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**ON THE ROBUSTNESS OF
CONTESTABILITY THEORY**

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1. INTRODUCTION

The theory of contestable markets offers an analytic framework within which the fundamental features of demand and technology determine the industry structure and the characteristics of industry prices. The theory accomplishes this by making the following simplifying assumptions:

- i) all producers have access to the same technology;
- ii) the technology may have fixed costs, but no sunk costs;¹
- iii) there is no entry lag, that is, a potential entrant can enter at any scale instantaneously;
- iv) the incumbent's adjustment price lag is greater than the exit lag; that is, a potential entrant can enter the market, make a profit and exit before the incumbent can react to entry.

In other words, the theory "strips away through its assumptions all barriers to entry and exit and the strategic behaviour that goes along with them both in theory and reality".² In particular, the assumptions of no entry lag and of a positive adjustment price lag are relevant in that they capture the idea of "hit-and-run entry", which represents a fundamental element in disciplining active firms. Indeed, a crucial issue of this literature is the extent to which potential competition is able to serve the role that actual competition does in traditional economic models: under the assumptions above, potential competition can be as effective as actual competition in disciplining the industry.

In this paper the robustness of the relevant assumptions of contestable markets is discussed, with special attention to those applying to firms' reaction time. Although Baumol, Panzar and Willig carefully acknowledge the importance of fast price responses by incumbent firms, this question is frequently overlooked in the literature which provides criticisms to the contestable markets theory. On the

contrary, structural conditions that make entry and exit easy, such as low sunk costs, are taken as sufficient to ensure contestability.³

Schwartz (1986) is an exception. He tackles the question of how small the neighborhood of zero sunk costs must be in order to have "almost perfectly contestable" markets. He argues that this neighborhood is arbitrarily small: as a consequence, a small deviation from zero sunk costs is sufficient to make the threat of entry irrelevant and yield the monopoly price. Available empirical evidence offered in that paper indicates that this is typically the case.

Furthermore, he argues that as the price response lag goes to zero, whatever the level of sunk cost is, the market becomes "non-contestable". In other words, the ability of incumbent firms to change price rapidly in response to entry can offset ease of entry and exit and make markets non-contestable, in the sense that pricing behaviour becomes unaffected by the threat of entry. However, these results are not quite satisfactory in some respects. We show in Section 2 that in order to get non-contestable markets it is necessary to know whether the level of sunk costs is small in relation to the price response lag, and not only that the price response lag goes to zero. That is to say, we cannot predict the relationship of price to average costs based only on the smallness of the sunk costs or of the price response lag: we need to have an estimate of their relative size too. Moreover, our analysis is more rigorous and specifies the type of market competition after entry, an element which is left unspecified in Schwartz's paper.

One may wonder whether it is exhaustive to examine the robustness of the theory of contestable markets by considering the behaviour of sunk costs and price response lags only. For example, is it possible to obtain a non-contestable outcome when the firms, instead of competing in the post-entry market, were to collude? If firms were to collude, potential competition would not benefit consumers and it would merely encourage entry, as monopoly profits would be redistributed among firms.

Our analysis in Section 3 shows that this is indeed the case. The framework within which we examine collusion is that of infinitely repeated games. As is well-known, collusion is indeed a possible outcome in infinitely repeated games.

A game-theoretic framework is used also in Section 4, where we examine the necessary conditions under which the "hit-and-run" strategy is the unique subgame perfect equilibrium solution of a repeated game with infinite horizon.

The story is similar to that in Benoit (1984). In his model he supposes that the entrant can survive an aggressive response for only a limited number of periods, say Y , while the incumbent can respond aggressively *ad infinitum*; both the incumbent and the entrant know Y , the horizon is unlimited and the incumbent is surely willing to respond aggressively if the entrant can be driven out in one period⁴. In this situation the entrant's optimal strategy is not to enter (and if it does, it capitulates immediately and exits), and the incumbent's to play tough; this result can be proved by induction.

In our formulation a specification of that model is presented and is applied to the contestable markets. We allow the incumbent the option to continue or not fighting each period and to the entrant to stay or not in each period. Our process of entry is sequential. Moreover, in our formulation we allow an entrant to re-enter the industry after playing "exit".

In what follows we adopt a discrete-time formulation. This does not seem to be harmful because the main results of our analysis do not depend on time interval. It is well-known, however, that different outcomes may sometimes arise when continuous time formulations are adopted instead of discrete time ones: some issues related to this question are briefly tackled in Section 3.

This paper is organized as follows. In Section 2 the basic model is set up. Here the price response lag hypothesis is discussed and the consequences of dropping it are then developed as far as entry is concerned. In Section 3 the possibility of collusion in

the post-entry game is analysed. Section 4 studies the exit decision of the entrant: in particular, it gives the necessary conditions to obtain a "hit-and-run" strategy as the unique subgame perfect equilibrium of a repeated game with infinite horizon. In Section 5 final remarks are presented and different possible research strategies are suggested.

2. A MODEL OF LIMIT-PRICING WITH SUNK COSTS AND PRICE RESPONSE LAGS: THE ROLE OF FAST PRICE RESPONSES.

2.1 THE BASIC MODEL

In this section we present the basic model which will be used throughout the paper. We consider a market for a homogeneous product characterized by a demand function $g(p)$ which is defined for all $p > 0$ and satisfies the following assumptions⁵:

- A.1 (i) g is continuous on \mathbb{R}_{++} and continuously differentiable on the set P , where $P = \{p > 0 \mid g(p) > 0\}$,
- (ii) $g(p) \geq 0$ for all $p > 0$,
- (iii) $g(p)$ is non increasing everywhere and strictly decreasing on P ,
- (iv) $\lim_{p \rightarrow \infty} p \cdot g(p) = 0$.

The marginal cost of production is constant and equal to $c > 0$. The profit function is then defined by $\Pi(p) = (p - c) \cdot g(p)$. The following properties hold: Π is continuous on \mathbb{R}_{++} and continuously differentiable on P ; $\Pi(c) = 0$, $\Pi(p) < 0$ for all p , and $0 < p < c$, $\Pi(p) \geq 0$ for $p > c$. Furthermore, $\lim_{p \rightarrow \infty} \Pi(p) = 0$. Consequently, the profit function has a maximum that is denoted by Π_m . We assume that the following property⁶ holds:

- A.2 Π is strictly quasi-concave on $[c, +\infty)$ and $c \in P$.

This ensures that $\Pi_m > 0$ and that there exists a unique price at which Π is maximum. This defines the monopoly price p_m which is solution of the first order condition

$\Pi'(p) = 0$, i.e.:

$$(1) \quad (p_m - c)g'(p_m) + g(p_m) = 0.$$

Notice that a further consequence of our assumptions is that Π is strictly increasing on the interval $[c, p_m]$.

Let us suppose that there are two firms; we denote by i the incumbent firm and by e the potential entrant. Firm i sets a pre-entry price p , which it can change with a lag T , called the response lag, $T \geq 0$. The potential entrant observes p and decides whether or not to enter. If e does not enter, its payoff is zero. If e chooses to enter, then i is unable to react instantaneously to entry by lowering the price: until time T e can price just below p and get the whole market. After time T , i is allowed to change its price in response to e 's entry: i and e compete in some way which will be specified later. We denote by W_e the present value at date T of e 's profit flow after time T .

We suppose that entry into the industry requires a cost s , $s \geq 0$, to be sunk. For a given interest rate, we denote by r the discount factor, $0 < r < 1$ and we define $k(t) = (1 - r^t)/(1 - r)$. The present discounted value of the entrant's profit is then given by:

$$(2) \quad V_e(p|T, s) = \Pi(p)k(T) + W_e r^T - s.$$

Of course e will enter if and only if $V_e > 0$. If $V_e = 0$, e is indifferent between staying out and entering. Two cases may occur:

$$(a) \quad \Pi_m \leq (s - W_e r^T)/k(T),$$

$$(b) \quad \Pi_m > (s - W_e r^T)/k(T).$$

In case (a) the incumbent firm ignores the threat of entry and charges p_m . In case (b)

the entry threat is binding. Let us denote by $p^* = p(s, T)$ the entry-preventing price. It satisfies the equation : $V_e(p^* | T, s) = 0$, i.e.:

$$(3) \quad \Pi(p^*) = (s - W_e r^T) / k(T).$$

It is uniquely defined in case (b) and such that $c \leq p^* < p_m$; as a consequence, it satisfies the following condition:

$$(4) \quad (p^* - c)g'(p^*) + g(p^*) > 0$$

In the following subsection, $W_e = 0$ will be assumed. This is the case normally considered in the theory of contestable markets: if the entrant's best strategy is to "hit-and-run", then certainly $W_e = 0$. Alternatively, this may occur as a result of price competition after time T , as a conventional Bertrand equilibrium, with price equal to marginal cost. If $s = 0$ but $T > 0$, then the outcome of contestable markets arises: from (2), i is vulnerable to entry whatever price it charges above c .

Here we will first test the robustness of the theory of contestable markets to small changes in assumptions, in particular the claim of Baumol, Panzar and Willig (1983): "when there are almost no sunk costs, markets are almost perfectly contestable".

2.1 SUNK COST APPROACH

Baumol, Panzar and Willig propose the following representation of imperfect contestability. In their approach exit can take place anytime, but a sunk cost s is lost if exit occurs. In other words, in expression (2), $W_e = 0$ and any exit cost is included in s . Therefore expression (2) becomes:

$$(5) \quad V_e(p | T, s) = \Pi(p)k(T) - s$$

Let s_0 be such that $s_0 = \Pi_m k(T)$. Thus for any $s \leq s_0$, case (b) occurs and therefore there exists an entry-preventing price p^* which is a solution of (2), that is:

$$(6) \quad \Pi(p^*) = s/k(T)$$

Given that inequality (4) holds, a straightforward consequence of the differentiation of (6) with respect to s and T is that p^* is increasing in s and decreasing in T .

The following Proposition assesses the robustness of contestability theory with respect to small sunk costs:

Proposition 1. Let $T > 0$. When there are almost no sunk costs, then there is (almost) no deviation of p^* from the average cost price, i.e.,

$$\lim_{s \rightarrow 0+} p(s, T) = c.$$

Proof. The proof is straightforward. Indeed since $p(0, T) = c$ and $p(s, T)$ is continuous at $s = 0$, then $\lim_{s \rightarrow 0+} p(s, T) = c$. ■

Remark 1. Proposition 1 is in keeping with Baumol, Panzar and Willig's claim about the robustness of contestable markets with respect to small sunk costs. However, if $T \rightarrow 0$ and $s \rightarrow 0$, then the level of p^* depends on the relative speeds at which T and s go to zero. If s does not go more rapidly to zero than T , then the market is not "almost" contestable. In other words, we cannot predict the relationship of price to average cost based on the smallness of s and T only, but we need to know whether s is small in relation to T .

2.2 EXIT LAG APPROACH

An alternative way of modeling imperfect contestability is to assume a positive exit lag, say Y , due for example to contractual obligations. Let us consider the possibility that e can recover the costs entirely if it leaves the market at time τ , where $\tau = T + Y$, but suppose that $W_e < 0$, e.g. the two firms incur a price war after T which ends up with losses for both firms. We denote by $-F_j$ the one period loss of firm j , $j = i, e$, $F_j > 0$; therefore we get $W_e = -F_e r^T (1-r^Y)/(1-r)$. Then expression (2) becomes:

$$(7) \quad V_e(p|T, s) = \Pi(p)k(T) - F_e k(Y)r^{2T}$$

Let Y_0 be such that $\Pi_m = F_e r^{2T} k(Y_0)/k(T)$. Thus for any $Y \leq Y_0$ there exists an entry-preventing price $p^* = p(Y, T)$ which satisfies equation $V_e(p^*|T, s) = 0$, i.e.:

$$(8) \quad \Pi(p^*) = F_e r^{2T} k(Y)/k(T)$$

Given that condition (4) holds, a straightforward consequence of the differentiation of (8) with respect to Y and T is that p^* is increasing in Y and decreasing in T .

The following proposition is the analogue in the exit lag approach of Proposition 1:

Proposition 2. Let $T > 0$. When there is almost no exit lag, there is (almost) no deviation of p^* from the average cost price, i.e.,
 $\lim_{Y \rightarrow 0+} p(Y, T) = c$.

Proof. The proof is straightforward. Indeed since $p(0,T) = c$ and $p(Y,T)$ is continuous at $Y = 0$, then $\lim_{Y \rightarrow 0^+} p(Y,T) = c$. ■

Proposition 2 states that a short exit lag implies that exit from the market is easy. Therefore "hit-and-run" is easier and the market is more contestable. Again, if $T \rightarrow 0$, $Y \rightarrow 0$ but Y does not go to zero more rapidly than T , then the market is not "almost" contestable. Accordingly, both the sunk cost model and the exit lag model show that instantaneous price responses can lead the incumbent to ignore entry threats and set the monopoly price.

3. ENTRY ACCOMMODATION

Let us consider expression (2) with the assumption $W_e > 0$. For this case to occur, e must expect either (i) that i will leave the market at T , so that e could become the incumbent, or (ii) that the two firms could share the market and make a profit.

Case (i) is examined by Farrell (1986). Obviously, this case is not considered in the theory of contestable markets, since this theory assumes that the incumbent faces both a price response lag and an exit lag, that is, exit is not frictionless to the incumbent: in this way the threat of "hit-and-run" entry can constrain the incumbent's behaviour. Indeed, if the possibility of exit was allowed to the incumbent, he would price monopolistically to exploit any entry lag and hence potential competition would be completely ineffective. Notice the implausible asymmetry between incumbent and entrants' behaviour: in this theory entrants can costlessly "hit-and-run", but for the incumbent firm both entry and exit are not frictionless.

We examine now case (ii), that is, the incumbent rather than fight entry may seek to accommodate it. If firms were instead to collude, potential competition would not benefit consumers, it would merely encourage entry, as monopoly profits would be redistributed among firms. It is therefore significant to explore under what conditions it is possible to have a result of collusion. Such collusion is a possible outcome in infinitely repeated games.

To study this case let us consider the following game with infinite horizon. There are two firms in the market, the incumbent firm i and the entrant e . Assume as before that the incumbent firm can change the price with a lag T . Consider the following strategies for each agent. Firm i can either deter entry or allow entry by the choice of a price $p \in [c, p_m]$. We denote by p^* the entry preventing price and by Π^*

the corresponding level of profit, as defined by (6), i.e. $\Pi^* = s/k(T)$. Firm e decides whether to enter ($\alpha = 1$) or not to enter ($\alpha = 0$) and chooses a price level $p \in [c, p_m]$. When both firms are on the market and charge the price p_m , we assume that they share the market in a fixed way, a proportion γ being allocated to e , where $0 < \gamma < 1$.

Obviously, the choices available to the two firms are the following:

- firm e : to charge p_m if firm i is accommodating, and to undercut it by charging some $p < p_m$ for T periods if i is not accommodating.
- firm i : to charge p_m if firm e charges p_m , or to fight e with a permanent move to the competitive price c if e deviates from p_m by undercutting.

We want to establish under which circumstances tacit collusion will emerge, i.e. whether allowing entry and charging the monopoly price is a subgame perfect equilibrium for this game:

Proposition 3. Collusion is an equilibrium outcome if:

$$\text{Max} \left[1 - r^T, \frac{s(1-r)}{\Pi_m} \right] < \gamma < 1 - \frac{\Pi^*}{\Pi_m}.$$

Proof. Consider the payoffs that the two firms obtain from playing the strategies described above. Deviation from collusion is not profitable for e if the following two conditions are simultaneously satisfied:

$$(9) \quad \gamma \sum_{t=0}^{\infty} r^t \Pi_m > s$$

$$(10) \quad \gamma \sum_{t=0}^{\infty} r^t \Pi_m - s > \sum_{t=0}^{T-1} r^t \Pi(p) - s, \text{ for all } p < p_m$$

It is not profitable for i if:

$$(11) \quad (1-\gamma) \sum_{t=0}^{\infty} r^t \Pi_m > \sum_{t=0}^{\infty} r^t \Pi^*$$

Condition (9) is equivalent to:

$$(12) \quad s < \gamma \frac{\Pi_m}{1-r}$$

Since $\Pi_m > \Pi(p)$ for all $p < p_m$, the inequality (10) holds if $\gamma \Pi_m / (1-r) > \Pi_m k(T)$ or, equivalently, if:

$$(13) \quad \gamma > 1-r^T.$$

From expression (11) we get:

$$(14) \quad (1-\gamma)\Pi_m > \Pi^*.$$

Combining (12), (13) and (14), it follows that

$$(15) \quad \text{Max} \left[1-r^T, \frac{s(1-r)}{\Pi_m} \right] < \gamma < 1 - \frac{\Pi^*}{\Pi_m}$$

is a sufficient condition to get a collusive outcome. ■

Remark 2. When discounting is small enough and (15) holds, collusion is actually a subgame perfect equilibrium.

If expression (15) holds, then the market is served at monopoly price and the familiar perfectly contestable outcome, that is, price set at the competitive level, is not attainable. The result holds even if $s = 0$. Notice that expression (14) is not satisfied if $T = 0$. The instantaneous price response makes entry impossible and a collusive outcome cannot be achieved if $T = 0$. These results are obtained under the assumption that the proportion γ is exogenously given: one could construct a more complex game in which firms have also to establish the fraction of the market they will enjoy. Finally observe that the result obtained here holds under the assumption that there is one potential entrant only. If there are multiple entrants a collusive

outcome may not arise⁷: in particular, with a larger number of entrants (e.g. moving simultaneously) it is possible that none of them would actually enter.

Like in Section 2, the result obtained here shows that instantaneous response lags may alter the equilibrium outcome and can lead the incumbent to ignore the threat of entry.

More generally, this result is linked to the discrete formulation, that is to the fact that the period length during which firms can change their actions matters, and so some behavioural rules which cannot be supported as solutions to discrete formulations could be supported in games in continuous time where players can change their actions instantaneously.

Put another way, the problem in this formulation is in the incumbent's "cost of adjustment", which is extreme. The cost of changing the price before the commitment period has elapsed is in fact infinite, after which it drops to zero.

As is well known, the question of discrete vs continuous time formulations has been developed particularly within the literature on repeated games. Anderson (1984), for example, uses a "quick response" argument in a different context. He considers a discrete approximation of a continuous game, where players incur adjustment costs in changing their actions from one period to the next. He considers the limit of subgame perfect equilibria as the length of period approaches zero and shows that price matching policy for oligopolistic firms and thus kinked demand equilibria can be supported as quick response equilibria.

A similar argument can be found in Marschak and Selten (1978) for "inertia supergames", where inertia in decision making is formalised through the cost of changing one's action. Closely related to this is the work by Sabourian (1985) on conjectural equilibria.

4. THE EXIT DECISION

The previous sections have stressed the role of pre-entry competition in establishing the incumbent's behaviour. Here on the contrary we explore the exit decision of the entrant – that is, at what time the entrant exits, should it enter the industry – by referring to post-entry competition. In other words, in this section we deal with actual entry and not with threat of entry.

Under the assumptions of contestable markets, the exit decision is easily understandable. The "hit-and-run" strategy is the optimal one given that after T periods the incumbent reacts to entry and is assumed not to exit from the market. In other words, the following three conditions are met:

- (i) complete information,
- (ii) price war incurred by firms after T periods,
- (iii) larger "staying power" for the incumbent, i.e., larger number of periods the incumbent can endure a price war before exiting.

When there is complete information, the solution is straightforward⁸. There is no reason to fight if the firms' "staying power" is common knowledge: the one which can endure an aggressive response for a shorter time exits immediately. Obviously, the result is not straightforward if incomplete information is introduced⁹, for example, on the firms' "staying power". If it is not common knowledge that the incumbent never exits, then e 's optimal exit time will depend on the subjective probability that e assigns to firm i 's "staying power". Finally, it is not straightforward that the optimal strategy for e is to exit as soon as i reacts to e 's entry, when the possibility that both firms can coexist after e 's entry is considered and the post-entry game is modeled as a repeated game with infinite horizon: indeed in such contexts collusion may emerge.

We analyse the last question mentioned above: i.e., under what conditions would an entrant "voluntarily" exit (i.e. before i actually reacts to entry) in an industry where both "fight" and "cooperation" are i 's possible strategies after e 's entry?

Let us consider an industry with two firms i and e . Firms act in discrete time and their horizon is infinite. We assume that firm e unconditionally enters the market, i.e., we consider only the subgame after e 's entry. In particular, we assume that there is a preliminary period $-T$, the "hit-and-run" period, in which firm e makes positive profits by undercutting firm i , given that i cannot react to e 's entry until time $t = 0$, because of a response lag of length T . We assume that i 's profits during the "hit-and-run" period are non positive. We allow firm e the faculty to exit before firm i can react to e 's entry. If firm e exits, then firm i becomes a monopolist. If firm e stays in, then the two firms play a game in which firm i moves first in each period, deciding whether to "fight" (F) or "cooperate" (C), after which firm e moves, deciding whether to stay in (S) or to exit forever (E). We can interpret the decision of "fighting" and "cooperating" as in the previous sections: "fight" means that the two firms incur a price war which is assumed to end up with losses for both firms, if both firms stay in; "cooperate" means that the two firms agree in sharing the market according to some rule which is not necessary to specify here. In the sequel we will not specify the pricing strategy underlying "fighting" and "cooperating", but we will deal with reduced forms only, i.e. the profits resulting from these actions.

Let us consider the payoffs for each period, assuming that they only depend on the strategies and not on the time period. Firm e does not incur any exit cost and earns zero profits when it plays E: that is, $\Pi_e(F,E) = \Pi_e(C,E) = 0$. Let $\Pi_e(F,S)$ and $\Pi_e(C,S)$ denote firm e 's profits when it plays S and firm i is playing F or C, respectively. Analogously, we denote by $\Pi_i(F,S)$ and $\Pi_i(C,S)$ firm i 's profits when firm e is playing S, and by $\Pi_i(F,E)$ and $\Pi_i(C,E)$ firm i 's profits when firm e follows

with E (in this case no F or C actually take place). Let Π_m denote the one period monopoly profit. Firms discount future profits at the same rate r , $0 < r < 1$. The following assumptions are made:

$$\text{A.3.} \quad \Pi_i(F, S) < \Pi_i(F, E) \leq 0 \leq \Pi_i(C, S) \leq \Pi_i(C, E)$$

$$\text{A.4.} \quad \Pi_e(F, S) < 0 \leq \Pi_e(C, S)$$

$$\text{A.5.} \quad \Pi_i(F, S) + \sum_{t=1}^{\infty} r^t \Pi_m \geq \sum_{t=0}^{\infty} r^t \Pi_i(C, S)$$

A.5 means that if i can drive e out of the market by fighting one period, then i will prefer fighting one period and then earning monopoly profits rather than cooperating forever.

In what follows we assume that firm e can endure "fight" only for a finite number of periods, say Y_e : in other words, firm e will be certainly driven out of the market after Y_e periods of "fighting". Moreover, we assume that firm i can fight only for a finite number of periods, say Y_i . Let us suppose that:

$$\text{A.6.} \quad Y_i > Y_e$$

Alternatively, Y_i may be infinite. Notice that the case $Y_i = \infty$ is considered in the theory of contestable markets, since firm i never exits. The following result holds:

Proposition 4. Under A.3, A.4, A.5, A.6, the "hit-and-run" strategy is the unique subgame perfect equilibrium (SPE).

Proof. The proof follows from the following remark. Since subgame perfection requires e playing S following any C branch (indeed playing S is preferred to playing E since $\Pi_e(C, S) \geq 0$), then by A.5 i does not choose C because e does not exit unless i plays F and it is common knowledge that e will certainly exit after Y_e periods of fighting. Therefore let us consider i always playing F . At Y_e , if i plays F , after fighting all previous periods, then e will be driven out of the industry. Therefore e will play E . Now consider period $Y_e - 1$: again if i plays F after fighting all previous periods, then e will exit, since playing S brings it to period Y_e where it plays E . By repeating the same argument for each period, e chooses to exit before i can react to e 's being in (i.e., e exits before time 0 starts). The only SPE is therefore the "hit-and-run" strategy. ■

Firm e enters in period $-T$ and then "voluntarily" exits, following a "hit-and-run" strategy. Of course, this exit is not voluntary since e exits only because i is threatening its fight. However, to an observer it would appear voluntary as no fights have actually taken place. We note that in order to get the "hit-and-run" strategy as a unique SPE a strong asymmetry between firms is to be imposed. Firm e can decide whether or not to stay in, but must passively accept firm i 's decision on whether or not to fight, that is, firm i is assumed to move first. Moreover, firm i never exits, or, alternatively, A.6 must hold. In particular, it does not matter how large Y_i is: the crucial thing is that Y_e is smaller than Y_i . Indeed, if Y_e is not smaller than Y_i ¹⁰ then, besides "hit-and-run", cooperation is a possible equilibrium solution to this game.

Let us consider now the possibility that e can reenter after exiting (alternatively, interpret it as many potential entrants that enter sequentially, where the k -th entrant enters after the $(k-1)$ -th one has exited, and so on). We suppose that firm e can re-enter after exiting indefinitely without incurring any sunk cost or

incurring sunk costs in a way that it is still convenient to "hit-and-run" ad infinitum!! In this case, firm i will be able to keep e from ever actually staying in only by playing "fight" in every period. Indeed, if e reenters after exiting and i fights, e will play exit, given that staying in yields $\Pi_e(F, S) < 0$ and exiting yields 0. This repetition of exiting and re-entering can go on indefinitely under the assumption that the entrant will earn non-negative profits by playing the "hit-and-run" strategy. Notice however that under assumption A.3 it is not optimal for i to play "fight". Therefore the only credible equilibrium outcome is entry accommodation.

5. FINAL REMARKS

Two major questions, which are interrelated, have been tackled in this paper, namely the role of commitments in the process of entry and exit; and the relation between pre-entry and post-entry competition. These issues have been discussed with particular regard to the contestable market approach.

It is well-known that these questions have also been investigated within the "capital commitment" literature¹². However, the predictions of the "capital commitment" literature differ markedly from those of contestability theory as far as the effects of pre-entry and post-entry competition are concerned. In the former approach the role of pre-entry price is deemphasized, while preemptive investments and sunk costs, which are more credible deterrents, are stressed. On the contrary, in the theory of contestable markets post-entry competition is absent and hence pre-entry competition is most effective: in particular, the more competitive is post-entry competition, the less effective is the market discipline provided by potential competition.

In this paper it has been shown how sensitive the conclusions of contestability theory are to the assumptions: in particular, it has been argued that costlessly reversible entry by itself does not lead automatically to the nirvana of social optimality (see Sections 2 and 3).

A few issues for possible further research strategies can be identified. One is the question of information. If there is some doubt in the minds of the potential entrants concerning the incumbent's behaviour, an equilibrium with "reputation effects" may arise. Kreps and Wilson (1982) and Milgrom and Roberts (1982) show that it does not take very much uncertainty on the part of entrants about the incumbent, before an equilibrium emerges with reputation effects. The question then arises: how might a Kreps-Wilson-Milgrom-Roberts strategy manifest itself in a contestable markets

context? Surely it would generate game-theoretic interactions if it does not deter entry.

Another issue is the one of adjustment costs. In the contestable markets inertia in decision-making is formalised only on the side of the incumbent by assuming a T -period commitment to price decisions. In particular, the incumbent's "cost of adjustment" is extreme: before the commitment period has elapsed, it is infinite, while after T it drops to zero. Subtler forms of inertia should then be introduced since this way of modeling adjustment costs remains crude.

The concept of commitment is intimately related to the idea of reaction. The simplest way of accomplishing both concepts is to assume that firms move sequentially. In order to get contestability results we have to assume sequentiality as the only possible timing of moves: in particular, it matters whether the incumbent or the entrants move first (see Section 4) and whether the incumbent is allowed to exit or not. Contestability imposes an asymmetry between entrants and incumbents: the entrant can decide whether or not to be in the industry, but must passively accept the incumbent's decision on whether or not to fight; furthermore, the incumbent is not allowed to exit. Also in this sense, perfect contestability theory does not seem to be "robust" in some meaningful way.

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NOTES

¹ Fixed costs persist only as long as production continues, but are, strictly speaking, independent of scale. Pure sunk costs continue as a liability forever, they are incurred with or without production. Whether or not costs are sunk depends on the resale market for capital assets. Whether or not costs are fixed depends on the extent to which they vary with output.

² Baumol and Willig (1986), p.103.

³ See, for example, the discussion in Brock (1983), Shepherd (1984), Weitzman (1983). For empirical appraisal see the works surveyed in Schwartz (1986), Baumol and Willig (1986).

⁴ The last assumption means that there exists a discount rate such that the losses during the period of aggressive response plus the discounted flow of monopoly profits thereafter are greater than the discounted flow of profits that the incumbent gets by playing soft.

⁵ \mathbb{R}_{++} denotes the set of positive real numbers.

⁶ Assuming that g is twice differentiable, a sufficient condition for $\Pi(p)$ to be strictly quasi-concave on $[c, +\infty)$ is the following: $g(p) \cdot g''(p) < 2(g'(p))^2$ for all $p > c$. Indeed, under that condition, $\Pi''(p) < 0$ for all $p > c$ such that $\Pi'(p) = 0$.

⁷ Prof. S. Martin has kindly brought to my attention the fact that contestable markets theorists would appeal to the case where there is an infinite number of potential entrants or at least so many potential entrants that there is always one outside the market, no matter how many actually come in.

⁸ See for example the solution in Ghemawatt and Nalebuff (1985) to the exit decision in a complete information framework.

⁹ See Fudenberg and Tirole (1986) for the analysis of the exit decision in "wars of attrition" with incomplete information.

¹⁰ In this case the game appears as an infinitely repeated "reverse chain-store-paradox", where we interpret it as a problem of exit and not of entry (see Milgrom and Roberts, 1982, Appendix A).

¹¹ It means that there exists a discount rate such that the discounted flow of profits earned in the "hit-and-run" periods is greater than the discounted flow of sunk costs. Obviously, if firm e could reenter only for a finite number of times, the result of Proposition 4 would still apply. For a discussion of reentry costs with reference to predation see Ordover and Willig (1981).

¹² See, for example, Dixit (1979), (1980), Fudenberg and Tirole (1983), Spence (1977), (1979).

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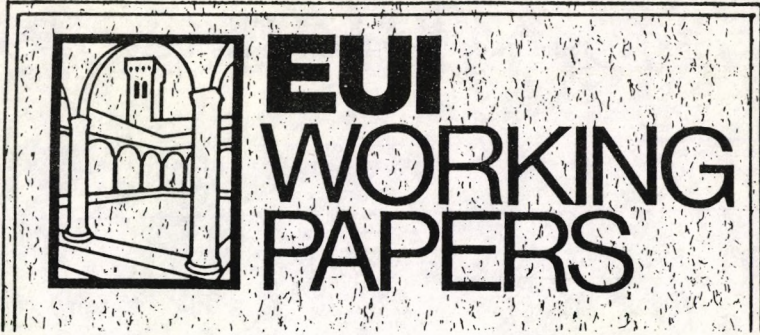
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