, with $b=m=P_b=1$.
2. To ensure that the price intercept, $f(0) > P_b$, we must have $a > 1$.
3. To ensure that the equilibrium capacity vector lies in Region 2, we must have $a \leq \frac{1351}{88} = 15.35$.
4. Entry deterrence is never even feasible.

TABLE 2

EQUILIBRIUM VALUES FOR MODEL 2

(Model Where Capacity Is Not Resalable)

o Stage 2 Optimal Values (given 'k')

$$e^*(k) = - \frac{k-a+1}{4}$$

o Overall Equilibrium

$$k^* = \frac{3(a-1)}{14}$$

$$e^* = \frac{11(a-1)}{56}$$

o Profits

$$\pi^I = \frac{9(a-1)^2}{112}$$

$$\pi^E = \frac{121(a-1)^2}{1568}$$

Notes:

1. These values also pertain to the special case of the linear-quadratic model, with $b=m=P_b=1$.
2. To ensure that the price intercept, $f(0) > P_b$, we must have $a > 1$.
3. To ensure that the equilibrium capacity vector lies in Region 2, we must have $a \leq \frac{59}{3} = 19.66$.
4. Entry deterrence is feasible, for $a \in (1, 1.33)$, but never optimal.

TABLE 3

Welfare Comparisons

	<u>Model 1</u>	<u>Model 2</u>
Consumer surplus	$\frac{1125721(a-1)^2}{12761352}$	$\frac{529(a-1)^2}{6272}$
Producer surplus	$\frac{82580(a-1)^2}{531723}$	$\frac{247(a-1)^2}{1568}$
Total surplus	$\frac{3107641(a-1)^2}{12761352}$	$\frac{1517(a-1)^2}{6272}$

INSEAD WORKING PAPERS SERIES

1985

- 85/01 Jean DERMINE "The measurement of interest rate risk by financial intermediaries", December 1983, Revised December 1984.
- 85/02 Philippe A. NAERT and Els GIJSBRECHTS "Diffusion model for new product introduction in existing markets" .
- 85/03 Philippe A. NAERT and Els GIJSBRECHTS "Towards a decision support system for hierarchically allocating marketing resources across and within product groups" .
- 85/04 Philippe A. NAERT and Marcel WEVERBERGH "Market share specification, estimation and validation: towards reconciling seemingly divergent views" .
- 85/05 Ahmet AYKAC, Marcel CORSTJENS, David GAUTSCHI and Ira HOROWITZ "Estimation uncertainty and optimal advertising decisions", Second draft, April 1985.
- 85/06 Kasra FERDOWS "The shifting paradigms of manufacturing: inventory, quality and now versatility", March 1985.
- 85/07 Kasra FERDOWS, Jeffrey G. MILLER, Jinchiro NAKANE and Thomas E. VOLLMANN. "Evolving manufacturing strategies in Europe, Japan and North-America"
- 85/08 Spyros MAKRIDAKIS and Robert CARBONE "Forecasting when pattern changes occur beyond the historical data" , April 1985.
- 85/09 Spyros MAKRIDAKIS and Robert CARBONE "Sampling distribution of post-sample forecasting errors" , February 1985.
- 85/10 Jean DERMINE "Portfolio optimization by financial intermediaries in an asset pricing model".
- 85/11 Antonio M. BORGES and Alfredo M. PEREIRA "Energy demand in Portuguese manufacturing: a two-stage model".
- 85/12 Arnoud DE MEYER "Defining a manufacturing strategy - a survey of European manufacturers".
- 85/13 Arnoud DE MEYER "Large European manufacturers and the management of R & D".
- 85/14 Ahmet AYKAC, Marcel CORSTJENS, David GAUTSCHI and Douglas L. MacLACHLAN "The advertising-sales relationship in the U.S. cigarette industry: a comparison of correlational and causality testing approaches".
- 85/15 Arnoud DE MEYER and Roland VAN DIERDONCK "Organizing a technology jump or overcoming the technological hurdle".
- 85/16 Hervig M. LANGOHR and Antony M. SANTOHERO "Commercial bank refinancing and economic stability: an analysis of European features".

- 85/17 Manfred F.R. KETS DE VRIES and Danny MILLER "Personality, culture and organization".
- 85/18 Manfred F.R. KETS DE VRIES "The darker side of entrepreneurship".
- 85/19 Manfred F.R. KETS DE VRIES and Dany MILLER "Narcissism and leadership: an object relations perspective".
- 85/20 Manfred F.R. KETS DE VRIES and Dany MILLER "Interpreting organizational texts".
- 85/21 Hervig M. LANGOHR and Claude J. VIALLET "Nationalization, compensation and wealth transfers: France 1981-1982" 1, Final version July 1985.
- 85/22 Hervig M. LANGOHR and B. Espen ECKBO "Takeover premiums, disclosure regulations, and the market for corporate control. A comparative analysis of public tender offers, controlling-block trades and minority buyout in France", July 1985.
- 85/23 Manfred F.R. KETS DE VRIES and Dany MILLER "Barriers to adaptation: personal, cultural and organizational perspectives".
- 85/24 Spyros MAKRIDAKIS "The art and science of forecasting: an assessment and future directions".
- 85/25 Gabriel HAWAVINI "Financial innovation and recent developments in the French capital markets", October 1985.
- 85/26 Karel O. COOL and Dan E. SCHENDEL "Patterns of competition, strategic group formation and the performance case of the US pharmaceutical industry, 1963-1982", October 1985.
- 85/27 Arnoud DE MEYER "European manufacturing: a comparative study (1985)".

1986

- 86/01 Arnoud DE MEYER "The R & D/Production interface".
- 86/02 Philippe A. NAERT Marcel WEVERBERGH and Guido VERSWIJVEL "Subjective estimation in integrating communication budget and allocation decisions: a case study", January 1986.
- 86/03 Michael BRIMM "Sponsorship and the diffusion of organizational innovation: a preliminary view".
- 86/04 Spyros MAKRIDAKIS and Michèle HIBON "Confidence intervals: an empirical investigation for the series in the M-Competition" .
- 86/05 Charles A. WYPLOSZ "A note on the reduction of the workweek", July 1985.

- 86/06 Francesco GIAVAZZI, Jeff R. SHEEN and Charles A. WYPLOSZ "The real exchange rate and the fiscal aspects of a natural resource discovery", Revised version: February 1986.
- 86/07 Douglas L. MacLACHLAN and Spyros MAKRIDAKIS "Judgmental biases in sales forecasting", February 1986.
- 86/08 José de la TORRE and David H. NECKAR "Forecasting political risks for international operations", Second Draft: March 3, 1986.
- 86/09 Philippe C. HASPELAGH "Conceptualizing the strategic process in diversified firms: the role and nature of the corporate influence process", February 1986.
- 86/10 R. MOENART, Arnoud DE MEYER, J. BARBE and D. DESCHOOLMEESTER. "Analysing the issues concerning technological de-maturity".
- 86/11 Philippe A. NAERT and Alain BULTEZ "From "Lydiametry" to "Pinkhamization": misspecifying advertising dynamics rarely affects profitability".
- 86/12 Roger BETANCOURT and David GAUTSCHI "The economics of retail firms", Revised April 1986.
- 86/13 S.P. ANDERSON and Damien J. NEVEN "Spatial competition à la Cournot".
- 86/14 Charles WALDMAN "Comparalson internationale des marges brutes du commerce", June 1985.
- 86/15 Mihkel TOMBAK and Arnoud DE MEYER "How the managerial attitudes of firms with FMS differ from other manufacturing firms: survey results", June 1986.
- 86/16 B. Espen ECKBO and Hervig M. LANGOHR "Les primes des offres publiques, la note d'information et le marché des transferts de contrôle des sociétés".
- 86/17 David B. JEMISON "Strategic capability transfer in acquisition integration", May 1986.
- 86/18 James TEBOUL and V. MALLERET "Towards an operational definition of services", 1986.
- 86/19 Rob R. WEITZ "Nostradamus: a knowledge-based forecasting advisor".
- 86/20 Albert CORHAY, Gabriel HAWAWINI and Pierre A. MICHEL "The pricing of equity on the London stock exchange: seasonality and size premium", June 1986.
- 86/21 Albert CORHAY, Gabriel A. HAWAWINI and Pierre A. MICHEL "Risk-premia seasonality in U.S. and European equity markets", February 1986.
- 86/22 Albert CORHAY, Gabriel A. HAWAWINI and Pierre A. MICHEL "Seasonality in the risk-return relationships some international evidence", July 1986.
- 86/23 Arnoud DE MEYER "An exploratory study on the integration of information systems in manufacturing", July 1986.
- 86/24 David GAUTSCHI and Vithala R. RAO "A methodology for specification and aggregation in product concept testing", July 1986.
- 86/25 H. Peter GRAY and Ingo WALTER "Protection", August 1986.
- 86/26 Barry EICHENGREEN and Charles WYPLOSZ "The economic consequences of the Franc Poincare", September 1986.
- 86/27 Karel COOL and Ingemar DIERICKX "Negative risk-return relationships in business strategy: paradox or truism?", October 1986.
- 86/28 Manfred KETS DE VRIES and Danny MILLER "Interpreting organizational texts.
- 86/29 Manfred KETS DE VRIES "Why follow the leader?".
- 86/30 Manfred KETS DE VRIES "The succession game: the real story.
- 86/31 Arnoud DE MEYER "Flexibility: the next competitive battle", October 1986.
- 86/31 Arnoud DE MEYER, Jinichiro NAKANE, Jeffrey G. MILLER and Kasra FERDOWS "Flexibility: the next competitive battle", Revised Version: March 1987
- 86/32 Karel COOL and Dan SCHENDEL "Performance differences among strategic group members", October 1986.
- 86/33 Ernst BALTENSPERGER and Jean DERMINE "The role of public policy in insuring financial stability: a cross-country, comparative perspective", August 1986, Revised November 1986.
- 86/34 Philippe HASPELAGH and David JEMISON "Acquisitions: myths and reality", July 1986.
- 86/35 Jean DERMINE "Measuring the market value of a bank, a primer", November 1986.
- 86/36 Albert CORHAY and Gabriel HAWAWINI "Seasonality in the risk-return relationship: some international evidence", July 1986.
- 86/37 David GAUTSCHI and Roger BETANCOURT "The evolution of retailing: a suggested economic interpretation".
- 86/38 Gabriel HAWAWINI "Financial innovation and recent developments in the French capital markets", Updated: September 1986.

86/39	Gabriel HAWAWINI Pierre MICHEL and Albert CORHAY	"The pricing of common stocks on the Brussels stock exchange: a re-examination of the evidence", November 1986.	87/13	Sumantra GHOSHAL and Nitin NOHRIA	"Multinational corporations as differentiated networks", April 1987.
86/40	Charles WYPLOSZ	"Capital flows liberalization and the EMS, a French perspective", December 1986.	87/14	Landis GABEL	"Product Standards and Competitive Strategy: An Analysis of the Principles", May 1987.
86/41	Kasra FERDOVS and Wickham SKINNER	"Manufacturing in a new perspective", July 1986.	87/15	Spyros MAKRIDAKIS	"METAFORCASTING: Ways of improving Forecasting. Accuracy and Usefulness", May 1987.
86/42	Kasra FERDOVS and Per LINDBERG	"FMS as indicator of manufacturing strategy", December 1986.	87/16	Susan SCHNEIDER and Roger DUNBAR	"Takeover attempts: what does the language tell us?", June 1987.
86/43	Damien NEVEN	"On the existence of equilibrium in hotelling's model", November 1986.	87/17	André LAURENT and Fernando BARTOLOME	"Managers' cognitive maps for upward and downward relationships", June 1987.
86/44	Ingemar DIERICKX Carmen MATUTES and Damien NEVEN	"Value added tax and competition", December 1986.	87/18	Reinhard ANGELMAR and Christoph LIEBSCHER	"Patents and the European biotechnology lag: a study of large European pharmaceutical firms", June 1987.
<u>1987</u>					
87/01	Manfred KETS DE VRIES	"Prisoners of leadership".	87/19	David BEGG and Charles WYPLOSZ	"Why the EMS? Dynamic games and the equilibrium policy regime", May 1987.
87/02	Claude VIALLET	"An empirical investigation of international asset pricing", November 1986.	87/20	Spyros MAKRIDAKIS	"A new approach to statistical forecasting", June 1987.
87/03	David GAUTSCHI and Vithala RAO	"A methodology for specification and aggregation in product concept testing", Revised Version: January 1987.	87/21	Susan SCHNEIDER	"Strategy formulation: the impact of national culture", Revised: July 1987.
87/04	Sumantra GHOSHAL and Christopher BARTLETT	"Organizing for innovations: case of the multinational corporation", February 1987.	87/22	Susan SCHNEIDER	"Conflicting ideologies: structural and motivational consequences", August 1987.
87/05	Arnoud DE MEYER and Kasra FERDOVS	"Managerial focal points in manufacturing strategy", February 1987.	87/23	Roger BETANCOURT David GAUTSCHI	"The demand for retail products and the household production model: new views on complementarity and substitutability".
87/06	Arun K. JAIN, Christian PINSON and Naresh K. MALHOTRA	"Customer loyalty as a construct in the marketing of banking services", July 1986.	87/24	C.B. DERR and André LAURENT	"The internal and external careers: a theoretical and cross-cultural perspective", Spring 1987.
87/07	Rolf BANZ and Gabriel HAWAWINI	"Equity pricing and stock market anomalies", February 1987.	87/25	A. K. JAIN, N. K. MALHOTRA and Christian PINSON	"The robustness of MDS configurations in the face of incomplete data", March 1987, Revised: July 1987.
87/08	Manfred KETS DE VRIES	"Leaders who can't manage", February 1987.	87/26	Roger BETANCOURT and David GAUTSCHI	"Demand complementarities, household production and retail assortments", July 1987.
87/09	Lister VICKERY, Mark PILKINGTON and Paul READ	"Entrepreneurial activities of European MBAs", March 1987.	87/27	Michael BURDA	"Is there a capital shortage in Europe?", August 1987.
87/10	André LAURENT	"A cultural view of organizational change", March 1987	87/28	Gabriel HAWAWINI	"Controlling the interest-rate risk of bonds: an introduction to duration analysis and immunization strategies", September 1987.
87/11	Robert FILDES and Spyros MAKRIDAKIS	"Forecasting and loss functions", March 1987.	87/29	Susan SCHNEIDER and Paul SHRIVASTAVA	"Interpreting strategic behavior: basic assumptions themes in organizations", September 1987
87/12	Fernando BARTOLOME and André LAURENT	"The Janus Head: learning from the superior and subordinate faces of the manager's job", April 1987.	87/30	Jonathan HAMILTON W. Bentley MACLEOD and Jacques-François THISSE	"Spatial competition and the Core", August 1987.

87/31	Martine QUINZII and Jacques-François THISSE	"On the optimality of central places", September 1987.	88/01	Michael LAWRENCE and Spyros MAKRIDAKIS	"Factors affecting judgemental forecasts and confidence intervals", January 1988.
87/32	Arnoud DE MEYER	"German, French and British manufacturing strategies less different than one thinks", September 1987.	88/02	Spyros MAKRIDAKIS	"Predicting recessions and other turning points", January 1988.
87/33	Yves DOZ and Amy SHUEN	"A process framework for analyzing cooperation between firms", September 1987.	88/03	James TEBOUL	"De-industrialize service for quality", January 1988.
87/34	Kasra FERDOVS and Arnoud DE MEYER	"European manufacturers: the dangers of complacency. Insights from the 1987 European manufacturing futures survey, October 1987.	88/04	Susan SCHNEIDER	"National vs. corporate culture: implications for human resource management", January 1988.
87/35	P. J. LEDERER and J. F. THISSE	"Competitive location on networks under discriminatory pricing", September 1987.	88/05	Charles WYPLOSZ	"The swinging dollar: is Europe out of step?", January 1988.
87/36	Manfred KETS DE VRIES	"Prisoners of leadership", Revised version October 1987.	88/06	Reinhard ANGELMAR	"Les conflits dans les canaux de distribution", January 1988.
87/37	Landis GABEL	"Privatization: its motives and likely consequences", October 1987.	88/07	Ingemar DIERICKX and Karel COOL	"Competitive advantage: a resource based perspective", January 1988.
87/38	Susan SCHNEIDER	"Strategy formulation: the impact of national culture", October 1987.	88/08	Reinhard ANGELMAR and Susan SCHNEIDER	"Issues in the study of organizational cognition", February 1988.
87/39	Manfred KETS DE VRIES	"The dark side of CEO succession", November 1987	88/09	Bernard SINCLAIR-DESGAGNÉ	"Price formation and product design through bidding", February 1988.
87/40	Carmen MATUTES and Pierre REGIBEAU	"Product compatibility and the scope of entry", November 1987	88/10	Bernard SINCLAIR-DESGAGNÉ	"The robustness of some standard auction game forms", February 1988.
87/41	Gavriel HAWAWINI and Claude VIALLET	"Seasonality, size premium and the relationship between the risk and the return of French common stocks", November 1987	88/11	Bernard SINCLAIR-DESGAGNÉ	"When stationary strategies are equilibrium bidding strategy: The single-crossing property", February 1988.
87/42	Damien NEVEN and Jacques-F. THISSE	"Combining horizontal and vertical differentiation: the principle of max-min differentiation", December 1987	88/12	Spyros MAKRIDAKIS	"Business firms and managers in the 21st century", February 1988
87/43	Jean GABSZEWICZ and Jacques-F. THISSE	"Location", December 1987	88/13	Manfred KETS DE VRIES	"Alexithymia in organizational life: the organization man revisited", February 1988.
87/44	Jonathan HAMILTON, Jacques-F. THISSE and Anita WESKAMP	"Spatial discrimination: Bertrand vs. Cournot in a model of location choice", December 1987	88/14	Alain NOEL	"The interpretation of strategies: a study of the impact of CEOs on the corporation", March 1988.
87/45	Karel COOL, David JEMISON and Ingemar DIERICKX	"Business strategy, market structure and risk-return relationships: a causal interpretation", December 1987.	88/15	Anil DEOLALIKAR and Lars-Hendrik ROLLER	"The production of and returns from industrial innovation: an econometric analysis for a developing country", December 1987.
87/46	Ingemar DIERICKX and Karel COOL	"Asset stock accumulation and sustainability of competitive advantage", December 1987.	88/16	Gabriel HAWAWINI	"Market efficiency and equity pricing: international evidence and implications for global investing", March 1988.
			88/17	Michael BURDA	"Monopolistic competition, costs of adjustment and the behavior of European employment",

- 88/18 Michael BURDA "Reflections on "Wait Unemployment" in Europe", November 1987, revised February 1988.
- 88/19 M.J. LAWRENCE and Spyros MAKRIDAKIS "Individual bias in judgements of confidence", March 1988.
- 88/20 Jean DERMINE, Damien NEVEN and J.F. THISSE "Portfolio selection by mutual funds, an equilibrium model", March 1988.
- 88/21 James TBOUL "De-industrialize service for quality", March 1988 (88/03 Revised).
- 88/22 Lars-Hendrik RÖLLER "Proper Quadratic Functions with an Application to AT&T", May 1987 (Revised March 1988).
- 88/23 Sjur Didrik FLAM and Georges ZACCOUR "Equilibres de Nash-Cournot dans le marché européen du gaz: un cas où les solutions en boucle ouverte et en feedback coïncident", Mars 1988
- 88/24 B. Espen ECKBO and Herwig LANGOHR "Information disclosure, means of payment, and takeover premia. Public and Private tender offers in France", July 1985, Sixth revision, April 1988.
- 88/25 Everette S. GARDNER and Spyros MAKRIDAKIS "The future of forecasting", April 1988.
- 88/26 Sjur Didrik FLAM and Georges ZACCOUR "Semi-competitive Cournot equilibrium in multistage oligopolies", April 1988.