ENTRY UNDER AN INFORMATION-GATHERING MONOPOLY*

by

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The effects of information-gathering activities on an entry model with asymmetric information are analysed. The baseline game is a classical entry game where an incumbent monopoly faces potential entry by a firm without knowing for certain whether this potential entrant is weak or strong. If the entrant decides to enter, the incumbent must compete with him and decide whether to accommodate or to fight. The paper extends this entry game and considers that the monopoly credibly informs the entrant that she is able to gather information about his type if he finally enters the market, thereby helping her to better decide whether to accommodate or fight. Since knowing this might reduce the entrant’s willingness to compete with her, we focus the analysis on the effectiveness of this monopoly’s communicative action as an entry deterrence strategy. The results suggest that such an action is effective regardless of the precision of the Intelligence System (IS) only for a relatively low payoff gained by the entrant from competing with the incumbent. For higher payoffs for the entrant, the effectiveness of this action requires a considerably accurate IS.

1 Introduction

Information is an important resource for a firm, as much so as material, financial and human resources are, because information can make the difference between success and failure. An important part of it consists of information about other firms (competitors, incumbent firms, potential entrants, etc.) and it can be related to production processes and techniques, costs, efficiency and strength, recipes and formulas, customer datasets, actions, decisions, plans, strategies and so forth. These information-gathering activities may have competitive implications which are particularly important in markets with barriers to entry.

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The present paper considers an entry game in which the entrant has superior information and the incumbent may counter such a disadvantage by operating an information-gathering technology. Thus, the paper proposes a model that complements our understanding of the role of asymmetric information in market entry settings, a topic started by the studies conducted by Milgrom and Roberts (1982a, 1982b) and Kreps and Wilson (1982). Later papers on the topic include those by Milgrom and Roberts (1986), Bagwell and Ramey (1988), Leblanc (1992) and Bagwell (2007).

Nevertheless, the theoretical analysis of the impact of information-gathering activities on entry deterrence is more recent and it is illustrated by papers such as those by Barrachina et al. (2014, 2015). The first of these two studies considered the stylized model of entry deterrence by capacity expansion and assumed that the entrant can obtain noisy information about the incumbent’s action. The second carried out a similar analysis but considering the classical entry game developed by Milgrom and Roberts (1982a) and assuming that the entrant can gather noisy information about the monopoly’s cost structure.

However, could an incumbent use information-gathering activities as an entry deterrence strategy? The goal of the present paper is to develop a theoretical setting that addresses this research question. It elaborates on the previous related work to assume that the monopoly credibly informs the entrant that she will be able to gather information about him if he finally enters the market in an attempt to analyse the effectiveness of this action as an entry deterrence strategy.

The paper considers a simple classical entry game where a monopoly incumbent attempts to deter potential entry by considering the option of battling the potential entrant (Wilson, 1992). It is plausible to assume that the entrant’s type (strong or weak) is not known by the monopoly, but under symmetric information the monopoly would only fight against a weak entrant, deterring his market entry. In this sense, by credibly informing a potential entrant that his level of strength is known (or it will be known if he finally enters the market), in this context it can be considered as another entry deterrence strategy of the monopoly. On the other hand, although the incumbent’s information about the entrant’s type is not perfect, it could still help her to better decide whether to accommodate or fight under market entry. But, would knowing this still reduce the entrant’s willingness to compete with her?

In an attempt to answer this question, the paper extends this entry game by assuming that the incumbent credibly informs the entrant that she will conduct noisy information-gathering activities if he finally enters the market. It is assumed that the monopoly already has an Intelligence System (IS) that will allow her to gather (noisy) information about the entrant’s
level of strength.\footnote{For instance, the incumbent would be able to plant a Trojan horse in the entrant’s computer system if he finally enters the market.} Therefore, if the entrant decides to enter the market, this IS sends out one of two signals. One signal, labelled $s$, indicates that the entrant is strong, and the other, labelled $w$, indicates the opposite (that the entrant is weak). The IS has a level of precision, meaning that the signal sent by the IS will be correct with a probability equal to this IS precision. Based on the signal received, the incumbent must decide whether to accommodate or to fight the entrant (or with what probability she will do so).

The results obtained suggest that the monopolist’s action of credibly informing the entrant about how accurate her information about his type will be if he finally enters the market might have an entry deterrence effect regardless of this accuracy. In fact, this is true when the entrant’s payoff from competing with the incumbent is relatively small. Otherwise, the effectiveness of this action by the monopolist as an entry deterrence strategy requires credibly informing the entrant about a relatively accurate IS, not necessarily perfect but almost perfect, when the entrant’s payoff from entering the market is considerably high.

As stated above, this paper is related to Barrachina et al. (2014, 2015) and, consequently, to the references therein that theoretically analysed information-gathering (or information-sharing) activities in general and in an economic context. Moreover, this paper is related, on the one hand, to Begg and Imperato (2001), who analysed an information-gathering monopoly (as in this paper) that in an attempt to learn more about uncertain market demand, and, on the other hand, to the principal-agent literature where the agent can gather information before signing the contract. In the information-gathering models of Su (2017), Terstiege (2016), and Crémer et al. (1998a, 1998b), among others, the agent’s information acquisition can be either strategic (it improves the bargaining position of the agent although it is socially wasteful) or productive (socially useful in terms of production efficiency).

More recent developments in the theoretical analysis of information-gathering activities (not only in an economic context) include Zhang (2014), Kozlovskaya (2015) and Grabiszewski and Minor (2016). Zhang (2014) and Kozlovskaya (2015) consider, like the present paper, information-gathering activities in a setting with asymmetric information. Zhang (2014) analysed information-gathering activities in one-sided contests. Although their particular framework was not restricted to an economic context, it could be adapted to analyse 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.
The information-gathering technology considered is noisy as in the present paper. Finally, Grabiszewski and Minor (2016) analysed the effectiveness of counterespionage policies by considering the interaction between a domestic firm and a foreign firm, in which the former decides to try 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. Information-gathering 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 analyses the effects on market entry of the incumbent’s action of credibly informing the entrant about her information-gathering activity. Section 4 concludes the paper and discusses the analysis in the present paper as part of a broader perspective where credibly informing the entrant about information-gathering activities is the strategic decision of the incumbent.

2 The Model

The model considers a simple classical entry game, where a monopoly incumbent attempts to deter a potential entrant by considering the option of battling him (Wilson, 1992). As usually considered in this entry game, the monopoly faces the potential entry without knowing for certain whether the entrant is weak or strong (and this is common knowledge). In fact, she assigns probability $\mu$ that the entrant is strong (in which case he is referred to as being type $S$) and $1 - \mu$ that he is weak (namely, he is of type $W$). If the entrant decides not to enter ($NE$), he obtains zero and the monopoly obtains the monopoly profit ($\Pi_M$). However, if the entrant chooses to enter ($E$), the incumbent 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 ($a - 1$) if she decides to fight and a positive one if she decides to accommodate ($a$). The strong entrant obtains a positive payoff in both cases, but the payoff is higher if the monopoly decides to accommodate ($B > B - 1$). If the entrant is weak, the monopoly obtains a positive payoff regardless of whether she decides to fight or accommodate, but the payoff from fighting is higher ($A > A - 1$). The weak entrant obtains a positive payoff from entering the market if the monopoly decides to accommodate ($b$) but a negative one if she decides to fight ($b - 1$).

To analyse the effectiveness of using information-gathering activities as an entry deterrence strategy in this context, let us consider that the monopoly credibly informs the entrant that she has access to an Intelligence System (IS) that will allow her to gather (noisy) information about his level of strength if he finally enters the market. More precisely, this IS will send one of two signals: signal $s$, which indicates that the entrant is strong, and
signal \( w \), which indicates that the entrant is weak. The precision of the IS is assumed to be (without loss of generality) \( \alpha, \frac{1}{2} \leq \alpha \leq 1 \). That is, the signal sent by the IS is correct with probability \( \alpha \) (namely, \( \Pr(s/S) = \Pr(w/W) = \alpha \) and \( \Pr(w/S) = \Pr(s/W) = 1 - \alpha \)). This IS is of exactly the same nature as that considered by Barrachina et al. (2014, 2015) and the information devices in Solan and Yariv (2004).

When we say that the incumbent credibly informs the entrant, we mean that the incumbent informs the entrant about her actual information-gathering activity, the entrant trusts her completely and this is common knowledge. In practical terms, the model assumes that the precision, \( \alpha \), of the IS is commonly known by both firms. In this context, the case in which \( \alpha = 1/2 \), i.e. when the signal sent by the IS is not informative, is equivalent to the case in which the monopoly credibly informs the entrant that she does not use any IS (the basic entry game discussed 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 credibly informs the entrant that she will detect his type if he finally enters the market (the symmetric information case). To analyse the effect of informing about the different possible levels of accuracy of the IS, we also assume that \( \alpha \) is exogenous and costless.\(^2\)

Once the incumbent has credibly informed the potential entrant that she has access to this IS, the interaction between these two firms is described as a two-stage game of incomplete information \( G(\alpha) \). It is analysed, following Harsanyi’s approach, as a three-player game, in which the players are the two types of entrant, \( S \) and \( W \), and the monopoly. In the first period, the potential entrant chooses between entering the market or not, depending on his type and the accuracy of the IS he has been informed about. If he decides not to enter the market, the game ends. But if he enters, the incumbent conducts her information-gathering activity through the IS, which will send one of two signals (either \( s \) or \( w \)). Based on the signal received, the monopoly must decide whether to accommodate or fight the entrant. The payoffs are the same as the ones in the basic entry game considered above.

Figure 1 describes this game \( G(\alpha) \) in extensive form, where \( 0 < a < 1 < A \) and \( 0 < b < 1 < B \). Note that the first element in each 2-tuple of payoffs represents the payoff for the entrant.

3 Information-Gathering Activity

This section analyses the effectiveness of the incumbent’s action of credibly informing the entrant that she will conduct information-gathering activities if he finally enters the market as an entry deterrence strategy.

\(^2\)This assumption allows us to study the effectiveness of credibly informing the entrant as an entry deterrence strategy. A discussion about the analysis of the case where credibly informing is the strategic decision of the incumbent (which may include the case where \( \alpha \) is endogenous) can be found in the last section of the paper.
First of all, it is straightforward to see that entering is the strictly dominant strategy for the strong entrant regardless of the precision, $\alpha$, of the IS, since $0 < B - 1 < B$ (see Fig. 1). This assumption simplifies the analysis in two ways. On the one hand, under this assumption the most interesting case is that in which, according to her prior beliefs, the incumbent considers it likely that the entrant is weak (namely, $\mu < 1/2$). On the other hand, this assumption allows us to analyse the effect of information-gathering on market entry considering only the probability that the weak-type entrant assigns to $E$ in equilibrium for the different values of $\alpha$.

As will be shown in the following discussion, $b$ (as a measure of weak entrant payoff from competing with the incumbent) plays an important role in the model as a threshold to assess the precision of the IS and the weak-type entrant’s decision to enter the market.

Let $\text{Prob}_W^E(\alpha)$ be the probability the weak-type entrant assigns to $E$ in equilibrium as a function of the precision, $\alpha$, of the IS. The main result of the paper is summarized in the following proposition.

3 Actually, the conclusion about the effectiveness of the monopoly’s action of credibly informing the entrant as an entry deterrence strategy when $\mu < 1/2$ is not modified when $\mu \geq 1/2$. 

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Proposition. Consider the game $G(\alpha)$ for $1/2 \leq \alpha \leq 1$ and $\mu < 1/2$. Then $Prob^E_W(\alpha)$ is strictly decreasing in $\alpha$ if and only if $\alpha \in [\max\left(1/2, b\right), 1]$.

Proof: See Appendix A.

In fact, the monopoly’s action of credibly informing the entrant has an entry deterrence effect regardless of the precision of the IS ($1/2 \leq \alpha \leq 1$) when the weak entrant’s payoff from entering the market is sufficiently low ($b \leq 1/2$). Otherwise ($b > 1/2$), it has this effect only when the monopoly credibly informs about a relatively accurate IS ($b \leq \alpha \leq 1$). In this sense, the higher the weak entrant’s payoff from entering the market is, the more accurate the IS he is informed about must be in order to discourage him from entering the market. In particular, only credibly informing about an almost perfect IS could discourage him when this payoff is considerably high (when $b$ is relatively close to 1).

Figure 2 (which can be easily obtained from the results proven in the Appendix A together with Fig. A1) gives more details about the behaviour of the probability the weak entrant assigns to entering the market in equilibrium, $Prob^E_W(\alpha)$, depending on the different possible values of $b$.

As Fig. 2 shows, credibly informing the entrant about a relatively inaccurate IS may have a procompetitive effect when the weak entrant’s payoff
from entering the market is sufficiently high.\textsuperscript{4} In such a situation, not only can the probability assigned in equilibrium by the weak entrant to entering the market increase with the precision, $\alpha$, of the IS (see Fig. 2(b)–(d)), but also the weak entrant may decide to enter the market for sure, as shown in Fig. 2(c) and (d).\textsuperscript{5}

To analyse these results, consider first the case in which the monopoly credibly informs the entrant that there is no IS ($\alpha = 1/2$). Note that, in such a situation, the monopoly is quite comfortable fighting the entrant by considering he is likely to be weak. For this reason, the weak entrant does not rule out the option of staying out in an attempt to induce the incumbent to consider the accommodation option\textsuperscript{6} (given that entering and being fought is his worst scenario). Nevertheless, he enters the market with a positive probability, specifically $\bar{p} = \mu/(1 - \mu)$.

However, when the monopoly credibly informs the entrant that she has access to an informative IS (namely, $\alpha > 1/2$), the probability the weak entrant can assign to entering the market without discouraging the monopoly from accommodating depends on the signal sent by the IS. In particular, if the monopoly receives signal $s$, she will not be discouraged from accommodating for a higher range of probabilities of entry than if signal $w$ is received. Moreover, the more accurate the IS (the entrant is credibly informed about) is, the more the monopoly will trust the signal received and the higher the range of probabilities of entry for which the monopoly will follow the signal sent by the IS (fighting when receiving the signal $w$ and accommodating when the signal $s$ is received).

In this context, the weak entrant could assign a relatively high probability to entering the market (higher than when he is credibly informed that there is no IS), which increases with the accuracy of the IS he is informed about, without discouraging the monopoly from accommodating if she receives signal $s$. But in that case he would be assuming the risk of being fought if he is detected, i.e. if the monopoly receives signal $w$. As shown in Fig. 2(b)–(d), the weak entrant will consider it worth taking this risk and

\textsuperscript{4}This result is similar to the one found by Barrachina et al. (2015). According to them, a commonly known information-gathering activity conducted by the entrant in a context of asymmetric information, as in the present paper, potentially increases competition. However, in a market entry setting with imperfect information, Barrachina et al. (2014) found that the entrant is more likely to enter the market only when the precision of the information-gathering technology is his private knowledge.

\textsuperscript{5}The incumbent would not be interested in credibly informing the entrant about an informative IS if it is not effective in discouraging him from entering the market. However, these results suggest that, in a different setting in which the incumbent operates no IS, the entrant might be interested in sending the incumbent an informative but relatively imperfect and noisy signal about his type (à la Crawford and Sobel (1982), for instance), thereby letting her know its accuracy.

\textsuperscript{6}Note that fighting (not accommodating) is the best strategy for the incumbent if she knows the entrant is weak.
will enter the market with relatively high probability when his payoff from entering the market and competing with the incumbent is sufficiently high \((b > 1/2)\) and, at the same time, the IS he is informed about is inaccurate enough to make it quite unlikely to be detected \((\alpha < b)\).

The incumbent will fully trust signal \(s\), no matter how likely the weak entrant is to enter the market, when the IS is sufficiently accurate (more precisely when \(\alpha \geq 1 - \mu\)).\(^7\) The weak entrant will take advantage of this situation and will enter the market for sure only when his payoff from entering the market is so high that the precision of the IS he is informed about can be high enough for the incumbent to fully trust signal \(s\) and, at the same time, not too high so that the weak entrant still considers it worth taking the risk of being fought. This is the case when \(1 - \mu \leq \alpha \leq b\) (see Fig. 2(c) and (d)).

Nevertheless, when he is informed about a relatively accurate IS \((\alpha > b)\), the weak entrant considers it is likely to be detected and it is not worth taking the risk of being fought even though his payoff from entering the market is quite high and the monopoly is not discouraged from accommodating when observing signal \(s\). In such a situation, he assigns a small probability to entering the market (smaller than when he is informed that there is no information-gathering activity) to induce the monopoly to consider the accommodation option even when receiving signal \(w\).

Given that the more accurate the IS is, the more the monopoly trusts its signals, then the higher the precision of the IS is, the smaller the range of probabilities of entry the monopoly will accept without fighting when she receives signal \(w\). Hence, the more accurate the IS he is informed about is, the smaller the probability the weak entrant can assign to entering the market without discouraging the monopoly from accommodating when observing signal \(w\), staying out of the market for sure only when he is informed that the IS is perfect (see Fig. 2(b)–(d) for \(b \leq \alpha \leq 1\)). That is to say, only when the monopoly credibly informs the entrant that she will correctly detect his type if he finally enters the market is the weak entrant completely deterred from entering the market. Otherwise \((1/2 \leq \alpha < 1)\), under the staying-out decision of the weak entrant, the monopoly would have no doubt about accommodating regardless of the signal sent by the IS, thus making the weak entrant regret his decision.

As Fig. 2(a) shows, this anticompetitive effect of the monopoly’s action of credibly informing the entrant about her information-gathering activity is always the case (regardless of the accuracy of this information-gathering activity) when the weak entrant’s payoff from entering the market is quite small \((b \leq 1/2)\). He, therefore, does not consider it worth taking the risk of being fought even when it is unlikely to be detected.

\(^7\)This is basically due to the assumption of the model according to which entering is the dominant strategy for the strong entrant.
4 Summary and Conclusions

Firms usually gather information about other firms. Although these firms’ information-gathering activities may have competitive effects, which can be especially important in markets with barriers to entry, little theoretical work has been undertaken to analyse them. This paper takes a modest step forward in closing this gap in the literature by considering a model in which a monopoly incumbent does not know the level of strength (strong or weak) of a potential entrant and uses an Intelligence System (IS), of a certain precision, that will send noisy signals about this level of strength if the entrant finally enters the market. The monopoly uses this information to decide whether to accommodate or to fight the entrant.

The goal of the paper is to analyse the effectiveness of the monopoly’s action of credibly informing the entrant about this information-gathering activity as an entry deterrence strategy. The results suggest that this monopoly’s action would not always be effective in discouraging the entrant from entering the market. It would be effective regardless of the precision of the information obtained by the monopoly only when the entrant’s payoff from competing with the incumbent is relatively low. For a higher payoff for the entrant, the effectiveness of this action in terms of entry deterrence would require considerably more accurate information.

This analysis would be part of a broader perspective where credibly informing the entrant about this information-gathering activity is the strategic decision of the incumbent. Consider first that that the precision of the IS is exogenous, as in the present paper, and the incumbent decided not to inform the entrant about her information-gathering activity. In this case, the actual precision of the IS would be the private information of the incumbent and the model would incorporate two-sided asymmetric information. In such a game, the entrant would have some beliefs about the precision of the IS, and it would include the case where the incumbent does not operate any IS, namely the actual precision of the IS is $\alpha = 1/2$, but the entrant considers it likely to be $\alpha > 1/2$.

This two-sided asymmetric information situation, together with the credible communication case analysed in the present paper, would be the two subgames in a game in which in the first period the incumbent strategically decides whether or not to communicate the exogenous precision of the IS to the entrant.

Nevertheless, note that in this setting in which the precision of the IS is exogenously given, it makes no sense for the incumbent to cheat the entrant about this precision since it is assumed that the IS is costless. This cheating strategy would only make sense in a setting where the precision of the IS is the strategic choice of the incumbent and the IS is increasingly costly with this precision. In this setting the incumbent, after choosing the precision of the IS, may have incentives to convince the entrant that the IS is sufficiently precise (in an attempt to deter him from entering the market) when, in fact, it is not that accurate.
The other two strategies for the incumbent after choosing the precision of the IS in this setting would be to inform the entrant about the actual precision chosen and not to inform him about any precision at all. If the incumbent chooses to communicate some precision, the entrant should decide whether or not to enter the market depending not only on the precision communicated by the incumbent, but also on the extent to which he considers this precision is likely to be true. We leave these analyses for future research.

APPENDIX A

The present Appendix A proves the Proposition and the behaviour of the probability that the \(W\)-type entrant assigns to \(E\) in equilibrium, \(\Pr_b^E\), depicted in Fig. 4 in the main text. First, as stated in the main text, \(E\) is the \(S\)-type entrant’s dominant strategy in \(G(\alpha)\) for all \(\alpha \in [1/2,1]\) because \(0 < B - 1 < 1\) (see Fig 1 in the main text). Let \(\Pr(E/t)\) be the probability assigned to \(E\) by the \(t\)-type entrant. Hence, \(\Pr(E/S) = 1\) in every possible equilibrium of \(G(\alpha)\) for all \(\alpha \in [1/2,1]\).

Next, the following analysis focuses on the equilibrium strategies of the \(W\)-type entrant in \(G(\alpha)\) for \(1/2 \leq \alpha \leq 1\) and \(\mu < 1/2\). Consider first the two extreme cases \(\alpha = 1/2\) and \(\alpha = 1\). The following lemma summarizes the equilibrium strategies of the \(W\)-type entrant in these two cases.

**Lemma A1.** Consider the game \(G(\alpha)\) for \(0 < \mu < 1/2\). Then,

1. if \(\alpha = 1/2\), the \(W\)-type entrant assigns in equilibrium a probability \(\bar{p} = \mu/(1 - \mu)\) of entering the market;
2. if \(\alpha = 1\), the \(W\)-type entrant stays out in the only equilibrium of the game.

**Proof**

(1) Note that, when \(\alpha = 1/2\), the game \(G(\alpha)\) is the basic entry game discussed in the main text in which it is common knowledge that the monopoly faces the potential entry without knowing for certain whether the entrant is weak or strong.

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

\[
\Pr(t/E) = \frac{\Pr(E/t) \Pr(t)}{\sum_{t=S,W} \Pr(E/t) \Pr(t)}
\]

where \(\Pr(t)\) 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 from choosing \(F\) and \(Ac\) can be calculated by applying the expression for her updated beliefs given by (A1). These two expected payoffs are given by

\[
EU_M(F) = \Pr(S/E)(\alpha - 1) + \Pr(W/E)A
\]

(2)
\[ EU_M(Ac) = \Pr(S/E) a + \Pr(W/E) (A - 1) \]  

Assume next that the \( W \)-type entrant assigns a certain probability \( p \in [0,1] \) to \( E \), namely \( \Pr(E/W) = p \). From (A1),

\[ \Pr(S/E) = \frac{\mu}{\mu + p(1 - \mu)} \]  

and

\[ \Pr(W/E) = \frac{p(1 - \mu)}{\mu + p(1 - \mu)} \]

Further, substituting (A4) and (A5) in (A2) and (A3),

\[ EU_M(F) = \frac{\mu(a - 1) + p(1 - \mu) A}{\mu + p(1 - \mu)} \]  

and

\[ EU_M(Ac) = \frac{\mu a + p(1 - \mu)(A - 1)}{\mu + p(1 - \mu)} \]

Note that (A6) is equal to (A7), and the monopoly is indifferent between \( F \) and \( Ac \) only if the \( W \)-type entrant chooses to enter the market with probability \( p = \bar{p} \), where \( \bar{p} = \mu/(1 - \mu) \) and \( \bar{p} \in (0,1) \) since \( 0 < \mu < 1/2 \).

Hence, if the \( W \)-type entrant assigns probability \( \bar{p} \) 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 \( (\bar{p}, 1 - \bar{p}) \) only if he is indifferent between his two pure strategies, \( E \) and \( NE \). Specifically, \( \beta(b - 1) + (1 - \beta) b = 0 \), and this semi-pooling equilibrium exists if the monopoly chooses to fight the entrant with probability \( \bar{\beta} = \bar{b} \), where \( 0 < b < 1 \).

If the \( W \)-type entrant assigns probability \( 0 \leq p < \bar{p} \) to \( E \), (A6) is smaller than (A7), namely, the monopoly accommodates if she observes a market entry, and the \( W \)-type entrant has incentives to deviate to choose \( E \) purely. Similarly, if the \( W \)-type entrant assigns probability \( \bar{p} < p \leq 1 \) to \( E \), (A6) is higher than (A7), which implies that the monopoly fights if she observes a market entry and the \( W \)-type entrant has incentives to deviate and choose \( NE \) purely.

(2) When \( a = 1 \), namely the IS is perfect, and it is common knowledge that \( M \) can detect the entrant’s type perfectly (when \( a = 1 \), \( G(a) \) becomes a game of complete information). Since it is common knowledge that \( M \) will know the entrant’s type if he finally enters the market, and she will choose her action based on it (\( Ac \) if the entrant is strong and \( F \) if the entrant is weak), the weak entrant does not enter the market because \( b - 1 < 0 \).

Consider next the intermediate cases in which \( 1/2 < a < 1 \). Before analysing the equilibrium strategies of the \( W \)-type entrant, let \( \bar{q}(a) = \mu(1 - \alpha)/\alpha(1 - \mu) \) and \( \bar{\mu}(a) = a\mu/(1 - \alpha)(1 - \mu) \) be two threshold probabilities assessing the monopoly’s decision to accommodate or fight depending on the probability of entering the market assigned by the \( W \)-type entrant. The following lemma summarizes important features of these two threshold probabilities.
Lemma A2. Consider the threshold probabilities \( \tilde{q}(\alpha) \) and \( \tilde{\alpha}(\alpha) \).

1. \( 0 < \tilde{q}(\alpha) < \tilde{\alpha}(\alpha) \) for every precision, \( \alpha \), of the IS, \( \alpha \in (1/2, 1) \).
2. \( \tilde{q}(\alpha) < 1 \) for all \( \mu \in (0, 1/2) \) and \( \tilde{\alpha}(\alpha) < 1 \) iff \( \alpha < 1 - \mu \).
3. \( \tilde{\alpha}(\alpha) \) decreases with the precision, \( \alpha \), of the IS, while \( \tilde{q}(\alpha) \) increases;
4. both \( \tilde{q}(\alpha) \) and \( \tilde{\alpha}(\alpha) \) are convex (relative to \( \alpha \)); and
5. \( \tilde{q}(1/2) = \tilde{\alpha}(1/2) = \mu/(1 - \mu) \tilde{q}(1) = 0 \), and \( \tilde{q}(1) \) is not well defined (but \( \tilde{\alpha}(\alpha) \) approaches infinity as \( \alpha \) approaches 1).

PROOF

1. It is straight forward to see that \( \tilde{q}(\alpha) > 0 \) and \( \tilde{\alpha}(\alpha) > 0 \) for all \( \mu \in (0, 1/2) \) and \( \alpha \in (1/2, 1) \). It is also easy to see that \( \tilde{q}(\alpha) < \tilde{\alpha}(\alpha) \) for all \( \alpha > 1/2 \).
2. (2) \( \tilde{q}(\alpha) < 1 \) iff \( \mu (1 - \alpha) < \alpha (1 - \mu) \), which is always satisfied since \( \mu < 1/2 < \alpha \). \( \tilde{\alpha}(\alpha) < 1 \) iff \( \alpha \mu < (1 - \alpha) (1 - \mu) \), which is straight forward to see that it is equivalent to \( \alpha < 1 - \mu \).
3. (3) \( \partial \tilde{q}(\alpha)/\partial \alpha = -\mu(1 - \mu)/(\alpha(1 - \mu))^2 < 0 \) for all \( \alpha \in (1/2, 1) \) because \( \mu \in (0, 1) \); and \( \partial \tilde{\alpha}(\alpha)/\partial \alpha = \mu(1 - \mu)/((1 - \alpha)(1 - \mu))^2 > 0 \) for all \( \alpha \in (1/2, 1) \).
4. (4) \( \partial^2 \tilde{q}(\alpha)/\partial \alpha^2 = 2\mu(1 - \mu)^2/(\alpha(1 - \mu))^3 > 0 \) and \( \partial^2 \tilde{\alpha}(\alpha)/\partial \alpha^2 = 2\mu(1 - \mu)^2/((1 - \alpha)(1 - \mu))^3 > 0 \) for all \( \alpha \in (1/2, 1) \).
5. Straight-forward.

It is useful to draw \( \tilde{q}(\alpha) \) and \( \tilde{\alpha}(\alpha) \) according to their features in Lemma A2.

![Figure A1](image)

The following lemma summarizes the equilibrium strategies of the \( W \)-type entrant in \( G(\alpha) \) for \( 1/2 < \alpha < 1 \).

Lemma A3. Consider the game \( G(\alpha) \) for \( 1/2 < \alpha < 1 \) and \( \mu < 1/2 \). Then,

1. when \( 1/2 < \alpha < 1 - \mu \), the equilibrium strategy of the \( W \)-type entrant depends on \( \alpha \) and \( b \): if \( \alpha < b \), the \( W \)-type entrant enters the market with probability \( \tilde{q}(\alpha) \); if \( \alpha = b \),
the game has a multiplicity of equilibria in which the $W$-type entrant enters the market with probability $q \in \overline{\tilde{q}}(\alpha), \tilde{q}(\alpha)$; and if $\alpha > b$, the $W$-type entrant assigns probability $\tilde{q}(\alpha)$ of entering the market;

2. when $\alpha = 1 - \mu$, the equilibrium strategy of the $W$-type entrant depends on $b$: if $b < 1 - \mu$, the $W$-type entrant enters the market with probability $\tilde{q}(\alpha)$; if $b = 1 - \mu$, the game has a multiplicity of equilibria in which the $W$-type entrant enters the market with probability $q \in \overline{\tilde{q}}(\alpha), 1$; and if $b > 1 - \mu$, the $W$-type entrant enters the market for sure; and

3. when $1 - \mu < \alpha < 1$, the equilibrium strategy of the $W$-type entrant depends on $\alpha$ and $b$: if $\alpha < b$, the $W$-type entrant enters the market for sure; if $\alpha = b$, the game has a multiplicity of equilibria in which the $W$-type entrant enters the market with probability $q \in \overline{\tilde{q}}(\alpha), 1$; and if $\alpha > b$, the $W$-type entrant enters the market with probability $\tilde{q}(\alpha)$.

Proof

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 by 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,

$$\Pr(t/E, \sigma) = \frac{\Pr(E/t) \Pr(\sigma/t) \Pr(t)}{\sum_{t=S,W} \Pr(E/t) \Pr(\sigma/t) \Pr(t)} \tag{8}$$

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

Let $EU_M(F/\sigma)$ and $EU_M(Ac/\sigma)$ be the monopoly’s expected payoffs from choosing $F$ and $Ac$, respectively, when she observes a market entry and the IS sends signal $\sigma$, which can be obtained by applying (A8),

$$EU_M(F/\sigma) = \Pr(S/E, \sigma) (a - 1) + \Pr(W/E, \sigma) A \tag{9}$$

$$EU_M(Ac/\sigma) = \Pr(S/E, \sigma) a + \Pr(W/E, \sigma) (A - 1) \tag{10}$$

Consider next that the $W$-type entrant assigns probability $q \in [0, 1]$ to $E$, namely $\Pr(E/W) = q$. From (A8),

$$\Pr(S/E, s) = \frac{\alpha \mu}{\alpha \mu + q (1 - \alpha) (1 - \mu)} \tag{11}$$

$$\Pr(W/E, s) = \frac{q (1 - \alpha) (1 - \mu)}{\alpha \mu + q (1 - \alpha) (1 - \mu)} \tag{12}$$
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\[ \Pr (S/E,w) = \frac{(1-\alpha) \mu}{(1-\alpha) \mu + q\alpha (1-\mu)} \]  

(13)

\[ \Pr (W/E,w) = \frac{q\alpha (1-\mu)}{(1-\alpha) \mu + q\alpha (1-\mu)} \]  

(14)

By substituting (A11) and (A12) in (A9) and (A10), the monopoly’s expected payoffs when observing signal \( S \) are obtained,

\[ EU_M (F/S) = \frac{\alpha \mu (a-1) + q (1-\alpha) (1-\mu) A}{\alpha \mu + q (1-\alpha) (1-\mu)} \]  

(15)

\[ EU_M (Ac/S) = \frac{\alpha \mu a + q (1-\alpha) (1-\mu) (A-1)}{\alpha \mu + q (1-\alpha) (1-\mu)} \]  

(16)

Note that (A15) is strictly higher than (A16) and consequently the monopoly will choose \( F \) when observing signal \( S \) only if \( q > \hat{q} (\alpha) \).

The monopoly’s expected payoffs when observing signal \( W \) are obtained by substituting (A13) and (A14) in (A9) and (A10),

\[ EU_M (F/w) = \frac{(1-\alpha) \mu (a-1) + q\alpha (1-\mu) A}{(1-\alpha) \mu + q\alpha (1-\mu)} \]  

(17)

\[ EU_M (Ac/w) = \frac{(1-\alpha) \mu a + q\alpha (1-\mu) (A-1)}{(1-\alpha) \mu + q\alpha (1-\mu)} \]  

(18)

The monopoly will choose \( F \) when observing signal \( W \), namely (A17) is strictly higher than (A18) only if \( q > \hat{q} (\alpha) \).

As stated by the first and second parts of Lemma A2, \( \hat{q} (\alpha) < 1 \) and \( \hat{q} (\alpha) < 1 \) for all \( \mu \in (0,1/2) \) and \( \alpha \in (1/2,1) \).

The proof of Lemma A3 follows from considering the following cases.

Case 1. Consider the case where \( \alpha \in (1/2,1-\mu) \). In this case, according to the second part of Lemma A2, \( \hat{q} (\alpha) < 1 \). If in this case the \( W \)-type entrant assigns a probability \( q \in [0,\hat{q} (\alpha)] \) to \( E \), (A15) is strictly smaller than (A16) and (A17) is strictly smaller than (A18). That is, the monopoly will choose \( Ac \) regardless of the signal sent by the IS, and the \( W \)-type entrant is better off deviating and choosing \( E \) purely. If in this case the \( W \)-type entrant assigns a probability \( q \in (\hat{q} (\alpha),1] \) to \( E \), (A15) is strictly higher than (A16), and (A17) is strictly higher than (A18). Namely, the monopoly will choose \( F \) regardless of the signal sent by the IS and the \( W \)-type entrant is better off deviating and choosing \( NE \).

If in this case the \( W \)-type entrant assigns a probability \( q = \hat{q} (\alpha) \) to \( E \), (A15) is strictly smaller than (A16) but (A17) is equal to (A18). That is to say, the monopoly will choose \( Ac \) when observing signal \( S \) and, being indifferent between \( F \) and \( Ac \) when observing signal \( W \), will assign some probability \( \gamma \in [0,1] \) to \( F \). The \( W \)-type entrant, knowing that if he enters
the market the IS sends the right signal $w$ with probability $\alpha$ (and the wrong signal $s$ with probability $1 - \alpha$), will not deviate from the mixed strategy only if he is indifferent between his two pure strategies. Namely,

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

Equivalently, $\gamma = \tilde{\gamma}$, where $\tilde{\gamma} = b / \alpha$.

Bearing in mind that $\tilde{\gamma} \leq 1$ if $a \geq b$, and the case $a \in (1/2, 1 - \mu)$ is being analysed, this semi-pooling equilibrium always exists when $b \leq 1/2$, and when $1/2 < b < 1 - \mu$ it exists only if $a \geq b$. 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 a probability $q \in (\tilde{q} (a), \tilde{q} (a))$ to $E$. (A15) is strictly smaller than (A16) but (A17) is strictly higher than (A18). That is, the monopoly will choose $Ac$ when observing signal $s$, and $F$ when observing signal $w$. The $W$-type entrant will not deviate from the mixed strategy only if

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

Equivalently, $\alpha = b$.

Bearing in mind that the case $a \in (1/2, 1 - \mu)$ is being analysed, this semi-pooling equilibrium only exists when $1/2 < b < 1 - \mu$.

If in this case the $W$-type entrant assigns a probability $q = \tilde{q} (a)$ to $E$. (A15) is equal to (A16) but (A17) is strictly higher than (A18). Hence, the monopoly being indifferent between $F$ and $Ac$ when observing signal $s$ will assign some probability $\lambda \in [0, 1]$ to $F$, and will choose $F$ when observing signal $w$. The $W$-type entrant will not deviate from the mixed strategy only if

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

Equivalently, $\lambda = \tilde{\lambda}$, where $\tilde{\lambda} = (b - \alpha) / (1 - \alpha)$.

Note that $\tilde{\lambda} < 1$ always because $b < 1$ but $\tilde{\lambda} \geq 0$ only if $a \leq b$. Bearing in mind that the case $a \in (1/2, 1 - \mu)$ is being analysed, this semi-pooling equilibrium does not exist when $b \leq 1/2$ because $a > b$ always in that case. When $1/2 < b < 1 - \mu$ this semi-pooling equilibrium exists only if $a \leq b$; and when $b \geq 1 - \mu$ this semi-pooling equilibrium always exists.

Case 2. Consider the case where $a \in [1 - \mu, 1]$. In this case, according to Lemma A2, $\tilde{q} (a) \geq 1$.

Similar to the previous case, there is no equilibrium in which the $W$-type entrant assigns a probability $q \in [0, \tilde{q} (a))$ to $E$. If the $W$-type entrant assigns a probability $q = \tilde{q} (a)$ to $E$, as explained in the previous case, the semi-pooling equilibrium exists only if the monopoly chooses $F$ with a probability of $\tilde{\gamma}$. However, considering that in this case $a \in [1 - \mu, 1]$ and $\tilde{\gamma} \leq 1$ if $a \geq b$, this semi-pooling equilibrium always exists when $b \leq 1 - \mu$. When $b > 1 - \mu$, this semi-pooling equilibrium exists only if $a \geq b$.

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

Finally, consider the case in which the $W$-type entrant chooses $E$ purely (namely, assigns to $E$ a probability $q = 1$). Two subcases must be considered here.

Subcase 2.1. Consider the case where $a = 1 - \mu$. In this case, according to Lemma A2,
\( \bar{q}(\alpha) = 1 \). Hence, if the \( W \)-type entrant assigns a probability \( q = 1 \) to \( E \), \( \bar{q}(\alpha) < q = \bar{q}(\alpha) \). Namely, the monopoly is indifferent between \( F \) and \( Ac \) when observing signal \( s \) and assigns some probability \( \bar{\lambda} \in [0, 1] \) to \( F \), but chooses \( F \) for sure when observing signal \( w \). The \( W \)-type entrant will not deviate from \( E \) only if

\[
(1 - \alpha)(\lambda(b - 1) + (1 - \lambda)b) + \alpha(b - 1) \geq 0
\]

Equivalently, \( \bar{\lambda} \leq \bar{\lambda} \).

Bearing in mind that \( \bar{\lambda} \geq 0 \) if \( \alpha \leq b \) and the case \( \alpha = 1 - \mu \) is being analysed, this pooling equilibrium only exists when \( b \geq 1 - \mu \) (otherwise \( \bar{\lambda} < 0 \) because \( \alpha = 1 - \mu > b \)).

**Subcase 2.2.** Consider the case where \( \alpha > 1 - \mu \). In this case, according to Lemma A2, \( q(\alpha) > 1 \). Hence, if the \( W \)-type entrant assigns a probability \( q = 1 \) to \( E \), \( \bar{q}(\alpha) < q < \bar{q}(\alpha) \). In other words, the monopoly will choose \( Ac \) when observing signal \( s \) and \( F \) when observing signal \( w \). The \( W \)-type entrant will not deviate from \( E \) only if

\[
(1 - \alpha)b + \alpha(b - 1) \geq 0
\]

Equivalently, \( \alpha \leq b \).

Bearing in mind that the case \( \alpha > 1 - \mu \) is being analysed, this pooling equilibrium only exists when \( b > 1 - \mu \) (otherwise \( \alpha > b \) always and the \( W \)-type entrant will have incentives to deviate).

The proof of the Proposition and Fig. 4 in the main text follows immediately from Lemmata A1–A3.

**REFERENCES**


