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Entry under an information-gathering monopoly

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Abstract

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Keywords: Entry Deterrence; Information-Gathering; Asymmetric Information; Credible Communication

JEL classification: C72, D82, L10, L12

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1. Introduction

Information is an important resource for a firm, as much as material, financial and human resources are, because information can make the difference between success and failure. An important part of this information is relative to other firms (competitors, incumbent firms, potential entrants, etc.), and it can be about production processes and techniques, costs, efficiency and strength, recipes and formulas, costumer datasets, actions, decisions, plans and strategies, etc.

Competitive intelligence is the ethical and legal process of collecting, analyzing and managing information of strategic value about the industry and competitors. This activity can include reviews of newspapers, corporate publications and Web sites, patent filings and specialized databases, among others[1]. However, firms do not always obtain this information ethically and legally. The unethical and illegal process of obtaining information from other firms is called "industrial espionage". Although it is often difficult to discern the legality and ethicality of the methods employed by firms to obtain information about other companies[2], over the last few years industrial espionage has become a worrying reality (Solan and Yariv, 2004, Barrachina et al., 2014, Zhang, 2014, Kozlovskaya, 2015).

Beyond ethical considerations, information-gathering activities can have competitive implications that should be considered when defining public policies against them. In this sense, only information-gathering activities that imply higher competition followed by lower prices and higher levels of output that increase economic welfare should be allowed. This restriction is particularly important in markets with barriers to entry.

This paper continues the recent theoretical analysis of the impact of information-gathering activities on entry deterrence, started by papers such as that of Barrachina et al. (2014, 2015) [3]. The first paper analyzed the effect of information-gathering activities when the incumbent can expand capacity to deter entry. In particular, the entrant operates an information-gathering technology, of a certain precision, to obtain noisy information about the decision made by the incumbent. The paper found that the entrant is more likely to enter the market only when the precision of the information-gathering technology is the private information of its owner, the entrant. The second paper extended the limit pricing model studied by Milgrom and Roberts (1982) including information-gathering activities conducted by the potential entrant attempting to obtain information about the monopoly's cost structure, which is private information. The information-gathering technology operated by the entrant is of the same nature as that considered in Barrachina et al. (2014), but in this case the information that the entrant is attempting to obtain is not about the decision of the monopoly but about her private knowledge. These authors only considered cases in which the precision of the information-gathering technology is common knowledge, and they founnd that these information-gathering activities cause the entrant to become more likely to enter the market in a pooling equilibrium. However, the present paper makes an "*information-gathering turn*" and, contrary to the last two papers, assumes that it is the monopoly (not the potential entrant) that who gathers information about the entrant to consider the effectiveness of this information-gathering activity as an entry deterrence strategy. Nevertheless, the information-gathering technology considered is the same as that in Barrachina et al. (2014, 2015), and as in Barrachina et al. (2015) the owner of the information-gathering technology is attempting to obtain information about the private knowledge of her opponent.

The base model considered in the present paper is a classical entry deterrence model by predation, which assumes that a monopoly incumbent attempts to deter potential entry considering the option of battling the potential entrant (Wilson, 1992). Although it is plausible to assume that the entrant's level of strength is not known by the monopoly, under symmetric information, the monopoly only would fight against a weak entrant, deterring his market entry. In this sense, to inform a potential entrant credibly that his level of strength is known, it can be considered as another monopoly's entry deterrence strategy in this context, complementary to the fighting decision. However, some questions arise. Must the precision of this knowledge be perfect to deter a weak entrant from entering the market (given that perfect precision might

[1] Nasheri (2005). Although these activities are usually carried out by market research firms, many companies have their own competitive intelligence staffs (see Billand et al., 2009, and Barrachina et al., 2014).

[2] Crane (2005) is an interesting study of three cases in which competitive intelligence becomes industrial espionage. Perhaps the most curious case is Procter & Gamble attempting to obtain more information about Unilever by hunting through its garbage bins.

[3] These two papers, like most of those considered later, directly called these information-gathering activities espionage without considering the difference between espionage and competitive intelligence.

be very difficult or costly to achieve)? Might there be some precision of this knowledge that would cause a weak entrant to become more likely to enter the market?

The present paper attempts to answer these questions extending this entry game with asymmetric information (only the entrant knows his level of strength) to include information-gathering activities conducted by the monopoly incumbent. To simplify and avoid the possible strategic behavior of an independent information-gathering agent (Ho, 2008), such as a market research firm, it is assumed that the monopoly operates a costless Intelligence System (IS) to detect the entrant's level of strength[4]. This IS, similar to that considered by Solan and Yariv (2004) and Barrachina et al. (2014, 2015), sends out one of two signals. One signal, labeled s, indicates that the entrant is strong, and another signal, labeled w, indicates the opposite (that the entrant is weak). The IS has a precision, meaning that the signal sent by the IS will be correct with a probability equal to this IS precision. If the entrant decides to enter the market, the IS sends a signal to the monopoly that must compete with the entrant and, based on the signal received, decide whether (or with what probability) to accommodate or to fight.

Given that this paper attempts to analyze the effect of the monopoly's action of credibly informing the entrant how accurate her knowledge is about his level of strength (in particular, its possible effectiveness as an entry deterrence strategy), it is assumed that the precision of the IS is known not only by its owner, the monopoly, but also by the potential entrant (more precisely, it is common knowledge). To simplify the analysis, it is assumed that, if the entrant is strong, he is always willing to enter the market regardless of the later decision of the monopoly.

Consider first the benchmark case in which the monopoly performs no information-gathering activity (which is known by the potential entrant). In this case, the weak type entrant does not hesitate between entering the market or not (and enters for sure) only if the monopoly is not sure about the entrant's level of strength, or she considers the likely entrant to be strong; otherwise, he assigns some positive probability to stay out. If the monopoly is not sure about the entrant's level of strength, she will hesitate between fighting and accommodating if she observes a market entry, but a weak entrant will only feel comfortable entering the market if the monopoly assigns a relatively low probability to fighting. If the monopoly believes that the entrant is strong, she will choose to accommodate if she observes a market entry, even if the entrant is actually weak, attempting to avoid the negative outcome of fighting against a strong entrant; a weak entrant would exploit this situation and would certainly enter the market. However, if the monopoly considers the entrant likely to be weak, she will feel more comfortable fighting if she observes a market entry, and a weak entrant will hesitate between entering the market or not. Regardless of the monopoly's prior belief, a weak entrant is never sufficiently convinced to stay out because, in that case, the monopoly would accommodate when observing a market entry.

Next, the information-gathering case is analyzed. If the monopoly considers it likely that the entrant is weak, the weak entrant will assign a relatively high probability (higher than when there is no information-gathering activity) to entering if the precision of the IS is sufficiently small for him to consider that, if he finally enters the market, the IS is likely to send the wrong signal and confuse the monopoly. The higher the precision of the IS is, the more the weak entrant will want to enter the market because, on the one hand, the monopoly trusts more the signal sent by the IS (it is more accurate), and he can assign a higher probability to entering without making the monopoly sufficiently sure of not trusting the signal s and fighting the entrant; and, on the other hand, the precision of the IS is sufficiently small for the weak entrant to consider himself not likely to be detected. If the precision of the IS is sufficiently high, the weak type entrant considers himself likely enough to be detected if he finally enters the market and he assigns a relatively low probability to entering (smaller than when there is no information-gathering activity), which decreases with the precision of the IS.

However, the last scenario is only true when the weak entrant's payoff of entering the market and competing with the monopoly is sufficiently high. Otherwise, he does not feel sufficiently comfortable to enter the market and assigs not only a small probability to entering the market regardless of the precision of the IS but also a smaller probability the more accurate the IS is.

If the monopoly is not sure about the entrant's level of strength or considers it likely that he is strong, relatively inaccurate precision of the IS makes no difference on the weak entrant's decision of entering the market because he considers it likely that the IS will confuse the monopoly, or the monopoly does not trust the IS. However, for relatively accurate precision of the IS, the weak entrant considers that he is likely enough to be detected if he finally enters the market and assigns a relatively low (and decreasing with the precision of the IS) probability to enter. This outcome is true regardless of the weak entrant's payoff of entering the market, only when the monopoly considers it likely that the entrant is strong. If the

[4] The analysis of the case in which costly precision of the IS is endogenously chosen by the monopoly is straightforward once the equilibrium of the case in which exogenous precision is analyzed.

monopoly is not sure about the level of strength of the entrant, she trusts more the signal sent by the IS, and when the weak entrant's payoff of competing with the monopoly is sufficiently low, he is discouraged from entering the market regardless of how accurate the information-gathering activity undertaken by the monopoly is.

It is important to note that, for every possible monopoly's prior belief about the level of strength of the entrant, the higher the weak entrant's payoff is for competing with the monopoly, the more comfortable he feels about entering the market, and the more accurate the IS must be to discourage him from entering. When this payoff is considerably high, only an almost perfect IS could deter him from entering the market.

Therefore, in the context of a monopoly conducting information-gathering activities about a potential entrant's level of strength to better decide whether to battle him or not, the monopoly's action of credibly informing the entrant how accurate the information she obtained is has an entry deterrence effect if this precision is relatively accurate (but not necessarily perfect) or if the entrant's payoff from competing with the monopoly is sufficiently small. Although relatively inaccurate precision could have either no effect or a procompetitive effect, the monopoly would never choose an information-gathering precision with these effects. Hence, it would be recommendable for a public policy seeking increasing competition in such a market not to allow the monopoly to conduct information-gathering activities about potential entrants' level of strength unless their payoff from entering the market was considerably high. In this case, only almost perfect knowledge of their level of strength, which would be very difficult or costly to obtain for the monopoly, would discourage potential entrants from entering the market.

As stated above, the paper is related to Barrachina et al. (2014, 2015) and, consequently, to the papers they cited that theoretically analyzed information-gathering activities in general or in an economic context. Moreover, this paper is related to Begg and Imperato (2001), which analyzed an information-gathering monopoly (as in this paper) that attempted to learn more about uncertain market demand. More recent developments in the theoretical analysis of information-gathering activities (not only in an economic context) have included Zhang (2014), Kozlovskaya (2015) and Grabiszewski and Minor (2016). Zhang (2014) analyzed information-gathering activities in one-sided contests with private information. More precisely, as in the present paper, a player conducts information-gathering activities, attempting to obtain rival's private knowledge. In particular, although Zhang's (2014) particular framework was not restricted to an economic context, it could be adapted to analyze cases in which a firm attempts to learn more about another firm's strength, as in the present paper, but not in a market entry context. Kozlovskaya (2015) studied a duopoly market in which each competitor conducts information-gathering activities, attempting to obtain its rival's private information about market demand. Although the object of the information-gathering activities in Kozlovskaya (2015) is of the same nature as in the present paper (the rival's private information) and both papers consider noisy information-gathering technology, their set-ups were different. Finally, Grabiszewski and Minor (2016) analyzed the effectiveness of counterespionage policies considering the interaction between a domestic firm and a foreign firm, in which the former decides to attempt to obtain an innovation, and the latter decides on an information-gathering effort, attempting to copy this innovation and to compete with the former in its commercialization. The information-gathering technology is costly (a counterespionage policy is interpreted as an increase in this cost) but not noisy, and its precision is not observed by the domestic firm.

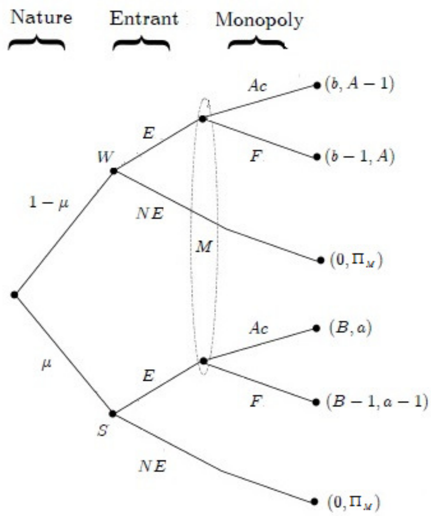
The remainder of the paper is organized as follows. Section 2 establishes the model. Section 3 analyzes the case without information-gathering (*benchmark case*), and Section 4 analyzes the information-gathering case. The effects of information-gathering activities over market entry are analyzed in Section 5, and Section 6 concludes the paper.

2. The Model

In the basic model (called the *benchmark case*), a monopoly incumbent M and a potential entrant EN are considered. The monopoly faces the potential entry without knowing with certainty whether the entrant is weak or strong. She assigns probability μ that the entrant is strong (and $1-\mu$ that he is weak). If the entrant decides not to enter (NE), he obtains zero and the monopoly obtains the monopoly profit (Π_M). However, if the monopoly observes market entry (namely the entrant chooses E), she must compete with the entrant and decide whether to accommodate (Ac) or fight (F). If the entrant is strong, the monopoly receives a negative payoff if she decides to fight and a positive one if she decides to accommodate. The strong entrant obtains a positive payoff in both cases, but the payoff if the monopoly decides to accommodate is higher. If the entrant is weak, the monopoly obtains a positive payoff

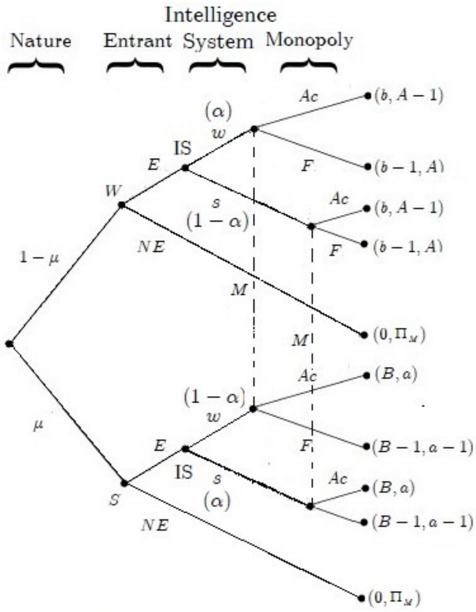
regardless of whether she decides to fight or accommodate, but the payoff of fighting is higher. The weak entrant obtains a positive payoff only if the monopoly decides to accommodate.
The interaction between M and EN in this benchmark case is described as a two-stage game of incomplete information G, and it is analyzed, following Harsanyi's approach, as a three player game, in which the players are the two types, S (strong) and W (weak), of entrant and the monopoly (see Figure 1, where $0 < a < 1 < A$ and $0 < b < 1 < B$). In the first period, EN chooses between entering the market or not as a function of his type. If he decides not to enter the market, the game ends, but if he enters, the monopoly must compete with him in the second period and decide whether to accommodate or fight.

Figure 1. The game G in extensive form



The situation in which the monopoly has access to an Intelligence System (IS) that allows her to gather (noisy) information about the entrant's level of strength (namely, whether he is strong or weak) is also considered and called the *information-gathering case*. The IS sends one of two signals: the signal s, which indicates that the entrant is strong (in which case he is referred as having the type S), and the signal w, which indicates that the entrant is weak (namely, he is of type W). The precision of the IS is assumed to be (without loss of generality) α, $\frac{1}{2} \le \alpha \le 1$. That is, the signal sent by the IS is correct with probability α (namely $\Pr(s/S) = \Pr(w/W) = \alpha$ and $\Pr(w/S) = \Pr(s/W) = 1-\alpha$). The case in which $\alpha = 1/2$ is equivalent to the case in which the monopoly does not use any IS (namely the benchmark case considered above). The case $\alpha = 1$ is one in which the IS is perfect (the signal sent by the IS is correct with a probability of 1) and the monopoly knows exactly the type of the entrant. It is assumed that the precision of the IS is exogenously given and common knowledge. This IS is exactly the same as that considered by Barrachina et al. (2014, 2015) and as the information devices in Solan and Yariv (2004).
Similar to the benchmark case G, the interaction between M and EN in this information-gathering case is described as a two-stage game of incomplete information $G(\alpha)$. However, if the entrant decides to enter the market in this case, the IS sends one of two signals (s and w) in the second period, and the monopoly must decide, based on the signal received from the IS, whether to accommodate or to fight the entrant (see Figure 2).

Figure 2. The game $G(\alpha)$ in extensive form



The following sections 3 and 4 analyze the equilibrium of G and $G(\alpha)$, respectively.

3. The Benchmark Case with No Information-Gathering Activity ($\alpha = 1/2$)

This section analyzes the equilibrium of G (the benchmark case where $\alpha = 1/2$). The following proposition summarizes the equilibria for the different possible values of μ.

Proposition 1. *Consider the game G for $0 < \mu < 1$. Then,*

(1) if $\mu < \frac{1}{2}$, $\left(E,(\overline{p},1-\overline{p}),(\overline{\beta},1-\overline{\beta})\right)$ (where $\overline{p} = \mu/(1-\mu)$ is the probability assigned by W to enter, and $\overline{\beta} = b$ is the probability assigned by M to fight) is the unique semi-pooling equilibrium of G;

(2) if $\mu = \frac{1}{2}$, G has multiple pooling equilibria of the form $\left(E,E,(\beta,1-\beta)\right)$, where $0 \le \beta \le \overline{\beta}$; and

(3) if $\mu > \frac{1}{2}$, (E,E,Ac) is the unique pooling equilibrium of G.

Proof: *See Appendix A.*

According to Proposition 1, the S-type entrant always enters the market (in fact, to enter is his dominant strategy because $0 < B-1 < B$) and there is no separating equilibrium (where S decides to enter and W to stay out) regardless of the value of μ. Note that, in a separating equilibrium, the monopoly can detect perfectly the type of the entrant and assigns a probability of one to it being the strong type that enters the market. In this case, the monopoly will choose to accommodate, and the W-type entrant is better off deviating (becasue $b > 0$), thereby upsetting the separating equilibrium.

A pooling equilibrium only is possible when the monopoly is not sure about the entrant's level of strength ($\mu = 1/2$) or when she considers it likely that he is strong ($\mu > 1/2$). If W chooses to enter purely when the monopoly considers it likely that he is weak ($\mu < 1/2$), the monopoly cannot distinguish the type of the entrant, but considering it likely that he is the weak type, she decides to fight and the weak type entrant is better off deviating from NE to E and upsetting the pooling equilibrium. Hence, because the W-type entrant choosing NE purely is not a stable situation either (as explained above), if the monopoly considers that it is likely that the entrant is weak, the weak type entrant always deviates from one pure strategy to another. Hence he hesitates between his two pure strategies and will decide to enter the market with probability $\overline{p}$, causing the monopoly to hesitate between fighting and accommodating (she is indifferent between both). The unique stable situation is the monopoly choosing to fight with probability

$\bar{x} = b$ (note that, if the monopoly assigns a different probability, the weak type entrant would have an incentive to deviate from his mixed strategy to a pure strategy).

If the weak type entrant chooses E when the monopoly has no idea about the entrant's type, namely $\mu = \frac{1}{2}$, the monopoly is indifferent between F and Ac because she considers equally likely both types of entrant, and she hesitates between these two pure strategies. The weak type entrant will not deviate from E to NE, upsetting the pooling equilibrium if the monopoly chooses to fight with a relatively small probability, to compensate for his payoff being negative when the monopoly fights after he enters ($b-1$). More precisely, the monopoly should choose to fight with a probability as maximum equals $\bar{x} = b$.

If the W-type entrant chooses to enter the market with a probability of one when the monopoly considers that it is likely that the entrant is strong, namely $\mu > 1/2$, the monopoly cannot distinguish the type of the entrant, but considering it likely that he is the strong type, she decides to accommodate, and the weak type entrant has no incentive to deviate and does not upset the pooling equilibrium.

Regarding the monopoly, she would choose to fight with probability 1 if she knew that the type of entrant who entered the market is the weak type. However, because the strong type entrant always chooses to enter with a probability of 1 (it is his dominant strategy) and in equilibrium, the weak type entrant never assigns s probability of 1 to not entering (there exists no separating equilibrium), the monopoly never can be sufficiently sure whether the type of entrant is the weak type, and she never chooses to fight with a probability of 1. In addition, the more likely the monopoly considers it that the entrant is strong (the higher μ is) the more the monopoly wants to choose to accommodate (her best response if she knows the entrant is strong), attempting to avoid the negative payoff of fighting against a strong entrant, thus the more the weak type entrant wants to enter to the market (note that the probability that the weak type entrant assigns to entering when $\mu < 1/2$, $\bar{p}$, is increases in μ).

4. The Information-Gathering Case ($\frac{1}{2} < \alpha \leq 1$)

This section extends the previous benchmark case and assumes that the monopoly has access to an Intelligence System (IS) of a certain precision α, where $\frac{1}{2} < \alpha \leq 1$. In particular, the equilibrium of $G(\alpha)$ (the information-gathering case) is analyzed.

Note that, in this case, a pure strategy of M is a pair (x, y), where both x and y are in $\{F, Ac\}$, x is the action of M if she observes the signal s, and y is her action if she observes the signal w. For instance, M's strategy (Ac, F) is to accommodate if she observes the signal s and to fight if she observes the signal w, and her strategy (Ac, Ac) is to accommodate irrespective of the signal sent by the IS.

First, consider the case in which the IS is perfect ($\alpha = 1$). In this case, M can detect perfectly the entrant's type (it would be the complete information case), and it is straightforward to see that the unique equilibrium is (E, NE, Ac, F). Because it is common knowledge that M knows the entrant's type and she will choose her action based on it (Ac if the entrant is strong and F if the entrant is weak), W does not enter the market (S does enter the market because it is his dominant strategy).

The case in which the IS is informative but not perfect, namely $1/2 < \alpha < 1$, is more complicated. Before analyzing the equilibrium of this case, let $\bar{q} = \mu(1-\alpha)/\alpha(1-\mu)$ and $\tilde{q} = \alpha\mu/(1-\alpha)(1-\mu)$ be two threshold probabilities assessing the monopoly's decision of accommodating or fighting when observing the signal sent by the IS. In particular, if she observes the signal w, she will trust it and fight the entrant only if the weak type entrant[5] chooses to enter the market with a probability strictly higher than $\bar{q}$; and if the IS sends the signal s, she will not trust it and fight only if the weak type entrant chooses to enter with a probability strictly higher than $\tilde{q}$. The following lemma summarizes important features of these two threshold probabilities.

[5] Similar to the benchmark case G, E is a dominant strategy for the S-type entrant and (as will be shown by the following propositions), the game has no separating equilibrium regardless of the value of μ. It makes sense because, in a separating equilibrium, the monopoly can identify the type of the entrant and the IS makes no difference.

Lemma. *Consider the threshold probabilities* $\bar{q}$ *and* $\tilde{q}$.

(1) $0<\bar{q}<\tilde{q}$ *for every precision,* α*, of the IS,* $\alpha \in (1/2,1)$*;*

(2) $\bar{q}<1$ *iff* $\alpha>\mu$ *and* $\tilde{q}<1$ *iff* $\alpha<1-\mu$*;*

(3) $\bar{q}$ *decreases with the precision,* α*, of the IS, while* $\tilde{q}$ *increases;*

(4) both $\bar{q}$ *and* $\tilde{q}$ *are convex (relative to* α*); and*

(5) when $\alpha=1/2$, $\bar{q}=\tilde{q}=\mu/(1-\mu)$*; when* $\alpha=1$, $\bar{q}=0$*, and* $\tilde{q}$ *is not well defined (but* $\tilde{q}$ *approaches infinity as* α *approaches 1).*

Proof:

(1) It is straight forward to see that $\bar{q}>0$ and $\tilde{q}>0$ for all $\mu \in (0,1)$ and $\alpha \in (1/2,1)$. It is also easy to see that $\bar{q}<\tilde{q}$ for all $\alpha>1/2$.

(2) $\bar{q}<1$ iff $\mu(1-\alpha)<\alpha(1-\mu)$, which is straight forward to see that it is equivalent to $\alpha>\mu$.

$\tilde{q}<1$ iff $\alpha\mu<(1-\alpha)(1-\mu)$, which is straight forward to see that it is equivalent to $\alpha<1-\mu$.

(3) The first derivative of $\bar{q}$ with respect to α is $\partial\bar{q}/\partial\alpha=-\mu(1-\mu)/(\alpha(1-\mu))^2$, which is negative for all $\alpha \in (1/2,1)$ because $\mu \in (0,1)$.

The first derivative of $\tilde{q}$ with respect to α is $\partial\tilde{q}/\partial\alpha=\mu(1-\mu)/((1-\alpha)(1-\mu))^2$ and it is positive for all $\alpha \in (1/2,1)$.

(4) The second derivative of $\bar{q}$ with respect to α is $\partial^2\bar{q}/\partial\alpha^2=2\mu(1-\mu)^2/(\alpha(1-\mu))^3$ and it is positive for all $\alpha \in (1/2,1)$.

The second derivative of $\tilde{q}$ with respect to α is $\partial^2\tilde{q}/\partial\alpha^2=2\mu(1-\mu)^2/((1-\alpha)(1-\mu))^3$ and it is positive for all $\alpha \in (1/2,1)$.

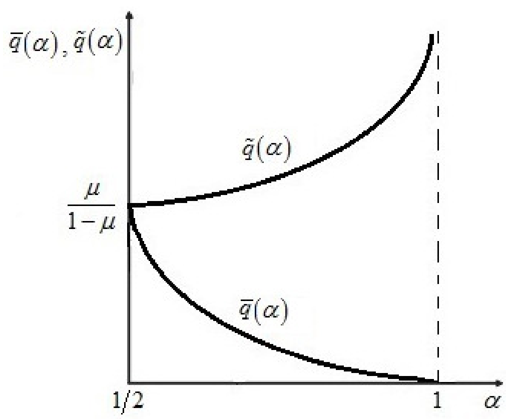
(5) Straight forward.

■

It makes sense that $\bar{q}<\tilde{q}$, as the first part of the Lemma states, because when the IS sends the signal s, the monopoly considers it likely that the entrant is strong and is willing to stand (without fighting) the weak type entrant assigning to enter a higher probability than if she observes the signal w. Regarding the fifth part of the Lemma, note that $\bar{p}=\mu/(1-\mu)$ is the probability that the weak type entrant assigns to entering when $\alpha=1/2$ and $\mu<1/2$ (see first part of Proposition 1).

It is useful to draw these two threshold probabilities as a function of the precision, α, of the IS ($\bar{q}(\alpha)$ and $\tilde{q}(\alpha)$) according to their features in the Lemma. They are drawn in the following figure.

Figure 3. $\bar{q}(\alpha)$ **and** $\tilde{q}(\alpha)$



Next, the equilibrium of $G(\alpha)$ is analyzed. The following propositions summarize the equilibria of $G(\alpha)$ for $1/2<\alpha<1$, accounting for the different possible values of μ. Their proofs appear in Appendix B. The next proposition considers $\mu<1/2$.

Proposition 2. *Consider the game* $G(\alpha)$ *for* $1/2<\alpha<1$ and $\mu<1/2$. *Then,*
(1) when $1/2<\alpha<1-\mu$, *the equilibrium of the game depends on* α *and* b*: if* $\alpha<b$, $\left(E,(\tilde{q},1-\tilde{q}),(\bar{\lambda},1-\bar{\lambda}),F\right)$ *where* $\bar{\lambda}=(b-\alpha)/(1-\alpha)$, *is the unique equilibrium of the game; if* $\alpha=b$, $G(\alpha)$ *has multiple equilibria of the form* $\left(E,(q,1-q),Ac,F\right)$ *where* $\bar{q}\le q\le\tilde{q}$*; and if* $\alpha>b$, $\left(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma})\right)$ *where* $\bar{\gamma}=b/\alpha$, *is the unique equilibrium of the game;*
(2) when $\alpha=1-\mu$, *the equilibrium of the game depends on* b*: if* $b<1-\mu$, $\left(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma})\right)$ *is the unique equilibrium of the game; if* $b=1-\mu$, $G(\alpha)$ *has multiple equilibria of the form* $\left(E,(q,1-q),Ac,F\right)$ *where* $\bar{q}\le q\le 1$*; and if* $b>1-\mu$, $G(\alpha)$ *has multiple equilibria of the form* $\left(E,E,(\lambda,1-\lambda),F\right)$ *where* $0\le\lambda\le\bar{\lambda}$*; and*
(3) when $1-\mu<\alpha<1$, *the equilibrium of the game depends on* α *and* b*: if* $\alpha<b$, $\left(E,E,Ac,F\right)$ *is the unique equilibrium of the game; if* $\alpha=b$, $G(\alpha)$ *has multiple equilibria of the form* $\left(E,(q,1-q),Ac,F\right)$ *where* $\bar{q}\le q\le 1$*; and if* $\alpha>b$, $\left(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma})\right)$ *is the unique equilibrium of the game.*

According to Proposition 2, not only the monopoly's prior belief about the entrant's type (in this case $1-\mu$) but also b, representing the W-type entrant's payoff of entering the market and competing with the monopoly (b if M chooses to accommodate and $b-1$ if she fights), play central roles in the model as a threshold to assess the precision, α, of the IS and therefore the players' choices of actions. For this reason, the following table details the different equilibria of $G(\alpha)$ when $\mu<1/2$ (summarized in Proposition 2 above) for the different values of α ($1/2<\alpha<1$) and b ($0<b<1$).

Table 1. Equilibria of $G(\alpha)$ when $\mu<1/2$

	$0<b\le 1/2$	$1/2<b<1-\mu$	$b=1-\mu$	$1-\mu<b<1$
$1/2<\alpha<1-\mu$	$\left(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma})\right)$	$\left(E,(\tilde{q},1-\tilde{q}),(\bar{\lambda},1-\bar{\lambda}),F\right)$ iff $\alpha<b$ $\left\{\left(E,(q,1-q),Ac,F\right)/\bar{q}\le q\le\tilde{q}\right\}$ iff $\alpha=b$ $\left(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma})\right)$ iff $\alpha>b$	$\left(E,(\tilde{q},1-\tilde{q}),(\bar{\lambda},1-\bar{\lambda}),F\right)$	$\left(E,(\tilde{q},1-\tilde{q}),(\bar{\lambda},1-\bar{\lambda}),F\right)$
$\alpha=1-\mu$	$\left(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma})\right)$	$\left(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma})\right)$	$\left\{\left(E,(q,1-q),Ac,F\right)/\bar{q}\le q\le 1\right\}$	$\left\{\left(E,E,(\lambda,1-\lambda),F\right)/0\le\lambda\le\bar{\lambda}\right\}$
$1-\mu<\alpha<1$	$\left(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma})\right)$	$\left(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma})\right)$	$\left(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma})\right)$	$\left(E,E,Ac,F\right)$ iff $\alpha<b$ $\left\{\left(E,(q,1-q),Ac,F\right)/\bar{q}\le q\le 1\right\}$ iff $\alpha=b$ $\left(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma})\right)$ iff $\alpha>b$

Note that, when the monopoly considers it likely that the entrant is weak ($\mu<1/2$), W only wants to choose to enter with a probability of one (and the pooling equilibrium exists) if the IS is relatively accurate ($\alpha\ge 1-\mu$), so that the monopoly trusts it when it sends the signal s, and she wants to accommodate (note that the monopoly only trusts that signal s if the precision of the IS is relatively accurate because she considers it likely that the entrant is weak), but it is not excessively accurate ($\alpha\le b$) so that W considers it not likely that he will be detected.
Hence, if the weak type entrant chooses to enter when the precision, α, of the IS is relatively small ($1/2<\alpha<1-\mu$), although the monopoly cannot distinguish the type of entrant, the monopoly does not trust the signal s and chooses to fight irrespective of the signal observed. Therefore, the weak type

entrant is better off deviating from E to NE, upsetting the pooling equilibrium. However, the W-type entrant choosing not to enter is not a stable situation either, as stated before. Hence, when the IS is not sufficiently accurate, the weak type entrant always deviates from one pure strategy to another, hesitating between them, and he will assign some positive probability to both.

First, note that there is no semi-pooling equilibrium where the weak type entrant assigns a too low or a too high probability to E (in particular where he chooses E with probability $q < \bar{q}$ or with probability $q > \tilde{q}$, respectively). In the first case, the probability assigned by the weak type entrant to E is sufficiently small for the monopoly to trust the signal s sent by the IS (and to choose Ac) when she observes a market entry (although her prior belief is that it is likely that the entrant's type is weak, $\mu < 1/2$, and the IS is not very accurate) but not sufficiently high enough to trust the signal w and to choose F. Namely, she chooses Ac irrespective of the signal sent by the IS. In this situation, the weak type entrant is better off deviating to E, upsetting the semi-pooling equilibrium. In the second case, the probability assigned by the weak type entrant to E is too high for the monopoly to trust the IS when it sends the signal s, and when the monopoly observes a market entry, she chooses to fight irrespective of the signal sent by the IS. In such a situation, the weak type entrant is better off deviating to NE, again upsetting again the semi-pooling equilibrium.

Therefore, there are three possible semi-pooling equilibria. Consider first the situation in which the weak type entrant assigns a relatively high probability to E (in particular, he chooses E with probability $q = \tilde{q}$). This probability is sufficiently high for the monopoly to trust the signal w of the IS, and she chooses F when observing a market entry and the IS sends that signal; however, it is not sufficiently small to trust the signal s and to choose Ac with probability 1. Actually, when observing the signal s, the relatively low precision of the IS and the relatively high probability assigned by the weak type entrant to E do not make the monopoly sure of choosing to accommodate, and she hesitates between F and Ac.

The weak type entrant, knowing that, if he finally enters the market, the monopoly will receive the signal s with probability $1-\alpha$ and the signal w with probability α, will not deviate from $(\tilde{q}, 1-\tilde{q})$ if the monopoly, observing the signal s, does not choose any of her strategies purely and assigns the probability $\bar{\lambda}$ to F (if the monopoly assigns a higher probability to F, the weak type entrant will have incentives to deviate and to choose NE purely; and if the monopoly assigns a lower probability, he will deviate and choose E purely).

Note that this semi-pooling equilibrium only exists for relatively low values of α, particularly for $\alpha \le b$ (note that $\bar{\lambda} \in [0,1)$ if $\alpha \le b$); otherwise, the weak type entrant considers that he is likely to be detected if he finally enters the market (it is likely that the monopoly receives the signal w and chooses F with a probability of one) and no probability that the monopoly can assign to F observing the signal s, regardless of how small it is, sufficiently decreases the effect of the W-type entrant's expected negative payoff of entering and prevents him from deviating from this mixed strategy to choose NE purely.

Considering that the case $1/2 < \alpha < 1-\mu$ is being analyzed, several cases must be considered. If $0 < b \le 1/2$, the weak type entrant's payoff of entering the market is too small so that all possible precisions of the IS $\alpha \in (1/2, 1)$ are sufficiently high for him to consider that he is likely to be detected by the monopoly (because, in this case $\alpha > b$ always) and no probability that the monopoly can assign to F observing that signal s prevents him from deviating and choosing NE purely.

However, if $b \ge 1-\mu$, the weak type entrant's payoff of entering the market is sufficiently high so that all of the possible precisions of the IS are sufficiently small for him and he considers the monopoly is not likely to detect him. Hence, he will not deviate if the monopoly chooses to fight with probability $\bar{\lambda}$ when she observes the signal s. For intermediate values of b ($1/2 < b < 1-\mu$), this semi-pooling equilibrium exists if $\alpha \le b$. In particular, if $\alpha = b$, the probability that the monopoly should assign to F to be compatible with this semi-pooling equilibrium is $\bar{\lambda} = 0$ (namely she must choose to accommodate with a probability of one).

Nevertheless, for these relatively low values of α, the higher that α is the higher the probability is that the weak type entrant assigns to enter the market (according to the third part of the Lemma, $\tilde{q}$ increases in α) because the higher that α is, the higher the probability is that the monopoly needs the weak type entrant to assign to enter for not trusting the signal s completely (because now the IS is more accurate). If the weak type entrant did not assign a higher probability to entering, the monopoly would trust completely the signal s and would choose Ac purely, causing the weak type entrant to deviate from his mixed strategy to E unless α increases until $\alpha = b$. This outcome leads to the next possible semi-pooling equilibrium.

Consider next the case in which the weak type entrant assigns an intermediate probability to E (in particular, he chooses E with probability $q \in (\bar{q}, \tilde{q})$). The probability assigned to E by the weak type entrant in this case is sufficiently small for the monopoly to trust the signal s and to choose Ac and, at the same time, sufficiently high to trust the signal w and to choose F if she observes a market entry. Hence, when the monopoly observes a market entry, she trusts and follows the signal sent by the IS.

The weak type entrant, knowing that if he decides finally to enter the market, the monopoly will receive the signal s with probability $1-\alpha$ and the signal w with probability α, will not upset this semi-pooling equilibrium if the precision, α, of the IS is not very low (in which case, he will deviate and choose to enter with a probability of one because it is far too much likely for him that the monopoly is going to be confused and, receiving the wrong signal, will choose to accommodate) or very high (in which case it is far too likely for him that the monopoly is going to detect him and will choose to fight and he would be better off deviating and choosing not to enter). The weak type entrant will not upset this semi-pooling equilibrium for an intermediate value of α, particularly $\alpha = b$, to compensate for the positive payoff he obtains if he enters and the monopoly decides to accommodate, b, and the negative payoff he obtains if he enters and the monopoly decides to fight, $b-1$.

Because the case $1/2 < \alpha < 1-\mu$ is being considered, this semi-pooling equilibrium is only possible when $1/2 < b < 1-\mu$; otherwise, α is always larger (if $0 < b \leq 1/2$) or smaller (if $b \geq 1-\mu$) than b. More precisely, in the first case, b is so small that no precision of the IS can reduce the effect of the negative payoff $b-1$, and in the second case, it is so high that no precision of the IS can reduce the effect of the positive payoff b.

Finally, consider the situation in which the weak type entrant chooses to enter the market with probability $q = \bar{q}$. This probability is sufficiently small for the monopoly to trust the signal s sent by the IS (and to choose Ac) when she observes an entrance to the market and sufficiently high to render the monopoly indifferent and to hesitate between F and Ac when she observes the signal w. The weak type entrant, knowing that he will be detected with probability α if he finally enters the market, will not deviate from $(\bar{q}, 1-\bar{q})$ if the monopoly, observing the signal w, does not choose any of her strategies purely and assigns the probability $\bar{\gamma}$ to F.

Note that this semi-pooling equilibrium only exists for relatively high values of α, particularly for $\alpha \geq b$ (note that $\bar{\gamma} \in (0,1]$ if $\alpha \geq b$); otherwise the weak type entrant considers that he is not sufficiently likely to be detected if he finally enters the market (it is sufficiently likely for him that the monopoly receives the wrong signal s and chooses Ac purely), and no probability that the monopoly can assign to F, observing the signal w, is sufficiently high to reduce the effect of the W -type entrant's expected positive payoff of entering and to prevent him from deviating and choosing to enter with a probability of one.

Considering that in this case $1/2 < \alpha < 1-\mu$, this semi-pooling equilibrium only is possible when $0 < b < 1-\mu$; otherwise the weak type entrant's payoff of entering the market is so high that all of the possible precisions of the IS $\alpha \in (1/2, 1)$ are sufficiently small for him. Hence, considering the monopoly is not likely to detect him, he will deviate to E regardless of the probability that the monopoly assigns to F when she observes the signal w.

Therefore, two cases must be considered. If $0 < b \leq 1/2$, the weak type entrant's payoff of entering the market is sufficiently small so that all of the possible precisions of the IS are sufficiently high for the weak type entrant to consider that he is likely to be detected by the monopoly (in this case, $\alpha > b$ always), but he will not deviate if the monopoly chooses to fight with probability $\bar{\gamma}$ when she receives the signal w. If $1/2 < b < 1-\mu$, this semi-pooling equilibrium exists if $\alpha \geq b$. In particular, note that, if $\alpha = b$, the probability that the monopoly should assign to F to be compatible with this semi-pooling equilibrium is $\bar{\gamma} = 1$ (namely she must choose to fight purely), otherwise the weak type entrant would deviate to E because he considers that the IS is not very accurate given his relatively high payoff for entering.

For these high values of α, the higher that α is, the smaller the probability is that the weak type entrant enters the market (according to the third part of the Lemma, $\bar{q}$ is decreasing in α) because the higher that α is, the smaller the probability is that the monopoly needs the weak type entrant to enter for not

trusting completely the signal w (because now the IS is more accurate). If the weak type entrant did not assign a smaller probability to entering, the monopoly would trust completely the signal w and would choose F purely, causing the weak type entrant to deviate from this mixed strategy to NE.
Consider now the case in which the weak type entrant chooses to enter when the precision of the IS is intermediate ($\alpha = 1-\mu$). In this case the monopoly cannot distinguish the type of the entrant, but considering it likely that it is the weak type ($\mu < 1/2$), the precision of the IS is sufficiently high for the monopoly to trust the IS when it sends the signal w and chooses F. However, it is not sufficiently high to make the monopoly sure of choosing to accommodate when she observes the signal s. More precisely, when the IS sends this signal, the monopoly is indifferent between F and Ac. The weak type entrant, knowing that the monopoly will receive the signal s with probability $1-\alpha$ and the signal w with probability α, will not deviate from E to NE (and will not upset the pooling equilibrium) if the monopoly, observing the signal s, assigns to F a relatively small probability to compensate for the negative payoff the weak type entrant obtains from entering because of the fighting decision of the monopoly. More precisely, the W-type entrant will not deviate if the monopoly assigns to F a probability $0 \le \lambda \le \bar{\lambda}$.
Hence, note that the pooling equilibrium in this case only exists for relatively high values of b, particularly for $b \ge 1-\mu$. On the one hand, if $b > 1-\mu$, $\alpha = 1-\mu < b$, $\bar{\lambda} \in (0,1)$, and there is a multiplicity of pooling equilibria where the monopoly chooses F with probability $0 \le \lambda \le \bar{\lambda}$. On the other hand, if $b = 1-\mu$, $\alpha = 1-\mu = b$ and $\bar{\lambda} = 0$. In particular, the weak type entrant will not deviate from E, and the pooling equilibrium exists only if the monopoly chooses Ac purely.
Although the weak entrant assigning a probability of one to entering is a stable outcome when $b = 1-\mu$, there is also a multiplicity of semi-pooling equilibria where the weak type entrant assigns a probability of $q \in [\bar{q}, \tilde{q})$ (note that $\tilde{q} = 1$ because $\alpha = 1-\mu$), and the monopoly trusts the signal sent by the IS when she observes an entrance to the market and chooses Ac when she receives the signal s and F when receiving the signal w.
For relatively low values of b, more precisely for $0 < b < 1-\mu$, $\alpha = 1-\mu > b$, and no probability that the monopoly can assign to F observing the signal s, regardless of how small it is, reduces sufficiently the effect of the W-type entrant's negative expected payoff of entering and prevents him from deviating from E to NE. However, as stated before, the situation in which the weak type chooses NE is not stable either. Hence, the weak type entrant will hesitate and deviate from one pure strategy to another, and he will assign some positive probability to both. The only semi-pooling equilibrium possible in this case is that in which the weak type entrant assigns to E the probability $\bar{q}$ (in particular, note that the situation in which the weak type entrant assigns a probability $q \in (\bar{q}, \tilde{q})$ to E is not stable because, as explained above, it requires $\alpha = b$, and in the case considered now $\alpha > b$ always). He will not deviate from $(\bar{q}, 1-\bar{q})$ if the monopoly, observing the signal w, assigns the probability $\bar{\gamma}$ to F (note that in this case $\bar{\gamma} \in (0,1)$).
To finish the analysis of the case in which the monopoly considers it likely that the entrant is weak ($\mu < 1/2$), consider a relatively accurate IS ($1-\mu < \alpha < 1$). If for these relatively high values of α the weak type entrant chooses E, the monopoly, without distinguishing the type of the entrant but considering that the IS is sufficiently accurate, follows the signal sent by the IS and chooses Ac when she observes the signal s (although her prior belief is that it is likely that the entrant's type is weak) and F when observing the signal w. The weak type entrant will not deviate from E to NE if the monopoly detects his type (and chooses F) with relatively low probability. More precisely, if $\alpha \le b$ to compensate for the negative payoff, the weak entrant obtains if he enters, and the monopoly decides to fight.
Note that, although the weak entrant assigning a probability of one to entering is a stable outcome when $\alpha = b$, there is also a multiplicity of semi-pooling equilibria in this case, where the weak type entrant assigns a probability $q \in [\bar{q}, 1)$ (in this case, $\tilde{q} > 1$ because $\alpha > 1-\mu$), and the monopoly trusts and follows the signal sent by the IS when she observes an entrance to the market.
As stated above, the pooling equilibrium does not exists when $\alpha > b$. Consequently, the weak type entrant, hesitating between his two pure strategies, will assign to E the probability $q = \bar{q}$, and he will not deviate if the monopoly, observing the signal w, assigns to F the probability $\bar{\gamma}$.

Regarding the weak type entrant's payoff of entering the market, the previous pooling equilibrium is only possible for relatively high values of b, more precisely for $b > 1-\mu$. If $0 < b \le 1-\mu$, $\alpha > b$ always, and the precision of the IS never is sufficiently small to compensate for the negative payoff the weak entrant obtains if he enters and the monopoly decides to fight, causing him to deviate to NE and to upset the pooling equilibrium. The only stable situation in this case is that in which the weak type entrant assigns to E the probability $q = \overline{q}$.

Now the case where $\mu = 1/2$, namely the monopoly has no prior idea about the entrant's type, is analyzed.

Proposition 3. *Consider the game* $G(\alpha)$ *for* $1/2 < \alpha < 1$ and $\mu = 1/2$. *Then, the equilibrium of the game depends on* α *and* b*: if* $\alpha < b$, (E, E, Ac, F) *is the unique equilibrium of the game; if* $\alpha = b$, $G(\alpha)$ *has multiple equilibria of the form* $(E, (q, 1-q), Ac, F)$ *where* $\overline{q} \le q \le 1$*; and if* $\alpha > b$, $(E, (\overline{q}, 1-\overline{q}), Ac, (\overline{\gamma}, 1-\overline{\gamma}))$ *is the unique equilibrium of the game.*

Similar to the previous case ($\mu < 1/2$), the following table details the different equilibria of $G(\alpha)$ summarized by Proposition 3 (case $\mu = 1/2$) for the different values of α and b.

Table 2. Equilibria of $G(\alpha)$ when $\mu = 1/2$

$0 < b \le 1/2 (= \mu = 1-\mu)$	$(\mu = 1-\mu =) 1/2 < b < 1$
$(E, (\overline{q}, 1-\overline{q}), Ac, (\overline{\gamma}, 1-\overline{\gamma}))$	(E, E, Ac, F) iff $\alpha < b$ $\{(E, (q, 1-q), Ac, F) / \overline{q} \le q \le 1\}$ iff $\alpha = b$ $(E, (\overline{q}, 1-\overline{q}), Ac, (\overline{\gamma}, 1-\overline{\gamma}))$ iff $\alpha > b$

Note that, in this case, $\alpha > \mu = 1-\mu$ always because $\alpha \in (1/2, 1)$. Hence, if the weak type entrant chooses to enter the market with a probability of one, although the monopoly cannot distinguish the type of the entrant, the monopoly considers the IS to be sufficiently accurate (in this case, all of the precisions of the IS $\alpha \in (1/2, 1)$ are considered sufficiently accurate by the monopoly because she has no idea about the entrant's type) and follows the signal sent by it. As explained before, in this situation, the weak type entrant will not upset the pooling equilibrium if the precision, α, of the IS is relatively small, more precisely if $\alpha \le b$.

This case is similar to that in which $\mu < 1/2$ and $1-\mu < \alpha < 1$. On the one hand, the pooling equilibrium is not the unique equilibrium when $\alpha = b$, and there is also a multiplicity of semi-pooling equilibria where the weak type entrant assigns to E a probability $q \in [\overline{q}, 1)$ (in this case $\tilde{q} > 1$ also because $\alpha > 1-\mu$), and the monopoly trusts the signal sent by the IS when she observes an entrance to the market. On the other hand, the pooling equilibrium does not exist when $\alpha > b$, and the only stable situation in that case is the weak type entrant assigning the probability $q = \overline{q}$ to E and the monopoly choosing to fight with probability $\overline{\gamma}$.

Moreover, because, in this case, $\alpha > \mu = 1-\mu$, the previous pooling equilibrium is only possible for relatively high b, more precisely for $b > 1/2$. If $0 < b \le 1/2$, $\alpha > b$ always, and the unique stable situation is the weak type entrant assigning to E the probability $q = \overline{q}$.

Finally, consider the case in which the monopoly considers it likely that the entrant is strong ($\mu > 1/2$).

Proposition 4. *Consider the game* $G(\alpha)$ *for* $1/2<\alpha<1$ and $\mu>1/2$. *Then,*

(1) when $1/2<\alpha<\mu$ (E,E,Ac,Ac) *is the unique equilibrium of the game;*

(2) when $\alpha=\mu$, *the equilibrium of the game depends on* b: *if* $b<\mu$, $(E,E,Ac,(\gamma,1-\gamma))$ *where* $0\le\gamma\le\bar{\gamma}$; *if* $b\ge\mu$, $G(\alpha)$ *has multiple equilibria of the form* $(E,E,Ac,(\eta,1-\eta))$ *where* $0\le\eta\le1$; *and*

(3) when $\mu<\alpha<1$, *the equilibrium of the game depends on* α *and* b: *if* $\alpha<b$, (E,E,Ac,F) *is the unique equilibrium of the game; if* $\alpha=b$, $G(\alpha)$ *has multiple equilibria of the form* $(E,(q,1-q),Ac,F)$ *where* $\bar{q}\le q\le1$; *and if* $\alpha>b$, $(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma}))$ *is the unique equilibrium of the game.*

These equilibria summarized by Proposition 4 are detailed for the different values of α and b in the following table.

Table 3. Equilibria of $G(\alpha)$ **when** $\mu>1/2$

	$0<b\le1/2$	$1/2<b<\mu$	$b=\mu$	$\mu<b<1$
$1/2<\alpha<\mu$	(E,E,Ac,Ac)	(E,E,Ac,Ac)	(E,E,Ac,Ac)	(E,E,Ac,Ac)
$\alpha=\mu$	$(E,E,Ac,(\gamma,1-\gamma))$	$(E,E,Ac,(\gamma,1-\gamma))$	$(E,E,Ac,(\eta,1-\eta))$	$(E,E,Ac,(\eta,1-\eta))$
$\mu<\alpha<1$	$(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma}))$	$(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma}))$	$(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma}))$	(E,E,Ac,F) iff $\alpha<b$ $\{(E,(q,1-q),Ac,F)/\bar{q}\le q\le1\}$ iff $\alpha=b$ $(E,(\bar{q},1-\bar{q}),Ac,(\bar{\gamma},1-\bar{\gamma}))$ iff $\alpha>b$

If in this case the weak type entrant chooses E when the precision, α, of the IS is relatively low ($1/2<\alpha<\mu$), the monopoly cannot distinguish the type of the entrant, but considering it likely that he is the strong type ($\mu>1/2$) and not trusting the IS if it sends the signal w (given that the system is not very accurate), the monopoly chooses to accommodate irrespective of the signal sent by the IS, and the weak type entrant has no incentive to deviate. Specifically, when the monopoly considers it likely that the entrant is strong and the IS is relatively inaccurate, it makes no difference compared to the benchmark case, and the pooling equilibrium exists.

For an intermediate value of the precision of the IS ($\alpha=\mu$), if the weak type entrant chooses to enter, the monopoly, without distinguishing the type of entrant but considering it likely that he is the strong type, trusts the IS when it sends the signal s and chooses Ac. However, the precision of the IS is not sufficiently high to make the monopoly sure of choosing to fight when she observes the signal w. More precisely, in this case, she is indifferent between F and Ac. The weak type entrant will not deviate from E to NE if the monopoly, observing the signal w, assigns to F a relatively small probability, particularly $0\le\gamma\le\bar{\gamma}$.

Note that the higher b is, the less negative the weak type entrant's payoff is if he enters and the monopoly decides to fight, and consequently, the higher the maximum probability is that the monopoly can assign to F without the weak type entrant upsetting the pooling equilibrium. In this sense, for relatively high values of b ($b\ge\mu$), the pooling equilibrium always exists regardless of the probability assigned by the monopoly to F ($\eta\in[0,1]$ in the second part of Proposition 4), although the monopoly chooses to fight with a probability of 1.

For relatively accurate precision of the IS ($\mu<\alpha<1$), if the weak type entrant chooses E, the monopoly cannot distinguish the type of the entrant, but considering that the IS is sufficiently accurate, the monopoly follows the signal sent by the IS and chooses F when observing the signal w (although her prior belief is that it is likely that the entrant's type is strong) and Ac when she observes the signal s. Hence, the weak type entrant will not upset the pooling equilibrium only if $\alpha\le b$, and the different possible equilibria in this case ($\mu<\alpha<1$) are similar to those in which the IS is relatively accurate, but the monopoly considers it likely that the entrant is weak ($\mu<1/2$ and $1-\mu<\alpha<1$), but consdiering that the relevant values for b in this case are $0<b\le\mu$ and $b>\mu$ (instead of $0<b\le 1-\mu$ and $b>1-\mu$) because the relevant threshold for α in this case is μ not $1-\mu$.

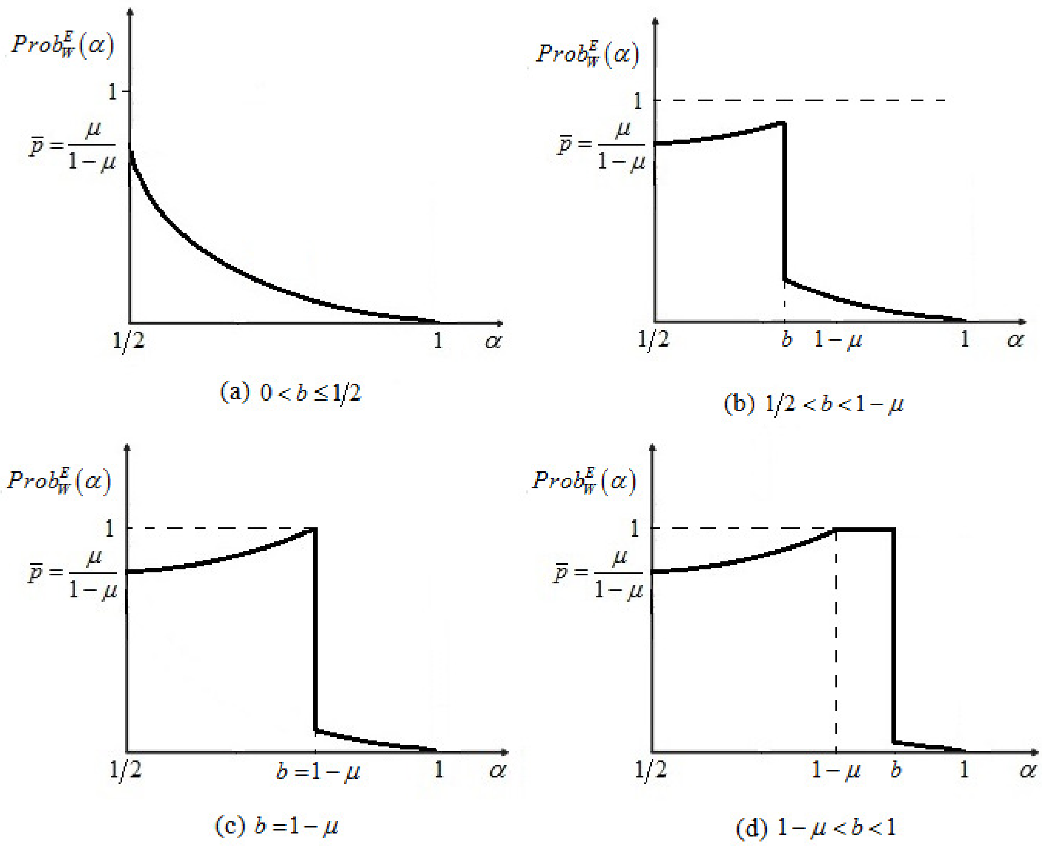
5. The Effect of the Common Knowledge Information-Gathering Activity on Market Entry

This section analyzes, from the results in the previous two sections (the equilibria of G and $G(\alpha)$), the effect of the monopoly's common knowledge information-gathering activity over market entry and, therefore, the effectiveness of monopoly's action of credibly informing the entrant how accurate the information she obtained is about his level of strength as an entry deterrence strategy.

To simplify the analysis and given that to enter the market is a dominant strategy for the strong type entrant in both G and $G(\alpha)$, the effect of information-gathering over market entry is analyzed only considering the probability that the weak type entrant assigns to E in equilibrium for the different values of the precision, α, of the IS in the different cases. As stated above and as will be shown in the following discussion, b plays an important role in the model as a threshold to assess the precision of the IS and the weak type entrant's decision of entering the market.

Consider first the case in which the monopoly considers it likely that the entrant is weak ($\mu<1/2$). The equilibrium of the benchmark case G when $\mu<1/2$ is given by the first part of Proposition 1, and the equilibrium of the information-gathering case $G(\alpha)$ is given by Proposition 2 and Table 1 (the equilibrium of $G(\alpha)$ when $\alpha=1$ is discussed at the beginning of Section 4). From these equilibria and the features of $\bar{q}(\alpha)$ and $\tilde{q}(\alpha)$, which are presented in Figure 3, the probability assigned by the weak type entrant to enter the market in the different cases can be calculated as a function of α. The following figures show this probability, $Prob_W^E(\alpha)$, for the different possible values of b.

Figure 4. $Prob_W^E(\alpha)$ **for the different values of** b **when** $\mu<1/2$



As shown in Figures 4 (b), (c) and (d), if the monopoly operates an informative but relatively inaccurate IS (in particular, an IS of precision $\alpha \in (1/2, b]$ [6]), the weak type entrant feels more inclined to enter the market than when the monopoly operates a relatively accurate IS, $\alpha \in [b,1]$ or when she operates no IS ($\alpha = 1/2$). When $\alpha \in (1/2, b]$, the weak type entrant assigns a relatively high probability (higher even than when there is no information-gathering activity, $\alpha = 1/2$) to enter because the precision of the IS is sufficiently small for him to consider that, if he finally enters the market, he is not likely to be detected (namely, it is sufficiently small and, at the same time, sufficiently high for the monopoly to be confused by the wrong signal). That this probability is increasing in α could seem counterintuitive because the higher that α is, the more accurate the IS is, and the weak type entrant knows that he is more likely to be detected by the monopoly if he finally enters the market. However, just because the IS is more accurate, and the monopoly trusts its signals more, the weak type entrant can assign a higher probability to entering without making the monopoly sure of not trusting the signal s sent by the IS, and he will do it so because, despite this improvement in the precision of the IS, he still considers the monopoly to be sufficiently likely to be confused by the IS. In contrast, when $\alpha \in [b,1]$, the weak type entrant believes that he is sufficiently likely to be detected if he finally enters the market and assigns a relatively low probability to entering. In this case, the higher that α is, the more that the monopoly trusts the signals sent by the IS, but now the weak type entrant assigns a smaller probability to entering because he knows he is more likely to be detected.

Obviously, the last observation is true for relatively high payoffs of entering (more precisely, for $b > 1/2$). If b is relatively low, particularly $0 < b \leq \frac{1}{2}$, the weak type entrant's payoff for entering the market is too small so that all possible precisions of the IS $\alpha \in (1/2, 1]$ are sufficiently high for him to consider that he is likely to be detected by the monopoly. Consequently, as Figure 4 (a) shows, he will assign a probability to entering the market that is not only relatively small but also that is decreasing in α.

However, for higher values of b, the weak type entrant feels more comfortable and starts to consider assigning a relatively higher (and increasing in α) probability to entering, as explained above. Note that, as shown in Figures 4 (b), (c) and (d), the higher that b is, the more the weak type entrant wants to enter the market, and the higher the maximum probability is that he is willing to assign to enter, deciding to enter with a probability of one for an intermediate precision of the IS when b is sufficiently high ($1-\mu \leq b < 1$), as Figures 4 (c) and (d) show. As stated in Section 3, given that the monopoly considers it likely that the entrant type is weak ($\mu < 1/2$), the existence of the pooling equilibrium requires a relatively accurate IS ($\alpha \geq 1-\mu$) or else the monopoly will choose to fight even observing the signal s and the weak type entrant will deviate, upsetting the pooling equilibrium; but not excessively accurate ($\alpha \leq b$) otherwise the weak type entrant would believe that he is likely to be detected if he finally enters the market, and would choose to enter with a relatively small probability. Note that, when b is very close to one, only an almost perfect IS would deter the weak type entrant from entering the market.

Therefore, if the monopoly wants to use the action of credibly informing the entrant how accurate her knowledge is about his level of strength as an entry deterrence strategy when she considers it likely that he is weak and the weak type entrant's payoff of entering the market is sufficiently high, the monopoly must operate a considerably accurate IS[7]. Otherwise, the action would have the opposite effect, similar to the procompetitive effect of the information-gathering activity performed by a potential entrant in Barrachina et al. (2015). Moreover, the higher the weak type entrant's payoff of entering is (namely the higher b is), the more comfortable he feels about entering the market and the more accurate the IS must be to deter him from entering (and in the extreme case in which his payoff of entering is very high, he only would be deterred by an almost perfect IS). However, when the weak type entrant's payoff of entering is sufficiently low, the monopoly can use this action as an entry deterrence strategy regardless of the precision of the IS operated.

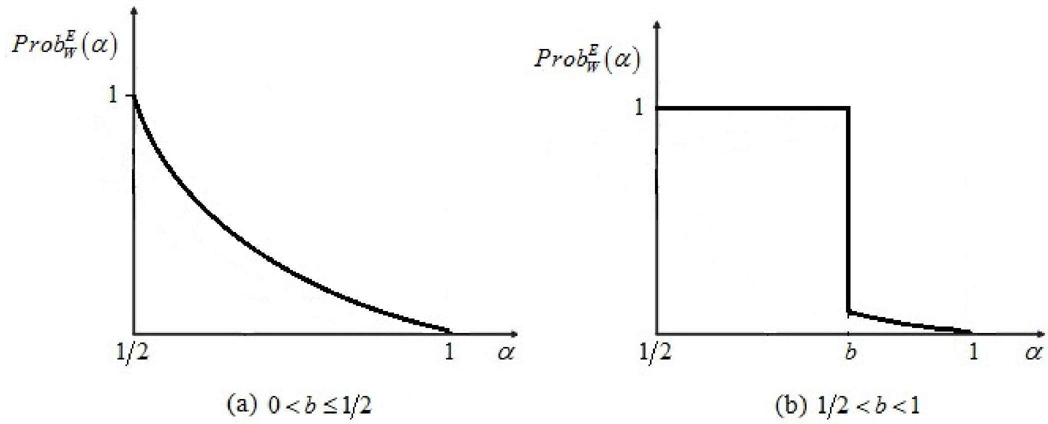
Consider next the case in which the monopoly has no prior idea about the entrant's type ($\mu = 1/2$). The equilibrium of the benchmark case G when $\mu = 1/2$ is given by the second part of Proposition 1, and the

[6] As stated in the previous section, there is a multiplicity of equilibria when $\alpha = b$.

[7] Common knowledge information-gathering activities have similar anticompetitive effects, but even if the precision of the IS is not that accurate, when these activities are performed by a potential entrant in a setting such as that considered by Barrachina et al. (2014.).

equilibrium of the information-gathering case $G(\alpha)$ is given by Proposition 3 and Table 2. Similarly as before, the probability assigned by the weak type entrant to entering the market as a function of α, $Prob_W^E(\alpha)$, can be determined for the different possible values of b.

Figure 5. $Prob_W^E(\alpha)$ **for the different values of** b **when** $\mu = 1/2$



Because the monopoly is not sure about entrant's type, she would trust and follow the signal sent by the IS (she would choose to fight when observing the signal w and to accommodate when observing the signal s), regardless of how accurate the IS is, if the weak type entrant chose to enter with a probability of one. Given this outcome, the weak type entrant chooses to enter purely (as when the monopoly performs no information-gathering activity, $\alpha = 1/2$) for a relatively inaccurate IS ($\alpha \in (1/2, b]$), considering it sufficiently likely for him that the monopoly is being confused by the IS, and he is not going to be detected. However, for relatively accurate precision of the IS ($\alpha \ge b$), the weak type entrant believes that he is sufficiently likely to be detected if he finally enters the market and assigns a relatively low (and decreasing in α) probability to entering (see Figure 5 (b)), as in the previous case $\mu < 1/2$.

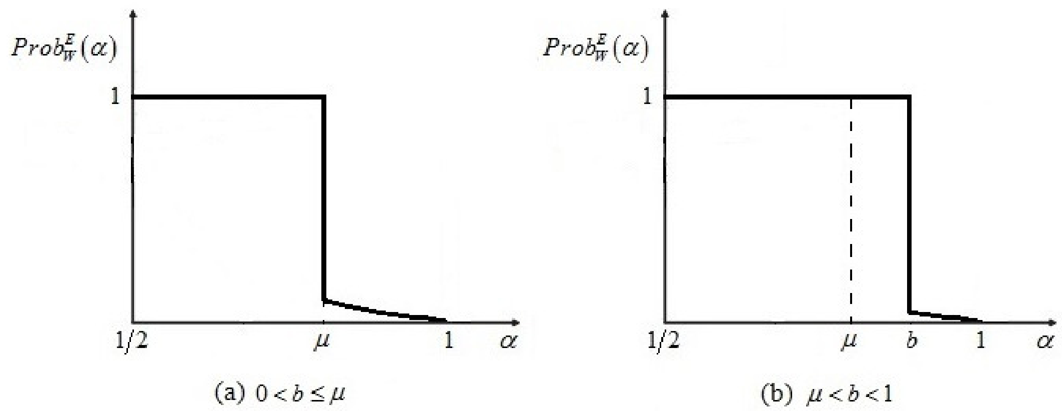
Similar to the previous case, this scenario is only true for relatively high values of b ($b > 1/2$), and when b is very high (very close to one) the weak type entrant can only be deterred from entering the market by an almost perfect IS. If b is sufficiently small ($0 < b \le \frac{1}{2}$), the weak type entrant believes that he is sufficiently likely to be detected if he finally enters the market regardless of the precision of the IS, and as Figure 5 (a) shows, he assigns a low and decreasing value of probability in α to enter.

However, because in this case the monopoly trusts the IS more than in the previous case, the weak type entrant does not need a payoff to entering (represented by b) as large as in the previous case to feel comfortable assigning a high probability to entering (in this case, a probability equal to one).

Hence, when the monopoly is not sure about the entrant's type, and the weak type entrant's payoff of entering the market is relatively high, the weak type entrant can only be discouraged from entering the market by knowing that the monopoly operates a relatively accurate IS (almost a perfect one if the weak type entrant's payoff for entering is extremely high); otherwise, the IS makes no difference, as in Barrachina et al. (2015), and the weak type entrant enters the market certainly as when the monopoly operates no IS. However, similar to the previous case, if the weak type entrant's payoff for entering is sufficiently low, the IS discourages him from entering the market regardless of its precision.

Consider finally the case in which the monopoly considers it likely that the entrant is strong ($\mu > 1/2$). The equilibrium of the benchmark case G when $\mu > 1/2$ is given by the third part of Proposition 1, and the equilibrium of the information-gathering case $G(\alpha)$ is given by Proposition 4 and Table 3. Similar to the previous cases, the probability assigned by the weak type entrant to entering the market in equilibrium depending on the precision, α, of the IS, $Prob_W^E(\alpha)$, can be determined for the different possible values of b.

Figure 6. $Prob_W^E(\alpha)$ **for the different values of** b **when** $\mu > 1/2$



Similar to the previous case ($\mu = 1/2$), when the monopoly considers it likely that the entrant is strong ($\mu > 1/2$), a relatively inaccurate IS makes no difference to the entry decision of the weak type entrant. For relatively low precision of the IS ($1/2 < \alpha \le \mu$), the monopoly would not trust the IS if it sends the signal w if the weak type entrant chooses to enter with a probability of one. The weak type entrant, taking advantage of this behavior, will choose to enter purely in that situation. However, for a relatively more accurate IS ($\mu < \alpha < 1$), the monopoly would trust and follow the signal sent by the IS if the weak type entrant chose to enter purely. Given this monopoly's behavior and considering that he is more likely to be detected, the weak type entrant only feels comfortable choosing to enter purely for a not extremely accurate IS ($\alpha \le b$). For higher precision of the IS ($\alpha > b$), the weak type entrant assigns a relatively low (and decreasing in α) probability to entering (see Figures 6 (a) and (b)).

Because, in this case, the monopoly considers it likely that the entrant is strong ($\mu > 1/2$), the weak type entrant feels comfortable assigning a high probability to entering (in this case, a probability equal to one) regardless of his payoff for entering and competing with the monopoly (represented by b). However, the higher his payoff for entering is, the more comfortable he feels, and the higher the maximum precision of the IS that he is willing to tolerate without assigning a smaller probability; similar to the previous cases, when b is very close to one, only an almost perfect IS could discourage the weak type entrant from entering the market.

Therefore, when the monopoly considers it likely that the entrant is strong, the monopoly's action of credibly informing the entrant how accurate her knowledge is about his level of strength can only be used as an entry deterrence strategy operating a relatively accurate IS (otherwise the IS has no effect over market entry), regardless of the weak type entrant's payoff for entering the market. Similar to the previous cases, the IS should be almost perfect to discourage the weak type entrant from entering the market when his payoff for competing with the monopoly is considerably high.

6. Summary and Conclusions

Sometimes firms' information-gathering activities are allowed or not, depending on the considered level of ethicality, without considering their possible competitive effects on the market. In particular, these competitive effects can be especially important in markets with barriers to entry. However, little theoretical work has been undertaken to analyze them.

This paper has attempted to take a modest step forward in closing this gap in the literature by considering a model in which a monopoly incumbent uses an Intelligence System (IS), of a certain precision, to obtain information about the level of strength of a potential entrant. If the entrant finally decides to enter the market, the monopoly uses this information to decide whether to accommodate or to fight the entrant.

In the model considered, when it is common knowledge that the monopoly is conducting no information-gathering activity, a weak entrant may hesitate between entering the market or not. However, when it is common knowledge that the monopoly knows exactly the entrant's level of strength, a weak entrant stays out for sure because the monopoly would battle him otherwise. In this sense, it might seem that to inform the entrant credibly regarding how accurate the knowledge obtained by the monopoly is about his level of strength has an entry deterrence effect (it can be considered a complementary entry deterrence strategy for the monopoly in this context) no matter the precision of this knowledge. However, it is shown that, when the monopoly operates a not perfectly accurate IS that sends noisy signals, relatively low precision might have either no effect on market entry or a procompetitive effect because the weak entrant considers it likely that the monopoly could be confused by the IS, and he is not going to be detected.

Nevertheless, not only would a monopoly never choose a precision with these effects, but also a relatively accurate precision (but not necessarily perfect) or every precision if the entrant's payoff for entering the market is considerably small has an entry deterrence effect. In this sense, a monopoly might have incentives to operate a relatively accurate IS and to inform the entrant credibly regarding how accurate the knowledge she obtained is about his level of strength. Obviously, this scenario will depend on how costly this accurate IS is. In particular, when a weak entrant's payoff from entering and competing with the monopoly is considerably high, only an almost perfect IS would discourage him from entering the market, but it could be very difficult or costly for the monopoly to operate.

Therefore, beyond ethical considerations and attempting to increase competition in markets with barriers to entry (in an attempt to increase economic welfare with lower prices and higher market output), it would be recommendable that a public policy be pursued that does not allow a monopoly to conduct information-gathering activities (even if they are not considered unethical) into potential entrants' level of strength unless their payoffs from entering the market and competing with the monopoly are considerably high. In that case, it might be very difficult or too costly for a monopoly to operate an IS with entry deterrence effects, and the cost of such a public policy might be unnecessary, with no intervention being the recommended policy.

However, more research is needed. In particular, it would be necessary to analyze the case where the precision of the IS is only known by its owner, the monopoly. This case, together with the one considered in this paper, will provide a complete analysis of the monopoly's incentives to use the action of credibly informing the entrant how accurate the information she obtained is about his level of strength (namely to inform the entrant credibly about the precision of the IS) as an entry deterrence strategy.

Appendices

Appendix A: Proof of Proposition 1

First, the expression for the monopoly's updated beliefs is obtained. Applying Bayes' rule, the probability that the monopoly assigns the entrant is of type $t=\{S,W\}$, given that she observes a market entry (the entrant chose E) is

$$\Pr(t/E)=\frac{\Pr(E/t)\Pr(t)}{\sum_{t=S,W}\Pr(E/t)\Pr(t)} \tag{A1}$$

where $\Pr(E/t)$ is the probability assigned to E by the t-type entrant, and $\Pr(t)$ is the prior probability the monopoly assigns to the t-type entrant, namely $\Pr(S)=\mu$ and $\Pr(W)=1-\mu$.

The monopoly's expected payoffs for choosing F and Ac can be calculated applying the expression for her updated beliefs given by (A1). These two expected payoffs are given by

$$EU_M(F)=\Pr(S/E)(a-1)+\Pr(W/E)A \tag{A2}$$

$$EU_M(Ac)=\Pr(S/E)a+\Pr(W/E)(A-1) \tag{A3}$$

Before analyzing the equilibrium of the game, note that E is the S-type entrant's dominant strategy because $0<B-1<B$ (see Figure 1). Specifically, $\Pr(E/S)=1$ in every possible equilibrium of G.

Next, the non-existence of a separating equilibrium is proved. Because E is the S-type entrant's dominant strategy, in a separating equilibrium, the W-type entrant should choose NE purely, namely, $\Pr(E/W)=0$. Hence, in this case, it is obtained from (A1) that $\Pr(S/E)=1$ and $\Pr(W/E)=0$ and from (A2) and (A3) that $EU_M(F)=a-1$ and $EU_M(Ac)=a$. In particular, if the W-type entrant chooses to stay out purely, the monopoly will accommodate if she observes a market entry because

$EU_M(F) = a - 1 < EU_M(Ac) = a$ because $a < 1$. In this situation, the W-type entrant would deviate from NE to E because $b > 0$, and the separating equilibrium does not exist.

Now the existence of pooling equilibrium is analyzed. Because $\Pr(E/S) = 1$ in every possible equilibrium, the only possible pooling equilibrium is that in which $\Pr(E/W) = 1$. Hence, from (A1), $\Pr(S/E) = \mu$ and $\Pr(W/E) = 1 - \mu$, and from (A2) and (A3),

$$EU_M(F) = \mu(a-1) + (1-\mu)A \tag{A4}$$

$$EU_M(Ac) = \mu a + (1-\mu)(A-1) \tag{A5}$$

Consider the following three cases.

Case 1. Consider the case where $\mu < 1/2$. Note that, in this case, $EU_M(F)$, given by (A4), is strictly greater than $EU_M(Ac)$, given by (A5), and the monopoly will choose to fight if she observes a market entry in this case. In this situation, the W-type entrant would deviate from E to NE because $b - 1 < 0$, and the pooling equilibrium does not exist when $\mu < 1/2$.

Case 2. Consider the case where $\mu = 1/2$. Note that, in this case, $EU_M(F)$ is equal to $EU_M(Ac)$, and the monopoly, indifferent between fighting and accommodating when observing a market entry, will assign some probability to both strategies. Let β be the probability that the monopoly assigns to F. The W-type entrant will not deviate from E to NE only if

$$\beta(b-1) + (1-\beta)b \geq 0 \tag{A6}$$

Note that (A6) is satisfied only if $\beta \leq b$, and the pooling equilibrium exists when $\mu = 1/2$ only if $\beta \in [0, b]$.

Case 3. Consider the case where $\mu > 1/2$. Note that, in this case, $EU_M(F)$ is strictly smaller than $EU_M(Ac)$, and the monopoly will choose to accommodate if she observes a market entry. The W-type entrant will not deviate from E to NE because $b > 0$. Therefore, the pooling equilibrium exists when $\mu > 1/2$.

Finally, the existence of semi-pooling equilibrium is analyzed. The only possible semi-pooling equilibrium is that in which the W-type entrant assigns to E a certain probability $p \in (0,1)$, hence $\Pr(E/W) = p$. From (A1),

$$\Pr(S/E) = \frac{\mu}{\mu + p(1-\mu)} \tag{A7}$$

$$\Pr(W/E) = \frac{p(1-\mu)}{\mu + p(1-\mu)} \tag{A8}$$

Further, substituting (A7) and (A8) in (A2) and (A3),

$$EU_M(F) = \frac{\mu(a-1) + p(1-\mu)A}{\mu + p(1-\mu)} \tag{A9}$$

$$EU_M(Ac) = \frac{\mu a + p(1-\mu)(A-1)}{\mu + p(1-\mu)} \tag{A10}$$

The semi-pooling equilibrium only exists if the monopoly is indifferent between F and Ac; otherwise, the W-type entrant is better off deviating from the mixed strategy to a pure strategy. Note that (A9) is equal to (A10), and the monopoly is indifferent between the two strategies only if the W-type entrant chooses to enter the market with probability $\overline{p} = \mu/(1-\mu)$. Note that $\overline{p} > 0$ always, but $\overline{p} < 1$ only if $\mu < 1/2$. Therefore, the semi-pooling equilibrium does not exist if $\mu \geq 1/2$.

Then, if $\mu < 1/2$, and the W-type entrant assigns $\overline{p}$ to E, the monopoly will choose F with a certain positive probability $\beta \in (0,1)$ when observing a market entry. The W-type entrant will not deviate from the mixed strategy $(\overline{p}, 1-\overline{p})$ only if he is indifferent between his two pure strategies, E and NE.

Specifically, $\beta(b-1)+(1-\beta)b=0$, and the semi-pooling equilibrium exists if the monopoly chooses to fight the entrant with probability $\bar{\beta}=b$.

■

Appendix B: Proof of Propositions 2, 3 and 4.

In $G(\alpha)$ for $1/2<\alpha<1$ the expression for the monopoly's updated beliefs when she observes a market entry and the signal $\sigma=\{s,w\}$ sent by the IS are obtained applying Bayes' rule and are given by

$$\Pr(t/E,\sigma)=\frac{\Pr(E,\sigma/t)\Pr(t)}{\sum_{t=S,W}\Pr(E,\sigma/t)\Pr(t)}$$

Equivalently,

$$\Pr(t/E,\sigma)=\frac{\Pr(E/t)\Pr(\sigma/t)\Pr(t)}{\sum_{t=S,W}\Pr(E/t)\Pr(\sigma/t)\Pr(t)} \tag{B1}$$

where $\Pr(\sigma/t)$ is the probability that the IS sends the signal σ given that the entrant is of type t. In particular, $\Pr(s/S)=\Pr(w/W)=\alpha$ and $\Pr(w/S)=\Pr(s/W)=1-\alpha$.

Let $EU_M(F/\sigma)$ and $EU_M(Ac/\sigma)$ be the monopoly's expected payoffs for choosing F and Ac respectively when she observes a market entry and the IS sends the signal σ, which can be obtained applying (B1),

$$EU_M(F/\sigma)=\Pr(S/E,\sigma)(a-1)+\Pr(W/E,\sigma)A \tag{B2}$$

$$EU_M(Ac/\sigma)=\Pr(S/E,\sigma)a+\Pr(W/E,\sigma)(A-1) \tag{B3}$$

It is straight forward to see that with the Intelligence System E is the S-type entrant's dominant strategy (namely, $\Pr(E/S)=1$ in every possible equilibrium) and there exists no separating equilibrium (see Figure 2), as in G.

Consider now the existence of pooling equilibrium in $G(\alpha)$. Similar to the benchmark case G, the only possible pooling equilibrium is that in which $\Pr(E/W)=1$. Hence, from (B1),

$$\Pr(S/E,s)=\frac{\alpha\mu}{\alpha\mu+(1-\alpha)(1-\mu)} \tag{B4}$$

$$\Pr(W/E,s)=\frac{(1-\alpha)(1-\mu)}{\alpha\mu+(1-\alpha)(1-\mu)} \tag{B5}$$

$$\Pr(S/E,w)=\frac{(1-\alpha)\mu}{(1-\alpha)\mu+\alpha(1-\mu)} \tag{B6}$$

$$\Pr(W/E,w)=\frac{\alpha(1-\mu)}{(1-\alpha)\mu+\alpha(1-\mu)} \tag{B7}$$

The monopoly's expected payoffs when observing the signal s are obtained substituting (B4) and (B5) in (B2) and (B3),

$$EU_M(F/s)=\frac{\alpha\mu(a-1)+(1-\alpha)(1-\mu)A}{\alpha\mu+(1-\alpha)(1-\mu)} \tag{B8}$$

$$EU_M(Ac/s)=\frac{\alpha\mu a+(1-\alpha)(1-\mu)(A-1)}{\alpha\mu+(1-\alpha)(1-\mu)} \tag{B9}$$

Note that (B8) is strictly higher than (B9) and consequently the monopoly will choose F when observing the signal s, only if $\alpha<1-\mu$.

The monopoly's expected payoffs when observing the signal w are obtained substituting (B6) and (B7) in (B2) and (B3),

$$EU_M(F/w)=\frac{(1-\alpha)\mu(a-1)+\alpha(1-\mu)A}{(1-\alpha)\mu+\alpha(1-\mu)} \tag{B10}$$

$$EU_M\left(Ac/w\right)=\frac{(1-\alpha)\mu a+\alpha(1-\mu)(A-1)}{(1-\alpha)\mu+\alpha(1-\mu)} \tag{B11}$$

Note that (B10) is strictly higher than (B11) and consequently the monopoly will choose F when observing the signal w, only if $\alpha > \mu$.

Consider the following cases.

Case 1. Consider the case where $\mu < 1/2$. In this case $\alpha > \mu$ for all $\alpha \in (1/2,1)$ and the monopoly always chooses F when observing the signal w because (B10) is strictly higher than (B11) for all $\alpha \in (1/2,1)$.

Subcase 1.1. Consider the case where $\mu < 1/2$ and $\alpha \in (1/2, 1-\mu)$. In this case the monopoly will choose F when observing the signal s because (B8) is strictly higher than (B9). Namely, the monopoly chooses F irrespective of the signal sent by the IS in this case and the W-type entrant will have incentives to deviate form E to NE because $b-1<0$. Therefore, there exists no pooling equilibrium in this case.

Subcase 1.2. Consider the case where $\mu < 1/2$ and $\alpha = 1-\mu$. In this case the monopoly is indifferent between F and Ac when observing the signal s because (B8) is equal to (B9). Namely, the monopoly chooses F when observing the signal w and assigns to F some probability $\lambda \in [0,1]$ when observing the signal s. The W-type entrant will not deviate form E to NE, knowing that if he enters the market the IS sends the right signal w with probability α (and the wrong signal s with probability $1-\alpha$), only if

$$(1-\alpha)\left(\lambda(b-1)+(1-\lambda)b\right)+\alpha(b-1)\geq 0$$

Equivalently, $\lambda \leq (b-\alpha)/(1-\alpha) \equiv \bar{\lambda}$.

Note that $\bar{\lambda} < 1$ always because $b<1$ but $\bar{\lambda} \geq 0$ only if $\alpha \leq b$. Considering that the case $\alpha = 1-\mu$ is being analyzed, this pooling equilibrium only exists when $b \geq 1-\mu$ (otherwise $\bar{\lambda} < 0$ because $\alpha = 1-\mu > b$).

Subcase 1.3. Consider the case where $\mu < 1/2$ and $\alpha \in (1-\mu, 1)$. In this case the monopoly will choose Ac when observing the signal s because (B8) is strictly smaller than (B9). Namely, the monopoly chooses F when observing the signal w and Ac when observing the signal s. The W-type entrant will not deviate form E to NE only if

$$(1-\alpha)b+\alpha(b-1)\geq 0$$

Equivalently, $\alpha \leq b$.

Considering that the case $\alpha > 1-\mu$ is being analyzed, this pooling equilibrium only exists when $b > 1-\mu$ (otherwise $\alpha > b$ always and the W-type entrant will deviate form E to NE).

Case 2. Consider the case where $\mu = 1/2$. In this case $\alpha > \mu = 1-\mu = 1/2$ for all $\alpha \in (1/2,1)$ and the monopoly chooses Ac when observing the signal s because (B8) is strictly smaller than (B9), and chooses F when observing the signal w because (B10) is strictly higher than (B11), for all $\alpha \in (1/2,1)$. Similar to the previous case 1.3, the W-type entrant will not deviate form E to NE only if $\alpha \leq b$, but considering that this case $\mu = 1/2$, this pooling equilibrium only exists when $b > 1/2$ (otherwise $\alpha > b$ and the W-type entrant will deviate form E to NE).

Case 3. Consider the case where $\mu > 1/2$. In this case $\alpha > 1-\mu$ for all $\alpha \in (1/2,1)$ and the monopoly always chooses Ac when observing the signal s because (B8) is strictly smaller than (B9) for all $\alpha \in (1/2,1)$.

Subcase 3.1. Consider the case where $\mu > 1/2$ and $\alpha \in (1/2, \mu)$. In this case the monopoly will choose Ac when observing the signal w because (B10) is strictly smaller than (B11). Namely, the monopoly chooses Ac irrespective of the signal sent by the IS. The W-type entrant will not have incentives to deviate form E to NE because $b>0$ and the pooling equilibrium exists.

Subcase 3.2. Consider the case where $\mu > 1/2$ and $\alpha = \mu$. In this case the monopoly is indifferent between F and Ac when observing the signal w because (B10) is equal to (B11). Namely, the monopoly chooses Ac when observing the signal s and assigns to F some probability $\gamma \in [0,1]$ when observing the signal w. The W-type entrant will not deviate form E to NE only if

$$(1-\alpha)b+\alpha\left(\gamma(b-1)+(1-\gamma)b\right)\geq 0$$

Equivalently, $\gamma \leq b/\alpha \equiv \bar{\gamma}$.

Note that $\bar{\gamma}>0$ always but $\bar{\gamma}\leq 1$ only if $\alpha \geq b$. Considering that the case $\alpha=\mu$ is being analyzed, if $b<\mu$, $\alpha>b$ always and $\bar{\gamma}<1$. If $b\geq\mu$, $\alpha\leq b$ and $\bar{\gamma}\geq 1$, namely the pooling equilibrium is compatible with the monopoly assigning to F any probability $\eta\in[0,1]$, as stated in the second part of Proposition 4.

Subcase 3.3. Consider the case where $\mu>1/2$ and $\alpha\in(\mu,1)$. In this case the monopoly will choose F when observing the signal w because (B10) is strictly higher than (B11). Namely, the monopoly chooses F when observing the signal w and Ac when observing the signal s. The W-type entrant will not deviate form E to NE only if $\alpha\leq b$ as in the previous case 1.3.

Considering that the case $\alpha>\mu$ is being analyzed, this pooling equilibrium only exists when $b>\mu$ (otherwise $\alpha>b$ always and the W-type entrant will deviate form E to NE).

Consider finally the existence of semi-pooling equilibrium in $G(\alpha)$. The only possible semi-pooling equilibrium is that where $\Pr(E/W)=q$ becasue $\Pr(E/S)=1$ always. From (B1),

$$\Pr(S/E,s)=\frac{\alpha\mu}{\alpha\mu+q(1-\alpha)(1-\mu)} \tag{B12}$$

$$\Pr(W/E,s)=\frac{q(1-\alpha)(1-\mu)}{\alpha\mu+q(1-\alpha)(1-\mu)} \tag{B13}$$

$$\Pr(S/E,w)=\frac{(1-\alpha)\mu}{(1-\alpha)\mu+q\alpha(1-\mu)} \tag{B14}$$

$$\Pr(W/E,w)=\frac{q\alpha(1-\mu)}{(1-\alpha)\mu+q\alpha(1-\mu)} \tag{B15}$$

Substituting (B12) and (B13) in (B2) and (B3), the monopoly's expected payoffs when observing the signal s are obtained,

$$EU_M(F/s)=\frac{\alpha\mu(a-1)+q(1-\alpha)(1-\mu)A}{\alpha\mu+q(1-\alpha)(1-\mu)} \tag{B16}$$

$$EU_M(Ac/s)=\frac{\alpha\mu a+q(1-\alpha)(1-\mu)(A-1)}{\alpha\mu+q(1-\alpha)(1-\mu)} \tag{B17}$$

Note that (B16) is strictly higher than (B17) and consequently the monopoly will choose F when observing the signal s only if $q>\tilde{q}$ (see Section 4 in the main text).

The monopoly's expected payoffs when observing the signal w are obtained substituting (B14) and (B15) in (B2) and (B3),

$$EU_M(F/w)=\frac{(1-\alpha)\mu(a-1)+q\alpha(1-\mu)A}{(1-\alpha)\mu+q\alpha(1-\mu)} \tag{B18}$$

$$EU_M(Ac/w)=\frac{(1-\alpha)\mu a+q\alpha(1-\mu)(A-1)}{(1-\alpha)\mu+q\alpha(1-\mu)} \tag{B19}$$

The monopoly will choose F when observing the signal w, namely (B18) is strictly higher than (B19) only if $q>\bar{q}$ (see Section 4 in the main text).

As stated by the first part of the Lemma in Section 4, $\bar{q}<\tilde{q}$.

Consider the following cases.

Case 1. Consider the case where $\mu<1/2$. In this case $\alpha>\mu$ for all $\alpha\in(1/2,1)$ and $\bar{q}<1$ (see Lemma in Section 4).

Subcase 1.1. Consider the case where $\mu<1/2$ and $\alpha\in(1/2,1-\mu)$. In this case $\tilde{q}<1$ (see Lemma in Section 4). If in this case the W-type entrant assigns to E a probability $q<\bar{q}$, (B16) is strictly smaller than (B17) and (B18) is strictly smaller than (B19). Namely, the monopoly will choose Ac irrespective of the signal sent by the IS and the W -type entrant is better off deviating from the mixed strategy and choosing E purely, upsetting the semi-pooling equilibrium. In contrast, if in this case the W -type entrant assigns to E a probability $q > \tilde{q}$, (B16) is strictly higher than (B17) and (B18) is strictly higher than (B19). Namely, the monopoly will choose F irrespective of the signal sent by the IS and the W -type entrant is better off deviating from the mixed strategy and choosing NE .

If in this case the W -type entrant assigns to E a probability $q = \bar{q}$, (B16) is strictly smaller than (B17) but (B18) is equal to (B19). Namely, the monopoly will choose Ac when observing the signal s and, being indifferent between F and Ac when observing the signal w , will assign some probability $\gamma \in [0,1]$ to F . The W -type entrant will not deviate from the mixed strategy only if he is indifferent between his two pure strategies. Namely,

$$(1-\alpha)b + \alpha\left(\gamma(b-1) + (1-\gamma)b\right) = 0$$

Equivalently, $\gamma = \bar{\gamma}$.

Considering that $\bar{\gamma} \leq 1$ if $\alpha \geq b$, and the case $\alpha \in (1/2, 1-\mu)$ is being analyzed, this semi-pooling equilibrium always exists when $b \leq 1/2$, and when $1/2 < b < 1-\mu$ it exists only if $\alpha \geq b$. When $b \geq 1-\mu$, this semi-pooling equilibrium does not exist because $\alpha < b$ always.

If in this case the W -type entrant assigns to E a probability $q \in (\bar{q}, \tilde{q})$, (B16) is strictly smaller than (B17) but (B18) is strictly higher than (B19). Namely, the monopoly will choose Ac when observing the signal s and F when observing the signal w . The W -type entrant will not deviate from the mixed strategy only if

$$(1-\alpha)b + \alpha(b-1) = 0$$

Equivalently, $\alpha = b$.

Considering that the case $\alpha \in (1/2, 1-\mu)$ is being analyzed, this semi-pooling equilibrium only exists when $1/2 < b < 1-\mu$.

If in this case the W -type entrant assigns to E a probability $q = \tilde{q}$, (B16) is equal to (B17) but (B18) is strictly higher than (B19). Namely, the monopoly being indifferent between F and Ac when observing the signal s will assign some probability $\lambda \in [0,1]$ to F , and will choose F when observing the signal w . The W -type entrant will not deviate from the mixed strategy only if

$$(1-\alpha)\left(\lambda(b-1) + (1-\lambda)b\right) + \alpha(b-1) = 0$$

Equivalently, $\lambda = \bar{\lambda}$.

Considering that $\bar{\lambda} \geq 0$ if $\alpha \leq b$, and the case $\alpha \in (1/2, 1-\mu)$ is being analyzed, this semi-pooling equilibrium does not exist when $b \leq 1/2$ because $\alpha > b$ always in that case. When $1/2 < b < 1-\mu$ this semi-pooling equilibrium exists only if $\alpha \leq b$; and when $b \geq 1-\mu$ this semi-pooling equilibrium always exists.

Subcase 1.2. Consider the case where $\mu < 1/2$ and $\alpha \in [1-\mu, 1)$. In this case $\tilde{q} \geq 1$ (see Lemma in Section 4). Hence, all of the possible probabilities $q \in (0,1)$ the W -type entrant can assign to E will satisfy $q < \tilde{q}$ and the monopoly will choose Ac when observing the signal s .

Similar to the previous case, there is no semi-pooling equilibrium in wich the W -type entrant assigns to E a probability $q < \bar{q}$. If the W -type entrant assigns to E a probability $q = \bar{q}$, as explained in the previous case, the semi-pooling equilibrium exists only if the monopoly chooses F with a probability of $\bar{\gamma}$ ($\bar{\gamma} = b/\alpha$). However, considering that in this case $\alpha \in [1-\mu, 1)$ and $\bar{\gamma} \leq 1$ if $\alpha \geq b$, this semi-pooling equilibrium always exists when $b \leq 1-\mu$. When $b > 1-\mu$, this semi-pooling equilibrium exists only if $\alpha \geq b$.

If in this case the W -type entrant assigns to E a probability $q > \bar{q}$, as explained in previous cases, the monopoly will choose Ac when observing the signal s and F when observing the signal w and the semi-pooling equilibrium exists only if $\alpha = b$. However, considering that the case $\alpha \in [1-\mu, 1)$ is being analyzed, this semi-pooling equilibrium exists when $b = 1-\mu = \alpha$ or when $b > 1-\mu$ and $\alpha \in (1-\mu, 1)$, otherwise $\alpha > b$ and the W-type entrant will have incentives to deviate.

Case 2. Consider the case where $\mu \geq 1/2$. In this case $\alpha > 1-\mu$ for all $\alpha \in (1/2, 1)$ and $\tilde{q} > 1$ (see Lemma in Section 4). Similar to case 1.2, all of the possible probabilities $q \in (0,1)$ the W-type entrant can assign to E will satisfy $q < \tilde{q}$.

Subcase 2.1. Consider the case where $\mu \geq 1/2$ and $\alpha \in (1/2, \mu]$. In this case $\bar{q} \geq 1$ (see Lemma in Section 4). Hence, all of the possible probabilities $q \in (0,1)$ the W-type entrant can assign to E will satisfy $q < \bar{q}$ and, as explained in case 1, no semi-pooling equilibrium exists in this case.

Subcase 2.2. Consider the case where $\mu \geq 1/2$ and $\alpha \in (\mu, 1)$ (note that this is the only possibility when $\mu = 1/2$). In this case $\bar{q} < 1$ (see Lemma in Section 4).

Similar to previous cases, there is no semi-pooling equilibrium in which the W-type entrant assigns to E a probability $q < \bar{q}$. If the W-type entrant assigns to E a probability $q = \bar{q}$, as explained in previous cases, the semi-pooling equilibrium exists only if the monopoly chooses F with probability $\bar{\gamma}$. Considering that in this case $\alpha \in (\mu, 1)$ and $\bar{\gamma} \leq 1$ if $\alpha \geq b$, this semi-pooling equilibrium always exists when $b \leq \mu$. When $b > \mu$, this semi-pooling equilibrium exists only if $\alpha \geq b$.

If in this case the W-type entrant assigns to E a probability $q > \bar{q}$, as explained in previous cases, the monopoly will choose Ac when observing the signal s and F when observing the signal w and the semi-pooling equilibrium exists only if $\alpha = b$. Considering that the case $\alpha \in (\mu, 1)$ is being analyzed, this semi-pooling equilibrium only exists when $b > \mu$, otherwise $\alpha > b$ for all $\alpha \in (\mu, 1)$ and the W-type entrant will have incentives to deviate.

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