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Where to locate to escape predation?

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Abstract

We study the credibility of predation to deter entry in the linear Cournot shipping model of spatial competition with strategic location choice, both on the linear and circular markets. For a high enough discount factor, the monopoly is preserved, but the credibility of predatory conduct is lower on the circular than on the linear market.

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1. Introduction

Since the seminal work of Hotelling (1929), the literature dealing with strategic location choices has become very rich. The impact of various factors (pricing strategy, shape of demand, form of delivery cost functions) on the ultimate spatial equilibrium has been gradually examined, with one conclusion being soon obvious: results are quite sensitive to assumptions[1]. However, the vast majority of these theoretical contributions chose not to deal with what may happen if the incumbent acted to prevent future potential entry[2].

Generally speaking, strategies designed to deter rival firms from competing in a market are called predatory conduct, and a firm engaging in such a conduct wants to influence the behavior of its rivals - either currently in the market or those contemplating entry. In this paper we deal with the predatory conduct that is designed to deter entry of a potential rival, and we use alternatively the terms 'predation', 'predatory conduct' and 'entry deterrence'. The mere existence of predation has long been debated, but nowadays there is a large consensus on its rationality (see Motta 2004 for a synthetic discussion).

In this paper we adopt a different perspective in analyzing predation: instead of questioning its rationale, we look into the impact of the spatial dimension on the likelihood for predation to occur. More precisely, we assume a 'deep pocket' explanation, and basically build on a textbook predation problem originally analyzed by Benoit (1984) in a spaceless economy with perfect information[3]. We focus on the relevance of the spatial dimension for the credibility of entry deterrence, by considering the entrant's optimal location choice. Explicitly, we determine whether it is possible for the new entrant to make a location choice such that the incumbent's subsequent incentive to block entry fails to be a credible threat. But the ultimate objective is to compare the linear and circular markets from this point of view. Therefore, the question that we wish to answer is whether the market stays a monopoly or not, and moreover, what type of market does so, linear or circular.

Both the linear and circular city models are relevant. The former represents situations where there are exogenous endpoints, leading the distinct locations to be differentiated in terms of their relative positions to the borders - thus the markets along the line are not

[1] The spatial equilibrim necessarily involves dispersion if firms compete in prices, but may involve complete agglomeration, partial clustering or even complete dispersion if firms compete in quantities, depending on the market shape. For a recent survey on this see Biscaia and Mota (2013).

[2] Notable exceptions are the models of incomplete information regarding the incumbent's cost, so as to compare the resulting location choices with those obtained under full information (Boyer et al. 1995, 2003), and those using brand proliferation as an entry deterring strategy (Hay 1976, Schmalensee 1978, Judd 1985, Bonanno 1987, Shaked and Sutton 1990).

[3] Motta (2004) discusses Benoit's (1984) model in Chapter 7. The most important limitation is arguably the fact that it is exogenously assumed that the prey is not able to raise outside funds. This may be overcome by introducing imperfect financial markets into the framework, but this falls far outside of the purpose of our paper, which merely attempts to check the relevance of the shape of the spatial framework for the credibility of predatory conduct.

perfectly homogenous. In turn, the circular city is perfectly homogenous since the location patterns are differentiated only regarding the firms' relative locations to each other. The choice of the spatial framework depends on the nature of the economic problems addressed[4], and as far as predatory conduct is concerned, one may note that some markets where predation allegedly occurred are better described as imperfectly competitive with differentiated products[5].

We find, based on the largely used linear Cournot shipping model, that if the incumbent values future profits sufficiently, then the market stays a monopoly and entry is not viable. This holds both for the linear and the circular markets, and is quite intuitive. However, we also find that the credibility of the predation threat is weaker on the circular than on the linear market, and this is the main result of our paper. We put this down to their respective intrinsic properties (homogenous or not distinct locations). In short, the linear market being prone to harsher competition in case of entry, the incumbent has a stronger incentive to avoid it. We can thus relate our result to how easy it is to monopolize a market through horizontal mergers: our finding is consistent with the literature on this issue building on the very same formal framework (Cournot spatial competition with strategic location) - the circular market is harder to monopolize.

Before turning to the model itself, let us remark on the overall relevance of our analysis. Although the question of how space affects the incentive to predate has already been tackled, the spatial framework that we use has not been exploited to deal with the role of location choices for the credibility of predatory conduct[6], despite the fact that the Cournot spatial model has some attractive features in terms of predictions[7]. Few papers

[4]The linear market assumption allows to determine location patterns arising from different market characteristics, due to its intrinsic heterogeneity. The circular framework remains more appropriate for certain real-life situations: traffic-jammed cities where large shopping malls are located on the outskirts, on the circular belt-way, so as to avoid consumers the downtown traffic. The dial of a clock being a circle, the circular market can also be used for competing television networks choosing time slots for their shows, or airlines choosing arrival and departure times for their flights. Still, in terms of product specification, the linear representation is often preferred because it applies to single-peaked consumer preferences, whereas no such analogy is available for the circular model.

[5]Lindsey and West (2003) quote a certain number of empirical studies revealing predatory conduct on markets such as city bus routes, computer disk drives, supermarkets, cable television and airlines.

[6]For instance, Aguirre et al. (1998) model the entry decision on the Hotelling line with fixed locations and price competition, and show that the monopolist incumbent may successfully use spatial price discrimination to deter entry with asymmetric information and no commitment on the pricing strategy. Götz (2005) reexamines sequential entry of firms in a Hotelling model of spatial product differentiation in order to analyze the pattern of locations. More recently, Zhou (2013) combined Dixit's model of deterrence with the Hotelling setting to identify the optimal entry location. All these models use spatial price competition.

[7]Arguably, this is why the literature on location choice with quantity competition has developed so much in the recent years - for a short and up-to-date review, see Ebina et al. (2011). For instance, whereas Bertrand competition yields exclusive sales territories for firms, *i.e.* consumers at each location are served only by the most cost-efficient firm there, Cournot competition exhibits market overlapping with intra-industry trade (Phlips 1983, McBride1983).

have looked into the issue of predation using spatial Cournot competition, and we intend to further advance this line of research. In particular, we can relate our analysis to Colombo (2013), that uses quantity competition on two discrete separate spatial markets to study the impact of transport cost on the incentive to deter entry in Benoit's (1984) model. We depart from this by assuming a continuous spatial framework (the linear and the circular cities), and by studying the impact of the entrant's location choice on the incumbent's ability to prey. We thus discuss the impact of the transport cost for the credibility of predation by endogenizing firm's locations, in a more general setting, the continuous space framework. This also allows us to tackle the impact of the 'shape' of the market, or rather the locations' intrinsic properties (homogenous or not) for the credibility of predation.

The rest of the paper is organized as follows: first we present our framework, then solve the model and discuss the results.

2. The model

Let there be an incumbent one-store firm (I) operating on the unit market (be it linear or circular), where infinitely many consumers lie uniformly. A potential new entrant (E) contemplates entry on this market by establishing a unique outlet. The firms, if active, will compete in quantities and produce the same homogenous good with the same technology characterized by constant marginal costs, normalized to zero. Firm's i location is denoted x_i, where $i \in \{I, E\}$. At any consumer location x on the circle, demand is given by $p(x) = a - Q(x)$, $a > 0$, where $p(x)$ is the product price at that location and $Q(x)$ is the total output supplied at x. Firms incur the same transport cost $t\,|x - x_i|$, linear in distance and quantity, in order to ship output to consumers[8]. t is a positive constant, and since the transport cost parameter enters as a multiple in the profits expression, we will assume $t = 1$ without loss of generality. Equivalently, let a be the transport-cost adjusted reservation price[9]. Consumers have a prohibitive costly transport cost, preventing arbitrage[10], so firms can and will price discriminate across the set of spatially differentiated markets[11]. Finally, to ensure positive duopoly quantities for each firm throughout the market, let $a \geq 2$ (this way, if the market stays a monopoly, it must be the result of predatory conduct).

[8]For the circular market, the norm stands for the shorter distance of the two possible ways to ship goods along the circumference.

[9]In the product-differentiation analogy of this model, a can be interpreted as an inverse measure of the extent to which consumer tastes are strongly localized.

[10]This assumption is not essential. Unless transport costs for consumers are strictly smaller than those of firms, consumer arbitrage plays no role in the model. For this discussion, see Hamilton et al. (1989).

[11]This assumption basically defines the shipping model of spatial competition: it is an approximation of the case where transport cost for firms is far more important than that of consumers - in real life, this is what justifies distribution networks. In addition, this is compatible with the flexible manufacturing production systems (see Eaton and Schmitt 1994), where the firm's basic product (its location) is customized at a cost (transport cost) to make it appropriate for a consumer.

The incumbent has to decide whether or not to react aggressively in case the entrant attempts to enter, by selling a predatory, *i.e.* supra-optimal quantity[12]. The incumbent faces a trade-off between current losses (associated with selling more that is optimal) and future gains (maintaining the monopoly profit), and thus the credibility of predation depends on this trade-off. We assume complete information, as in Benoit's (1984) model, so the entrant perfectly anticipates whether the threat is credible or not: if yes, it stays out, otherwise it enters and the market becomes a duopoly.

Starting from an initial monopoly location equilibrium, the following two-stage game takes place[13]: first, E chooses whether to enter or not, and I decides whether to prey or not. The E's entry decision also implies a location choice, before starting the actual production, *i.e.* if no location can guarantee a strictly positive profit, then there will be no entry and no location choice either. At the second stage, I decides whether to prey or to accommodate whereas E decides whether to stay or to exit. Indeed, following the 'deep pocket' theory, if the entrant makes non-positive profits, then it will leave the market. Therefore, at the end of stage 2, either the market remains a monopoly or it turns into a duopoly. Finally, there is no entry cost[14].

In order to establish whether the incumbent's predatory conduct is credible, we need to solve the game by backward induction. The equilibrium concept is the subgame perfect Nash equilibrium, and in what follows we distinguish between the linear and the circular market while solving the game.

2.1. The linear market

The initial spatial equilibrium has the incumbent locate at the middle of the unit segment, hence $x_I = 1/2$. This is the optimal location for a monopoly minimizing total transport cost when serving the whole segment. Denote $z \in [0, 1/2]$ the entrant's location choice: $x_E = z$. To solve the model, one has to start from the last period, where two cases are possible: the market is either a monopoly or a Cournot duopoly. Moreover, thanks to our constant marginal production cost assumption, each local market can be analyzed independently.

If at the end of the game I holds a monopoly position, then basic computations for profit maximization show that at each local market x on the unit segment, the incumbent I produces an output of $q_I^m(x) = \frac{a-\left|\frac{1}{2}-x\right|}{2}$ and makes a profit of $\pi_I^m(x) = \left(\frac{a-\left|\frac{1}{2}-x\right|}{2}\right)^2$.

If, on the contrary, a duopoly obtains at the end of the second stage, then at each local market $x \in [0, 1]$ each firm $i, j \in \{I, E\}$ maximizes its profit $\pi_i(q_i(x), q_j(x); x) =$

[12]We focus here on predatory conduct through output choice, not location choice. We discuss the possible location choice of the incumbent in the final section.

[13]We follow Benoit (1984) for the timing of the game that we adopt here.

[14]Thus we study the situation which is hardest for predation/etry deterrence entry to occur. If, despite the absence of entry cost, predatory conduct is credible, then it is necessarily so with some positive entry cost.

$(a - |x_i - x| - q_i(x) - q_j(x)) \times q_i(x)$. Solving for the Cournot duopoly outcome, and replacing $x_I = 1/2$ and $x_E = z$, one obtains at each local market x the following duopoly outputs and profits for the incumbent and the entrant respectively: $q_I^d(x) = \frac{a-2\left|\frac{1}{2}-x\right|+|z-x|}{3}$, $q_E^d(x) = \frac{a-2|z-x|+\left|\frac{1}{2}-x\right|}{3}$, $\pi_I^d(x) = \left(\frac{a-2\left|\frac{1}{2}-x\right|+|z-x|}{3}\right)^2$, and $\pi_E^d(x) = \left(\frac{a-2|z-x|+\left|\frac{1}{2}-x\right|}{3}\right)^2$.

One can now write the gain from predation G as the difference between the profit of I as a monopoly (Π_I^m) and the profit it makes when it competes with E (denoted Π_I^d):

$$G = \Pi_I^m - \Pi_I^d = \int_0^1 \pi_I^m(x)dx - \int_0^1 \pi_I^d(x)dx = 2\int_0^{\frac{1}{2}} \left(\frac{a-(\frac{1}{2}-x)}{2}\right)^2 dx$$
$$- \left(\int_0^z \left(\frac{a-2\left(\frac{1}{2}-x\right)+(z-x)}{3}\right)^2 dx + \int_z^{\frac{1}{2}} \left(\frac{a-2\left(\frac{1}{2}-x\right)+(x-z)}{3}\right)^2 dx + \int_{\frac{1}{2}}^1 \left(\frac{a-2\left(x-\frac{1}{2}\right)+(x-z)}{3}\right)^2 dx\right)$$
$$= \left(-\frac{1}{432}\right)\left(54a - 96az - 60a^2 - 48z^2 + 64z^3 + 96az^2 - 1\right).$$

Consider now stage 1, where firm I either accommodates entry or engages in predatory conduct to keep E out of the market. If the incumbent accommodates entry, its profit is given by the Cournot duopoly profit computed above (Π_I^d). We are thus left to compute its profit when it engages in predatory conduct. Denote Π_I^p this profit, *i.e.* obtained by producing q_I^p at each point x, where q_I^p is such that the entrant's best reply is to produce zero[15]. Explicitly, at each local market x, the best reply function for the entrant writes: $BR_E^d(x) = \frac{a-q_I(x)-|z-x|}{2}$. Thus q_I^p solves for $BR_E^d(x) = 0$, and therefore $q_I^p(x) = a - |z-x|$. Turning now to the profit made by the incumbent while producing this predatory output at each local market, it writes[16]: $\pi_I^p(x) = (a - q_I^p(x) - |x_I - x|) \times q_I^p(x) = \left(|z-x| - \left|\frac{1}{2}-x\right|\right)(a - |z-x|)$.

Defining the loss from predation L as the profit difference between the incumbent's duopoly profit and the one it makes when it effectively predates, one can write L as follows:

$$L = \Pi_I^d - \Pi_I^p = \int_0^1 \pi_I^d(x)dx - \int_0^1 \pi_I^p(x)dx = \int_0^1 \left(\frac{a-2\left|\frac{1}{2}-x\right|+|z-x|}{3}\right)^2 dx$$
$$- \int_0^1 \left(|z-x| - \left|\frac{1}{2}-x\right|\right)(a - |z-x|)\,dx$$
$$= \left(\int_0^z \left(\frac{a-2\left(\frac{1}{2}-x\right)+(z-x)}{3}\right)^2 dx + \int_z^{\frac{1}{2}} \left(\frac{a-2\left(\frac{1}{2}-x\right)+(x-z)}{3}\right)^2 dx + \int_{\frac{1}{2}}^1 \left(\frac{a-2\left(x-\frac{1}{2}\right)+(x-z)}{3}\right)^2 dx\right)$$
$$- \left(\begin{array}{c} \int_0^z \left((z-x) - (\frac{1}{2}-x)\right)(a-(z-x))\,dx \\ + \int_z^{\frac{1}{2}} \left((x-z) - (\frac{1}{2}-x)\right)(a-(x-z))\,dx + \int_{1/2}^1 \left((x-z) - (x-\frac{1}{2})\right)(a-(x-z))\,dx \end{array}\right)$$
$$= \frac{1}{216}\left(168az - 162z - 54a + 24a^2 + 84z^2 + 104z^3 - 168az^2 + 49\right).$$

Predation occurs when the long-term gain from maintaining the monopoly position outweighs the short-term loss of engaging in predation. Thus the incentive to block entry is

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[15] Equivalently, the entrant's profit is zero, since under linear spatial Cournot competition profits are proportional to quantities.

[16] This value may be negative, and our computations show it is, since typically predatory conduct involves the incumbent incuring losses to keep the entrant out of the market.

equal to $P = \delta G - L = \left(-\frac{1}{432}\right)\begin{pmatrix} 336az - 324z - \delta - 108a + 54a\delta - 96az\delta + 48a^2 + 168z^2 \\ +208z^3 - 336az^2 - 60a^2\delta - 48z^2\delta + 64z^3\delta + 96az^2\delta + 98 \end{pmatrix}$, where $\delta \in [0,1]$ is the discount factor. Predation is deemed credible if $P \geq 0$, otherwise it fails[17]. In other words, predatory conduct occurs when the future discounted gain from maintaining its market share by deterring the rival's entry outweighs the current loss incurred due to the production of a supra-optimal output. Note that adding more periods for the game (*i.e.* a string of discounted gains for several periods after the one where the predatory conduct occurs) does not change the results, as the gain from predation is a future gain, whereas the loss is a current loss. In other terms, if the incumbent finds it profitable to predate, it does so as soon as possible, from the very beginning[18]. Therefore, and as implied by Benoit's (1984) model, in equilibrium the predatory behavior does not occur if predation is credible.

To finish solving the game, one has now to consider the E's location decision at stage 1. If E anticipates $P \geq 0$, it will stay out, otherwise it will enter and start production. Therefore we are left to identify the optimal entry location of E when it anticipates a positive, duopoly profit, and check under which conditions this is conducive to $P < 0$ (the threat of predation fails for this location). Since E's duopoly profit writes $\Pi_E^d = \int_0^1 \left(\frac{a+\left|\frac{1}{2}-x\right|-2|z-x|}{3}\right)^2 dx = \int_0^z \left(\frac{a+(\frac{1}{2}-x)-2(z-x)}{3}\right)^2 dx + \int_z^{1/2} \left(\frac{a+(\frac{1}{2}-x)-2(x-z)}{3}\right)^2 dx + \int_{\frac{1}{2}}^1 \left(\frac{a+\left(x-\frac{1}{2}\right)-2(x-z)}{3}\right)^2 dx$

$= \frac{1}{108}\left(48az - 36z - 18a + 12a^2 + 24z^2 + 16z^3 - 48az^2 + 11\right)$, the FOC w.r.t. z yields $\frac{1}{9}(2z-1)(2z-4a+3) = 0$. Thus the optimal entry location for E, satisfying the SOC, is $\widetilde{z} = 1/2$. Finally, the value of the predation incentive P for $\widetilde{z} = 1/2$ is given by $\frac{1}{432}\left(12a^2 - 6a + 1\right)(5\delta - 4)$, therefore predation is credible for $\delta \geq \widetilde{\delta} = 0.8$.

[17] It is straightforward to check that the condition under which the incumbent will adopt the predatory behavior, $P = \delta G - L > 0$, is in fact equivalent to $\Pi_I^p + \delta \Pi_I^m > \Pi_I^d(1+\delta)$. The latter is simply the credibility of predation in Benoit's (1984) model.

[18] To see this, and following the proof provided in Motta (2004), chapter 7, consider the $T+K$ -period game: firm E can fight predation for K periods, whereas I can survive the price war T more periods. Once E exits, there can be no re-entry. At $T+1$, if E has always been fought, it will go banckrupt and therefore will exit, whereas I will get monopoly profit forever: $\Pi_I^m + \sum_{j=1}^{K-1} \delta^j \Pi_I^m$. Otherwise, predation in this period by I would not be credible, since by accommodationg, it would get $\Pi_I^d + \sum_{j=1}^{K-1} \delta^j \Pi_I^d > \Pi_I^p + \sum_{j=1}^{K-1} \delta^j \Pi_I^m$ (E would anticipate it, and both firms would earn Π_I^d forever). At T, if E is still on the market despite always having been fought, I knows it will make it exit by fighting one more time if $\Pi_I^p + \sum_{j=1}^{K} \delta^j \Pi_I^m > \Pi_I^d + \sum_{j=1}^{K} \delta^j \Pi_I^d$. Anticipating this, E would rather exit immediately. At $T-1$, I knows that by predating one more period it will induce exit in the next period, with a payoff of $\Pi_I^p + \sum_{j=1}^{K+1} \delta^j \Pi_I^m$, whereas by accommodating it will get $\Pi_I^d + \sum_{j=1}^{K+1} \delta^j \Pi_I^d$. If I chooses predation in this period, E optimally chooses to exit, to save the losses caused by a period of fighting. The argument goes on backwards to the very first period, where E prefers to exit instantly, i.e. not enter rather than incur any losses.

Result 1: *On the linear market, the Cournot potential entrant optimally chooses to share the same location as the incumbent (the middle of the segment). This location prevents predation iff the discount factor is low enough.*

We thus obtain that predatory conduct is successful for a high enough discount factor, despite the optimal location chosen by the entrant[19]. Instead, for lower values of the discount factor (indicating that the incumbent values the future gains from predation relatively less than the current loss it incurs), the predatory threat fails and entry is viable. Thus the market becomes a duopoly with both firms sharing the preferred location on the unit segment, its middle point.

In what follows, we extend our results by looking into the circular market case.

2.2. The circular market

At the initial spatial equilibrium, the incumbent may locate at any given point on the unit circle. Let us then arbitrarily denote it 0/1. Again, we analyze each local market on the circle separately, thanks to the constant marginal production cost assumption.

If the second stage competition yields a monopoly for I, then profit maximization at each local market x on the unit circle yields an output of $q_I^m(x) = \frac{a-|x|}{2}$ with a corresponding monopoly profit of $\pi_I^m(x) = \left(\frac{a-|x|}{2}\right)^2$. If, instead, the Cournot duopoly game takes place, then by using the Cournot expressions previously obtained, one obtains the following duopoly outputs and profits for the incumbent and the entrant respectively, provided one lets $x_I = 0$, $x_E = z$ with $z \in [0, 1/2]$: $q_I^d(x) = \frac{a-2|x|+|z-x|}{3}$, $q_E^d(x) = \frac{a-2|z-x|+|x|}{3}$, $\pi_I^d(x) = \left(\frac{a-2|x|+|z-x|}{3}\right)^2$, and $\pi_E^d(x) = \left(\frac{a-2|z-x|+|x|}{3}\right)^2$. Following the same definition as before, we can now write the gain G from predatory conduct as follows:

$$G = \Pi_I^m - \Pi_I^d = \int_0^1 \pi_I^m(x)dx - \int_0^1 \pi_I^d(x)dx = \left(\int_0^{1/2} \left(\frac{a-x}{2}\right)^2 dx + \int_{1/2}^1 \left(\frac{a-(1-x)}{2}\right)^2 dx\right)$$
$$- \left(\begin{array}{c} \int_0^z \left(\frac{a-2x+(z-x)}{3}\right)^2 dx + \int_z^{1/2} \left(\frac{a-2x+(x-z)}{3}\right)^2 dx \\ + \int_{1/2}^{z+1/2} \left(\frac{a-2(1-x)+(x-z)}{3}\right)^2 dx + \int_{z+\frac{1}{2}}^1 \left(\frac{a-2(1-x)+(1-x+z)}{3}\right)^2 dx \end{array}\right)$$
$$= \frac{1}{432}\left(60a^2 - 30a - 96z^2 + 128z^3 + 5\right).$$

Going back to the first stage, where the incumbent decides whether to deter entry or not, we compute the loss incurred from this action. This is, as before, given by the difference between the incumbent's duopoly profit Π_I^d and the profit it makes when it actively keeps the entrant out of the market (denoted Π_I^p), *i.e.* by producing q_I^p at each point x, where q_I^p is such that the entrant's best reply is to produce zero. Using the same computations as in the exposition of the linear case, but replacing $x_I = 0$, one obtains

[19] Due to the border effect on the linear market, implying that the quantity-median is unique for all firms, the mid-segment point, it is easy to check that this location choice also minimizes the incentive to prey P for any $a \geq 2$ and $\delta \in [0, 1]$.

that $\pi_I^p(x) = (|z-x| - |x|)(a - |z-x|)$ at each local market x. Therefore, the loss L from predation now amounts to: $L = \Pi_I^d - \Pi_I^p = \int_0^1 \pi_I^d(x)dx - \int_0^1 \pi_I^p(x)dx$

$$= \left(\begin{array}{c} \int_0^z \left(\frac{a-2x+(z-x)}{3}\right)^2 dx + \int_z^{1/2} \left(\frac{a-2x+(x-z)}{3}\right)^2 dx \\ + \int_{1/2}^{z+1/2} \left(\frac{a-2(1-x)+(x-z)}{3}\right)^2 dx + \int_{z+\frac{1}{2}}^1 \left(\frac{a-2(1-x)+(1-x+z)}{3}\right)^2 dx \end{array} \right)$$
$$- \left(\begin{array}{c} \int_0^z ((z-x)-x)(a-(z-x))\, dx + \int_z^{1/2} ((x-z)-x)(a-(x-z))\, dx \\ + \int_{1/2}^{z+1/2} ((x-z)-(1-x))(a-(x-z))\, dx \\ + \int_{z+\frac{1}{2}}^1 ((1-x+z)-(1-x))(a-(1-x+z))\, dx \end{array} \right)$$
$$= \left(-\tfrac{1}{108}\right)(6a - 12a^2 - 78z^2 + 104z^3 - 1).$$

The incentive to prey writes therefore $P = \delta G - L$
$= \frac{1}{432}(24a + 5\delta - 30a\delta - 48a^2 - 312z^2 + 416z^3 + 60a^2\delta - 96z^2\delta + 128z^3\delta - 4)$.

Finally, and as before, it remains to identify the entrant's optimal location choice when/if it anticipates a positive, Cournot duopoly profit, and to check whether the resulting value function for P, the predation incentive, is positive or negative. The entrant's profit in case of duopoly is $\Pi_E^d = \int_0^z \left(\frac{a+x-2(z-x)}{3}\right)^2 dx + \int_z^{1/2} \left(\frac{a+x-2(x-z)}{3}\right)^2 dx + \int_{1/2}^{z+1/2} \left(\frac{a+(1-x)-2(x-z)}{3}\right)^2 dx + \int_{z+\frac{1}{2}}^1 \left(\frac{a+(1-x)-2(1-x+z)}{3}\right)^2 dx$
$= \left(-\frac{1}{108}\right)(6a - 12a^2 - 24z^2 + 32z^3 - 1)$, therefore the FOC writes $\left(-\frac{4}{9}\right) z(2z-1) = 0$ and thus the optimal entry location, satisfying the SOC, is $\widehat{z} = 1/2$. Evaluating the value of the predation incentive for this optimal choice made by the potential entrant yields $P(\ z = \frac{1}{2}) = \frac{1}{144}(8a - \delta - 10a\delta - 16a^2 + 20a^2\delta - 10)$, therefore predation is credible for $\delta \geq \widehat{\delta}(a) = \frac{(16a^2 - 8a + 10)}{20a^2 - 10a - 1}$.

Result 2: *On the circular market, the Cournot potential entrant chooses to locate diametrically opposite to the incumbent. This location choice enables entry (i.e. predation fails) if the discount factor is low enough. However, the cut-off value for the discount factor is always higher than for the linear market, and depends on the size of demand.*

From a qualitative point of view, we confirm the result obtained on the linear market: for a high enough discount factor, the predatory conduct is successful, despite the optimal location chosen by the entrant. Otherwise, *i.e.* for lower values of the critical discount factor identified, the predatory threat fails and entry takes place at the location diametrically opposite to that of the incumbent.

Finally, concerning the value of the discount factor threshold that makes predation credible or not, note that as compared with the linear case, this threshold now depends on the demand size a. Straightforward computations show that $\widehat{\delta}$ is decreasing in a, with $\widehat{\delta}(2) = 0.98305$ and $\widehat{\delta}(a \to \infty) = 0.8 = \widetilde{\delta}$. Thus, predatory conduct is relatively less credible on the circular than on the linear market, since $\widehat{\delta}(a) \geq \widetilde{\delta}$, $\forall a \geq 2$.

This is quite intuitive, and consistent with the properties of the spatial equilibria on the linear and circular markets respectively. In case of entry, both firms share the same location on the segment, but are diametrically opposite on the circle (since the quantity-median is not unique, but double in this latter case). As a result, duopoly profits are lower on the segment than on the circle (equivalently, the spatial homogeneity of the circular market softens the rivalry between firms)[20], so the gain from deterring entry is higher on the linear than on the circular market. On the one hand, the predatory conduct is less costly on the segment than on the circle[21]. The bottom line is that predatory conduct is more credible on the linear rather than on the circular market.

Finally, we provide an intuition for the discount factor threshold being decreasing in demand size on the circular market (but not on the linear one). In the spatial Cournot model that we use, quantities (and thus profits) are decreasing with the delivery cost but increasing with the demand size. In other words, a firm's market share (or delivered output) is lower at further away locations than at closer ones. Potential entry means loss of market shares, but how much the incumbent loses to the entrant at each local market also depends on the entrant's location. On the linear market, if entry occurs, the entrant will share the same location as the incumbent, therefore the latter's loss at each local market, however far away toward the segment's border, is always 50% of demand at that point. Thus the incentive to protect its own market shares through predatory conduct does not depend on demand size[22], nor on distance. In turn, entry on the circular market will lead to the maximum dispersion spatial pattern. As a result, the market share loss from entry is the highest at the entrant's location, which is the furthest away possible from the incumbent's. More importantly, the larger the demand, the higher this loss in absolute terms. Therefore, the lower the demand at each local market, the lower the quantity delivered at more remote locations, and thus the lower the loss perceived in case of entry. To sum up, the fact that entry occurs at the location least served by the incumbent makes the credibility of predatory conduct dependant on the size of the demand: the higher the demand, the more important it is to keep it captive, and thus the more credible the predation.

3. Concluding remarks

Our purpose in this paper was to check whether predation, or rather entry deterrence, is credible or not, in a context of optimal location choice for the new entrant. Based on Benoit's (1984) predation framework combined with the linear spatial Cournot model, often used in the theoretical literature on strategic location choices, we find that predation

[20] The duopoly profit on the segment market equals $\frac{1}{108}\left(48az - 36z - 18a + 12a^2 + 24z^2 + 16z^3 - 48az^2 + 11\right)$, whereas on the circle market it is given by $\left(-\frac{1}{108}\right)\left(6a - 12a^2 - 24z^2 + 32z^3 - 1\right)$. Their difference is increasing in $z \in [0, 1/2]$, and equals $-\frac{1}{54}$ for $z = 1/2$ (the optimal entrant location).

[21] The profit loss from predation at stage 1 is $\left(-\frac{1}{24}\right)(2z-1)^2(2z - 6a + 5)$ on the segment, which equals 0 for $z = 1/2$, whereas it amounts to $\frac{1}{6}z^2(4z-3)$ on the circle, which equals $-1/24$ for $z = 1/2$.

[22] Recall that a is actually the transport-cost adjusted reservation price.

is a credible threat, both on the linear and the circular unit markets, provided the incumbent values enough the future gain from maintaining its market power. Equivalently, we conclude that on spatial markets, history can matter: if the discount factor is high enough, a monopoly stays a monopoly. We also show that entry is 'easier' or rather predatory conduct is less credible on the circular market as compared with the linear one, due to their intrinsic properties: local markets around the circle are perfectly homogenous, whereas the segment market exhibits a universally preferred location, its middle point. As a consequence, in case of entry with optimal rival location, rivalry is more intense on the segment rather than on the circle market, and thus the preservation of monopoly power is relatively more attractive. Finally, we find that the credibility of the predatory conduct is increasing in the transport-cost adjusted reservation price/demand size on the circular market, but does not depend on it on the linear one. Again, this is due to the properties of the spatial equilibria obtaining in case of entry for each type of market respectively.

Two final comments are worthwhile.

Let us first mention the robustness of our results to the incumbent's optimal location choice. Allowing for this would transform our game as follows: first, the incumbent chooses its location. At the second stage the entrant chooses its location. No profits accrue to the firms so far. Production and profit flows start at the third stage, following this Stackelberg-in-locations game, with the incumbent deciding to prey or accommodate and the entrant deciding to start producing or not. At the fourth stage, the incumbent chooses to prey or accommodate, while the entrant chooses to stay on the market or exit. If the predatory conduct is credible, the entrant will not start producing and so it will not choose a location at stage 2. In the Appendix we show that the spatial duopoly equilibrium obtaining in case entry deterrence fails involves central agglomeration of the incumbent and entrant on the segment market, but maximum dispersion on the circle one. In other words, the spatial equilibria obtained on the segment and circle markets for the 'standard' simultaneous-location-then-simultaneous-quantity game (see Anderson and Neven (1991) and Pal (1998)) are robust to the assumption of sequential entry with entry deterrence behavior on behalf of the incumbent.

Finally, we can relate our analysis to those dealing with the alternative way to monopolize a market, *i.e.* through horizontal merger. The theoretical literature dealing with the issue of profitability of Cournot horizontal mergers with optimal location choices on spatial markets such as the unit line or circle[23] (the very same framework as ours, actually) shows that market concentration is less profitable on the circular than on the linear market. Thus, the circular market appears harder to monopolize through the acquisition of rivals, and this is the same conclusion that we reach starting from the opposite point of view, that of rival entry deterrence.

[23] See Norman and Pepall (2000) and Cosnita (2005).

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Appendix

In order to solve the Stackelberg-in-locations part of the game, we start from the outcome of solving backwards the last two production stages, which is either a Cournot duopoly, if the incumbent chose to accomodate, or a predation stage followed by the return to monopoly, if the incumbent deterred entry. Thus the entrant will make a location choice only in case of a subsequent duopoly (*i.e.* if entry is accommodated). Let $x_I = y$ and $x_E = z$, and let us solve below the Stackelberg-in-locations part of the game.

Segment market:

The entrant's profit writes

$$\Pi_E^d(x) = \int_0^y \left(\frac{a+(y-x)-2(z-x)}{3}\right)^2 dx + \int_y^z \left(\frac{a+(x-y)-2(z-x)}{3}\right)^2 dx + \int_z^1 \left(\frac{a+(x-y)-2(x-z)}{3}\right)^2 dx$$

$$= \left(-\frac{1}{27}\right)\begin{pmatrix} 3a-3y+6z+6ay-12az+12yz-3a^2-3y^2-4y^3 \\ -12z^2+4z^3-6ay^2+12az^2-12yz^2+12y^2z-1 \end{pmatrix}.$$

The FOC and SOC yield respectively $\left(-\frac{2}{9}\right)(2y-2a-4z+4az-4yz+2y^2+2z^2+1) = 0$ and $\left(-\frac{8}{9}\right)(a-y+z-1) \leq 0$.

The entrant's best reply location to the one chosen by the incumbent at the first stage writes $BR_E^{seg}(y) = y - a + \frac{1}{2}\sqrt{2}\sqrt{2y-2a-4ay+2a^2+1}+1$.

For the incumbent's first stage optimal location one has to plug $z = BR_E^{seg}(y)$ into

$$\Pi_I^d(x) = \int_0^y \left(\frac{a-2(y-x)+(z-x)}{3}\right)^2 dx + \int_y^z \left(\frac{a-2(x-y)+(z-x)}{3}\right)^2 dx + \int_z^1 \left(\frac{a-2(x-y)+(x-z)}{3}\right)^2 dx$$

$$= \left(-\frac{1}{27}\right)\begin{pmatrix} 3a+6y-3z-12ay+6az+12yz-3a^2-12y^2 \\ -4y^3-3z^2+4z^3+12ay^2-6az^2-12yz^2+12y^2z-1 \end{pmatrix}.$$

One can check that 1/2 maximizes the resulting profit expression, and moreoever, $BR_E^{seg}(y=1/2) = 1/2$, q.e.d.

Circle market:

The entrant's profit now writes

$$\Pi_E^d(x) = \int_0^y \left(\frac{a+(y-x)-2(z-x)}{3}\right)^2 dx + \int_y^z \left(\frac{a+(x-y)-2(z-x)}{3}\right)^2 dx + \int_z^{y+\frac{1}{2}} \left(\frac{a+(x-y)-2(x-z)}{3}\right)^2 dx + \int_{y+\frac{1}{2}}^{z+\frac{1}{2}} \left(\frac{a+(1-x+y)-2(x-z)}{3}\right)^2 dx + \int_{z+\frac{1}{2}}^1 \left(\frac{a+(1-x+y)-2(1-x+z)}{3}\right)^2 dx$$

$$= \left(-\frac{1}{108}\right)\begin{pmatrix} 6a+48yz-12a^2-24y^2-32y^3 \\ -24z^2+32z^3-96yz^2+96y^2z-1 \end{pmatrix},$$

with the FOC and SOC respectively yielding $48(2z-2y-1)(z-y) = 0$ and $\left(-\frac{4}{9}\right)(4z-4y-1) \leq 0$.

The entrant's best reply location to the chosen by the incumbent at the first stage writes $BR_E^{circ}(y) = y + \frac{1}{2}$.

So whatever the incumbent's optimal location choice at the first stage, the entrant will choose the diametrically opposite location when it anticipates that entry will be accommodated, q.e.d.