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Preemptive investments under uncertainty, credibility and first mover advantages☆

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ABSTRACT

We present a continuous-time game in which two firms must decide at each instant of time whether to be in or out of a market that expands up to a random maturity date and declines thereafter. Firms are initially inactive, and they differ only in the opportunity costs of using their assets (e.g., owing to different redeployment or resale values). After characterizing the unique Markov perfect equilibrium of the entry and exit game under demand uncertainty, we challenge the result that the threat of preemption can partially or even totally dissipate a first mover advantage. When post-entry profits can be negative, the preemption threat of a firm may become weaker because its rival may force it out of the market after entering. As a result, there may be little or no dissipation of the first mover advantage when post-investment profits are not assumed to be always positive.

1. Introduction

That a preemption threat must be backed up by a credible commitment in order to be really effective is a recurrent theme in the industrial organization literature, starting from seminal work by Spence (1977) and Dixit (1980) on capacity investments. In a setting in which a firm has an incentive to preempt rival firms, the early literature on Stackelberg leadership examined how a firm can be in a position to preempt competition, highlighting the role of investment sunkness in conferring the desired ability to commit. The assumption that one of the competing firms ("the leader") enjoys an exogenous timing advantage was subsequently relaxed by the literature on irreversible investment timing games. Starting from the classical work by Fudenberg and Tirole (1985), the focus then shifted to how the threat of preemption affects dissipation of first mover advantages (FMAs) and investment patterns in equilibrium. To derive such a result, post-investment economic profits were assumed to be positive no matter what, which implied that a preemptive move necessarily entailed a credible commitment to remain active even if such a move were challenged by the competitor.

The main goal of the current paper is to draw implications for rent dissipation of the (non)credibility of a preemption threat when leadership is endogenously determined as in Fudenberg and Tirole (1985), but the ability to commit is not given exogenously (as in e.g. Caruana and Einav, 2008). In particular, we study a timing game played by two firms that have to decide when to enter a market subject to stochastic evolution under the possibility that post-entry profits may be negative, so exit is an option seriously contemplated by an actual or prospective entrant. The game is played by two firms that are ex ante identical except for the opportunity costs of using their (indivisible) assets.[1] This allows us to examine the role of the *ability to preempt* on the dissipation of FMAs, complementing the insights received from the literature on preemption games regarding how such rent dissipation depends on the *willingness to preempt*.

To address this question, we endogenize the entry and exit order of each of the two firms over the entire lifetime of an industry in which market demand grows up to a random date and thereafter irreversibly

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[1] Firms may use assets that differ in their opportunity costs if one uses a multipurpose plant while its rival uses a specialized plant, or if one of them can redeploy assets to other countries whereas its competitor cannot.

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declines until it disappears. The main focus is on the determinants of the initial entry decision, some of which are quite familiar. Thus, the stochastic nature of demand evolution introduces option value considerations when making entry decisions during the market growth phase, so an entrant has an incentive to wait and see how demand turns out to be. If firms can enjoy an FMA, though, the threat of preemption by the competitor may force the entrant to invest first at an earlier date than it would desire, thus dissipating some of the rents accruing from the FMA, as is also well-known.

How the rival (correctly) perceives the effectiveness of a firm's preemption threat depends critically on the option to exit the market. This aspect missing in previous work on preemptive investment – with the notable exception of Londregan (1990) – constitutes the core of the analysis in the current paper. If firms can make losses upon entering a growing market because of too intense competition, market exit becomes highly tempting. But a firm that foresees being forced out soon after entering will usually be led to delay entry in order to avoid such a suboptimal outcome. Therefore, the perceived effectiveness of the threat of preemption by a firm rests upon such a firm having an *incentive* to preempt competition (as argued by past literature; cf. Fudenberg and Tirole, 1985, 1986), but it may also require that the firm has the *ability* to credibly preempt competition. As a result, a firm's threat of preemption may need to be backed up by a credible commitment to continuing operations should the rival be willing to enter with the purpose of forcing the firm out, an aspect largely overlooked by previous literature. When applicable, such an extra restriction softens the severity of the threat of preemption and therefore mitigates the erosion that competition imposes on FMAs, an effect that becomes stronger as product market competition intensifies.

In light of these observations, the contribution of this paper is to show that allowing for negative profits and exit in a game of entry timing may mitigate rent dissipation because the threat of preemptive entry is not credible for some time. Rent dissipation is a classical theme in the literature on competition for markets (as opposed to competition in markets; see Fudenberg and Tirole, 1987). Reinganum's (1981a,b) seminal papers on adoption timing games show that there is no dissipation of an FMA when the adoption of a new technology takes time to implement.[2] Nevertheless, in those cases in which adoption hardly takes any implementation time and is almost instantaneous and observable (as assumed in the current paper), Fudenberg and Tirole (1985) strikingly show that the threat of preemption dissipates all the extra rents that accrue from an FMA. With asymmetric firms such as the ones we deal with in the current paper, the FMA is still partially dissipated because of the threat of preemption, as Fudenberg and Tirole (1986) demonstrate.[3] However, allowing for the possibility of forcing an incumbent out may weaken the preemption threat, which would result in lower dissipation of the FMA. Indeed, we show for the Bertrand competition case that no rent evaporation exists at all, unlike the results in Fudenberg and Tirole (1986) according to which there is partial rent dissipation even under Bertrand competition.

Our paper is one of countless efforts to improve our understanding of timing games and their empirical implications for industrial organization.[4] Recent efforts dealing with investment timing are the papers by Bouis et al. (2009) and Argenziano and Schmidt-Dengler (2014). These papers allow for more than two firms in the Fudenberg and Tirole (1985) framework, and show how firms' investments may be clustered even if rents end up being equalized across firms.[5] None of these papers deals with uncertainty and asymmetric firms, as for example does the paper by Pawlina and Kort (2006), which shows that, when two firms differ in their entry cost, an increase in the highest of the two costs may end up harming the low cost firm. There are also somewhat recent papers dealing with disinvestment timing under uncertainty and asymmetric firms, as exemplified by Murto (2004), who shows that Ghemawat and Nalebuff's (1985) well-known result that a small firm may outlast a large firm in a declining market may be reversed if there exists substantial demand uncertainty. Neither Murto (2004) nor Pawlina and Kort (2006) deal with timing games in which firms can (re)enter and (re)exit the market, though.

The only paper that deals with a game of entry and exit timing is Londregan (1990), which shows how a large firm with higher (re)entry costs than a small firm may nevertheless be able to preempt the market because it starts being committed to remain active at an earlier date. The large firm's greater ability to commit is critical for Londregan's (1990) preemption result, but it is very special because it solely arises from the large firm's higher *reentry* costs. Even though our model allows for reentry in order to simplify the exposition, it is worth noting that our qualitative insights remain true if firms cannot reenter the market after exiting: our point is more general than his in that it does not depend on reentry being feasible (proof available on request). In addition, Londregan (1990) does not examine the effect of investment sunkness on the incentive as well as the ability to preempt, and he does not give any condition under which the lack of credibility of preemption can mitigate dissipation of FMAs when firms compete to enter first.[6] From a technical standpoint, our setting is also richer than his in that profitability need not be bounded, so one cannot use recursion to work backwards during the market growth phase. In this sense, the current paper is the first in analyzing entry and exit timing decisions in an oligopolistic industry whose market demand is subject to a random evolution. [7]

The remainder of the paper is organized as follows. Section 2 describes the game. Section 3 examines entry and exit in a declining market, while Section 4 is dedicated to a growing market. Section 5 draws implications for the dissipation of FMAs. Section 6 concludes by sketching out avenues for further research, with proofs not in the text relegated to the technical Appendix, labeled A (there is another Appendix, labeled B, which gives sufficient conditions to identify which firm enters first based on Section 4's results).

2. Game description and solution concept

Let time, denoted by t, be continuous on $[0,\infty)$. Two firms, 1 and 2, are inactive at date 0, and each will have to decide at each point in time whether to be active or inactive in a market that evolves

[2] See Ruiz-Aliseda and Zemsky (2006) for a formalization of how an FMA can arise (and not be dissipated) in contexts of technology development, a concept related to Reinganum's conception of technology adoption as an adjustment process which results in decreasing adoption costs.

[3] The rent dissipation conclusions in Fudenberg and Tirole (1985) do not depend on the symmetry of players, as shown by Fudenberg and Tirole (1986), so we compare our results with the latter work rather than the former. It is worth noting that our results can still be derived if firms are symmetric but they play asymmetric equilibria during the war of attrition that would take place if both firms were active in a growing market too small to accommodate the two of them. If the date at which firms deem a growing market large enough to accommodate both arrives later than the date at which firms start having preemption incentives, it then holds that the winner of the war of attrition would preempt the rival and would not suffer from (complete) dissipation of its FMA. The main role of firm asymmetries is to directly focus on one of these asymmetric equilibria.

[4] See Hoppe (2002) for an extensive survey.

[5] See also Boyer et al. (2012) for another interesting reason why clustering may sometimes happen in a duopoly game of investment timing.

[6] Indeed, he never mentions equilibrium profits at any point, let alone relative to some benchmark. Perhaps more importantly, his main result (Proposition 4) states that the earliest time at which a firm is committed to fight for a duopolistic market (weakly) decreases with the cost of (re)entry. This is *not* a comparative statics exercise on equilibrium outcomes, since one does not know whether or not that firm is the first entrant in equilibrium: in fact, the earliest date at which a firm has an incentive to preempt the rival can be easily shown to increase with the cost of (re)entry. Because he does not give conditions for a firm to actually preempt the competitor in equilibrium, it is unclear whether his comparative statics refer to the first mover or the second mover.

[7] In contrast, there is a huge theoretical and empirical literature that deals with entrants that face a "now or never" choice of whether to enter the market (see e.g. Amir and Lambson, 2003, or Dunne et al., 2013). Papers in this stream of the industrial organization literature abstract away from entry timing to focus on other aspects. See also Dixit (1989) and Lippman and Rumelt (1992) for entry and exit timing under uncertainty for the cases of monopoly and perfect competition, respectively.