

Free entry does not imply zero profits

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Abstract

Traditional economic wisdom says that free entry in a market will drive profits down to zero. This conclusion is usually drawn under the assumption of perfect information. We assume that a priori there exists imperfect information about the profitability of the market, but that potential entrants may learn the demand curve perfectly at negligible cost by engaging in market research. Even if in equilibrium firms learn the demand perfectly, profits may be strictly positive because of insufficient entry. The mere fact that it will not become common knowledge that every entrant has perfect information about demand causes this surprising result.

Belief means doubt. Knowing means certainty.

Introduction to the *Kabalah*.

1 Introduction

Although numerous articles and books are devoted to the notion of entry barriers, a clear-cut and unambiguous definition of the notion is still missing. (See for example Demsetz (1982) for a discussion.) In spite of this lack of a precise definition, many authors have identified several factors that make entry more costly and less likely such as economies of scale, sunk costs, advertising by incumbents, and customer loyalty. For the purpose of this paper let us call something an entry barrier if it literally bars entry, that is, if in the absence of this factor more firms would enter in the industry. The purpose of this paper is to identify and illustrate a new type of entry barrier that is based on beliefs and uncertainty. Belief-based entry barriers are not new: A rational potential entrant will decide to enter if it expects to be able to make net profits, given its production possibilities and consumer demand and given certain expectations about how established firms will respond to entry. If a potential entrant expects the incumbent firm not to respond at all and keep its production level fixed, it may be optimal, given these expectations, to forego entry. (See Bain (1956).) However, it would not be rational for the incumbent not to respond if entry did occur, and therefore the beliefs of the entrant are not consistent. Milgrom and Roberts (1982) show that entry may be deterred by rationally formed Bayesian beliefs if the potential entrant does not know the costs of the incumbent firm. When the entrant bases its belief on observed pre-entry price, the incumbent has the possibility to influence the entrant's belief, and it may be optimal to choose the pre-entry price in such a way that entry will be deterred.

Our entry barrier will be different from the existing ones in that (i) beliefs are consistent and (ii) beliefs cannot be influenced by incumbents. Because of (ii) there is no role for entry deterring behavior in our model and antitrust legislators need not be too concerned about this barrier since there is no way to avoid it. Moreover, it turns out that this new barrier may actually be socially desirable since the social cost of entry may be higher than the private cost borne by the entrant. Although our concept is perhaps of little use to legislators, we believe it is interesting for economic theory. The fact that entrants' beliefs may deter entry implies that incumbent firms may earn supernormal profits in spite of the presence of potential competition and in spite of the absence of entry deterring behavior. That is, the assumption of *free entry* does not (necessarily) imply zero profits.

We will illustrate our concept of “beliefs as a barrier to entry” using a slight variation of the widely used two stage model of endogenous entry and market structure. In the first stage of this basic game (many) firms decide whether or not to enter. In the second stage the firms that decided to enter compete in some manner. Entry can be simultaneous or sequential and involves a sunk (irreversible) cost $K > 0$. Competition can be in prices (Bertrand) or quantities (Cournot) or otherwise (e.g. joint profit maximization). The competition stage with J active firms usually has a unique (and symmetric) equilibrium yielding unique equilibrium profits π_J for each firm that entered. Assuming that π_J is decreasing in J and approaches zero when $J \rightarrow \infty$, the number of firms that will enter in the first stage is equal to J^* , where¹

$$\pi_{J^*} - K > 0 > \pi_{J^*+1} - K.$$

That is, the number of firms that will enter will be the maximal number of firms that will be able to make profits high enough to recover the costs of entry. If an additional firm would enter it would make losses. Ignoring the integer number problem, this is usually referred to as the zero profit condition or average cost pricing.

In the basic model described above the zero profit condition is an equilibrium result. Similar results are obtained for example in the entry models with product differentiation by Shaked and Sutton (1982) and Salop (1979). However, in many other models in the literature on imperfect competition the zero profit condition is assumed, either directly or indirectly by a free entry assumption. For instance, a large part of the international trade literature builds on the monopolistic competition model of Dixit and Stiglitz (1977) which assumes free entry. In empirical work on entry and market structure the zero profit condition is often directly imposed. For instance, Bresnahan and Reiss (1988, 1990, 1991) estimate the market sizes needed to support monopoly and duopoly, based on the hypothesis that entry will occur in a monopolistic market when duopoly profits are positive.

It is certainly true that a rational potential entrant will enter a market when it expects a positive net post-entry profit. This does not exclude the possibility that a monopoly may be retained even if the market is large enough to support two competing firms. The extensive literature on entry deterrence has shown how an incumbent monopolist may successfully deter entry and still obtain above normal profits. (See for example Milgrom and Roberts (1982) on limit pricing or Aghion and Bolton (1987) on contracts as a

¹We ignore the case where $\pi_J - K$ happens to be zero for some integer J .

barrier to entry.) However, these entry deterrence models are based on the existence of an incumbent firm that has a first mover advantage over late entrants. We claim that even when no incumbents are around, all potential entrants are identical, and no firm that enters has any strategic or experience advantage over other firms that enter, it still could be true that, for example, a monopoly will develop in a market large enough to support a duopoly. Our result is driven by the fact that post-entry profits not only depend on the true profitability of the market, but also on what entrants *know* about the profitability, and on what entrants *believe* about how much other entrants know about this profitability, and so on.

In this paper we consider the following variation of the basic model described above. We assume that the profitability of the market for a homogeneous good is not known by the potential entrants. Demand is stochastic. Potential entrants, however, have the opportunity to learn the outcome of the underlying random variables, before deciding whether or not to enter.² It is clear that if only partial and noisy information can be obtained, firms will have to take entry decisions under uncertainty and there is some chance that expected profitability does not coincide with ex-post profitability, which leads either to excessive or insufficient entry. The same holds when information costs are very high. We will, however, assume that potential entrants can obtain perfect information at negligible cost. One might conjecture that this slight variation of the basic model does not really change anything: The number of firms that will enter in any (reasonable) equilibrium (for each realization of demand) must be equal to the maximal number of firms that can recoup the entry costs.³ However, we will show that this conjecture is false. In principal it would suffice to give just one single generic counterexample. In order to show that our claim is robust we will provide three (generic) examples where the above conjecture does not hold. In all examples we consider simultaneous entry in the entry stage and Cournot competition in the production stage. The driving force behind our main counterexamples (when information acquisition is secret) is that the entry of one firm signals information to the other firms that have entered. It signals additional information about the state of demand and it reveals (partially) the informedness of the entrant. This additional information will be taken into account in the post-entry

²Geroski (1991) remarks that information gathering is an important aspect of the entry process, but that it is often ignored in (econometric) models because of the complexity it would impose and because of the unavailability of data on information gathering.

³We will use the concept of sequential equilibrium (Kreps and Wilson (1982)) as the reasonable concept.

competition stage and thereby affects the expected post-entry payoffs.

We first model information acquisition as a *covert* event, that is, at the time firms take their entry decision they have not observed the amount of information collected by other potential entrants. Our first two examples show that in this case the conjecture is false. For the first example there exists a sequential equilibrium in which firms become partially informed. After observing the entry decision of the other firm, beliefs concerning the state of demand are updated. On the equilibrium path the firms that have entered will have full information about the demand. When a firm deviates, however, and enters in some state of demand where it was supposed not to enter, it deceives the other firm that entered. That firm consequently overestimates demand and overproduces so much that it makes the deviation unprofitable. This same example also shows that introducing an additional covert information acquisition stage after entry has taken place but before firms start producing, will not restore the conjecture.

Our second example is even more striking. On the equilibrium path all firms fully learn the outcome of the random variables. Therefore, a deviation by one firm cannot lead to overestimates of demand by the other firm. Still, the conjecture turns out to be wrong. The result is now driven by the fact that a deviation by one firm can induce the other to revise its beliefs about how well the deviating firm is informed. This, again, affects the post-entry Cournot production levels and, therefore, the expectations of potential entrants.

In our final example we model information acquisition as an *overt* event, that is, at the time firms take their entry decision they know how much information other firms have collected. We find this assumption somewhat unrealistic but it has the advantage that in this framework firms cannot under- or overestimate the informedness of their competitors. However, overt information acquisition introduces the possibility of sequential equilibria in which not all information about demand is learned. Such equilibria are supported by credible threats (off the equilibrium path) to punish firms that gather ‘too much’ information. As a result, firms may learn too little and enter too often (even in markets that are not profitable).

The first two examples show that there may be less entry than expected when information gathering is secret. It should be noted that for these examples there exist other equilibria in which the ‘right’ number of firms enter. Hence, we do not claim that too few entry necessarily occurs, but that it might occur. Making a selection amongst the multiple equilibria would be equivalent to selecting some beliefs for the entrants. As Scherer and Ross (1990. p. 378) write “... a certain amount of pessimism is in order

when one is contemplating entry in a new industry on a large scale.” Such rational pessimism may favor the equilibrium in which too few entry occurs. It is worthwhile to remark that too much entry is not possible in any equilibrium. A firm can namely always avoid entry in a small and unprofitable market by learning all variables and not enter in these bad states. As we have seen from the third and last example, this claim is no longer true when information acquisition is overt, because firms that deviate and learn all variables to avoid entry in bad states can be punished in the good states.

The rest of the paper is set up as follows. Section 2 introduces the model of information acquisition, entry and competition. Section 3 provides the details of the examples described before and shows that there exists a sequential equilibrium in which insufficient (in Examples 1 and 2) or excessive (Example 3) occurs. Section 4 concludes.

2 Entry with Sunk Costs and Stochastic Demand

There are two firms, A and B. They have to decide whether to enter in a new market. Inverse demand in this market is given by $p = x + y - q$, where q denotes the total production and where both x and y are stochastic. We assume that the two random variables are independent, and that each can take a high or low value: x is equal to x^H or x^L , with probability α and $1 - \alpha$, respectively. Similarly, y is equal to y^H or y^L , with probability β and $1 - \beta$, respectively. $x^H > x^L$, $y^H > y^L$. The idea behind this is that demand is determined by several factors, and that uncertainty might exist about each of them. One possible interpretation is that x stands for ‘international demand’ or ‘demand by men’ while y stands for ‘domestic demand’ or ‘demand by women’. Firms can become informed about the realization of (some of) these variables, at a small cost of $\varepsilon > 0$ per variable. After observing the information gathered, each firm decides whether or not to enter this market, which implies that a cost K has to be sunk. After observing who entered, the firms that entered compete in the usual Cournot fashion. We assume that production is at zero cost. We will consider two variations of the model described above. First we consider **covert** information acquisition. This means that when firms take their entry decision they do not know what type of information their rival has obtained (that is none, about x only, about y only, or about both x and y). Later we consider **overt** information acquisition, which means that firms do have this type of knowledge at the entry decision node.

The demand function is such that when x is high, two competing firms will be able to recover entry cost. The market is never large enough to support three competing firms

so that our assumption of having only two potential entrants is without loss of generality. When x is low and y is high, two competing firms will not be able to recover the entry cost, but a single firm exercising monopoly power will recover the entry cost. Finally, in the bad state where both x and y are low, not even a monopolist would recover its cost. Thus:

Assumptions:

- (A1) $(x^H + y^H)^2/16 < K$
- (A2) $(x^H + y^L)^2/9 > K$
- (A3) $(x^L + y^H)^2/4 > K > (x^L + y^H)^2/9$
- (A4) $(x^L + y^L)^2/4 < K$

Under these assumptions the conjecture mentioned in the introduction reduces to:

Conjecture. *In any sequential equilibrium of the information acquisition-entry-Cournot game the number of firms that enter in the high-high state is 2, in the high-low state is 2, in the low-high state is 1 and in the low-low state is 0.*

In the following section we show that this conjecture is false.

3 The Examples

3.1 Covert information acquisition

Example 1. Let $\alpha = \beta = 1/2$ and $x^H = 17$, $x^L = 7$, $y^H = 11$, $y^L = 5$, $K = 50$. The following strategies and beliefs form a sequential equilibrium: Firm A learns x , and enters only when it is high. If it does not meet a competitor, A's belief puts all weight on the high-low state and it will produce the monopoly quantity $(x^H + y^L)/2 = 11$. If it does meet a competitor, A's belief puts all weight on the high-high state and it will produce the Cournot quantity $(x^H + y^H)/3 = 28/3$. Firm B learns y and enters only when it is high. If it does not meet a competitor, B's belief puts all weight on the low-high state and it will produce $(x^L + y^H)/2 = 9$. If it does meet a competitor, B's belief puts all weight on the high-high state and it will produce $(x^H + y^H)/3 = 28/3$.

First note that (A1)—(A4) hold.

Note that all information sets are reached with positive probability. Firms update their belief after observing whether the other firm has entered or not. If the other firm

enters then it must mean that he has ‘good’ information, if he does not enter, it means that he has ‘bad’ information. Beliefs are therefore consistent. It suffices now to check that the strategies are sequentially rational, given the beliefs.

It is clear that firms make positive profits whenever they have decided to enter, and that their production levels maximize their profits given the decision of the other firm. The only deviations that might be profitable are (1) for firm A to get complete information and enter additionally in the case of low x and high y ; (2) for firm B to get completely informed and enter additionally in the case of high x and low y . It is obvious that deviation 1 is not profitable. After observing entry in this state, firm B will believe that both variables are high and will therefore produce $(x^H + y^H)/3 = 28/3$. Firm A’s optimal quantity is therefore $(x^L + y^H - 28/3)/2 = 13/3$ for a profit of approximately⁴ 18.78, which is certainly not enough to cover the entry cost of 50.

Deviation 2 is not profitable either. By the same token as before, entry by firm B will imply that firm A believes demand is very high and produces $(x^H + y^H)/3 = 28/3$. The optimal production level for firm B is, therefore, $(x^H + y^L - 28/3)/2 = 19/3$, yielding a profit of 40.11, which is again not enough to cover the entry cost. \square

This example shows that there exists a sequential equilibrium of the information acquisition and entry game in which in the high-low state only one firm will enter, when in fact two firms competing à la Cournot would make profits. This holds whatever the cost ε of becoming informed about the different variables. Even zero information cost do not destroy this equilibrium. The result is driven by the fact that when firm B deviates and enters in the high-low state, firm A is deceived and overestimates demand, which in turn leads to overproduction (relative to the Cournot equilibrium) which makes entry not profitable for the deviating firm, at least for some range of the parameters.

Notice that in the equilibrium described in Example 1, all information sets are reached with positive probability. Hence, this equilibrium will satisfy any refinement of sequential equilibrium which is based on restrictions on out-of-equilibrium beliefs (such as the Intuitive Criterion of Cho and Kreps (1987)).

Consider a small variation of our model of information acquisition. Suppose that firms can also gather information after entry has taken place but before production is determined. This variation does not restore the validity of the conjecture. Firms will not find it optimal to spend money to do late research, since Bayesian updating along the equilibrium path already yields the full information.

⁴We will round off all payoffs to two decimals.

One might believe that the fact that firms become (in first instance) only partially informed is crucial. The next example shows that this is not true.

Example 2. Let $\alpha = 1/10$, $\beta = 1/2$, and $x^H = 19$, $x^L = 7$, $y^H = 13$, $y^L = 7$, $K = 70$. The following strategies and beliefs form a sequential equilibrium:

s^A : Firm A learns x and y and enters, except in the low-low state of demand. If it does not meet a competitor, it will produce the corresponding monopoly quantity (16, 13 or 10). If it does meet a competitor in the high-high state of demand, it will produce $(x^H + y^H)/3 = 32/3$. If it meets a competitor in the high-low state of demand, A's belief puts all weight on the event that the competitor entered without having gathered any information, and it produces $q_A^{hl} = 953/102$. If it meets a competitor in the low-high state of demand, A's belief puts all weight on the event that the competitor entered without having gathered any information, and it produces $q_A^{lh} = 647/102$.

s^B : Firm B learns x and y , and enters only when both are high. If it does not meet a competitor, it will produce the monopoly quantity $(x^H + y^H)/2 = 16$. If it does meet a competitor it will produce the Cournot output $(x^H + y^H)/3 = 32/3$.

Note that assumptions (A1)—(A4) are satisfied.

Let us check that the beliefs are consistent. Consider the possibility that firm B trembles with small probability δ in which case it does not gather information and decides to enter. When it does not meet a competitor it produces $(x^L + y^L)/2 = 7$, when it does meet a competitor it produces $373/51$. Let all other pure information acquisition and entry decisions occur with probability of order δ^2 . When firm A meets a competitor when demand is high-high, it will assign probability of almost 1 to the event that firm B did not tremble. When firm A meets a competitor when demand is high-low or low-high, belief revision will imply that firm A believes with probability of almost 1 that firm B trembled and entered without having gathered information. As $\delta \rightarrow 0$ the fully mixed strategy pair converges to (s^A, s^B) , while the beliefs generated by the fully mixed strategy pair converge to the beliefs described above.

Now we have to check that the strategies s^A , s^B are sequentially rational, given the beliefs. It is clear that firm A's strategy is optimal along the equilibrium path. How much should firm A produce in case he meets a competitor when demand is high-low or low-high? When firm B has trembled and finds himself in the situation where it

entered without having gathered information and meeting a competitor, it will discard the possibility of a low-low demand state. It will update its beliefs using Bayes' rule:

$$\mu^{hh} = \alpha\beta / (1 - (1 - \alpha)(1 - \beta)) = 1/11$$

$$\mu^{hl} = \alpha(1 - \beta) / (1 - (1 - \alpha)(1 - \beta)) = 1/11$$

$$\mu^{lh} = (1 - \alpha)\beta / (1 - (1 - \alpha)(1 - \beta)) = 9/11$$

Now it can be verified that $q_B = 373/51$ maximizes $q_B(\mu^{hh}(x^H + y^H - (x^H + y^H)/3 - q_B) + \mu^{hl}(x^H + y^L - q_A^{hl} - q_B) + \mu^{lh}(x^L + y^H - q_A^{lh} - q_B))$, while $q_A^{hl} = 953/102$ maximizes $q_A^{hl}(x^H + y^L - q_B - q_A^{hl})$, and $q_A^{lh} = 647/102$ maximizes $q_A^{lh}(x^L + y^H - q_B - q_A^{lh})$. The strategy of firm A is indeed optimal, given the beliefs.

Firm B's strategy is also optimal along the equilibrium path. However, we have to consider whether a deviation by entering in the high-low or low-high state of demand is profitable. The best production level for firm B after entering in the high-low demand state is $q = (x^H + y^L - q_A^{hl})/2 = 1699/204$, which yields benefits of $q^2 - K \approx -0.64 < 0$. It is therefore not profitable to deviate and to enter in the case of high-low demand, given the expectations of firm A. Similarly, entering in the low-high state is not profitable since the optimal production level would be equal to $(x^L + y^H - q_A^{lh})/2 = 1393/204$, and the loss (≈ -23.37) would this time be even worse. \square

In this example firms learn demand perfectly in equilibrium. However, in the high-low state of demand only firm A enters. Were firm B to deviate and enter in this state, then firm A would be faced with an unexpected event and he might believe that firm B made a mistake and entered without having gathered information. The uninformed firm B would then assign relatively high probability to the low-high state, and produce only $373/51 \approx 7.31$, which is less than the production level of a Cournot duopolist in the high-low state ($26/3 \approx 8.67$). This implies then that firm A would produce more than that level ($953/102 \approx 9.34$) which then makes the deviation by B unprofitable.

3.2 Overt information acquisition

The result of Example 2 was driven by the fact that a firm, off the equilibrium path, may hold incorrect beliefs about the informedness of the other firm. We can exclude such incorrect beliefs by assuming that information acquisition is overt. In the case of overt information gathering, firms can observe the information acquisition choice of the opponent before deciding whether or not to enter. Consequently, they can and will

condition their behavior on the type of information of their opponent. This assumption of observable information acquisition is admittedly unrealistic. How can an entrant know for sure what another entrant knows about demand? Still, it has been fairly common to model information acquisition in this way. (See for example Vives (1988) and Hwang (1993).) Our next example shows that with overt information acquisition very strange things may occur: even when the cost of information is very cheap, firms may refrain from acquiring it in such a model. The entry decision are, therefore, taken under uncertainty and it is not surprising that excessive or insufficient entry occurs.

Example 3. Let $\alpha = 9/10$, $\beta = 1/2$ and $x^H = 19$, $x^L = 7$, $y^H = 11$, $y^L = 6$, $K = 56.5$. The following strategies and beliefs form a sequential equilibrium:

On the equilibrium path: Firm A learns x , and enters only when it is high. It will produce the Cournot quantity $\beta \cdot [(x^H + y^H)/3] + (1 - \beta) \cdot [(x^H + y^L)/3] = 55/6$. Firm B does not learn about any of the variables and enters. If it does not meet a competitor, it updates its belief (x is low) and it will produce the monopoly level $\beta \cdot [(x^L + y^H)/2] + (1 - \beta) \cdot [(x^L + y^L)/2] = 7.75$. If it does meet a competitor, it will update its belief (x is high) and it will produce $\beta \cdot [(x^H + y^H)/3] + (1 - \beta) \cdot [(x^H + y^L)/3] = 55/6$. It is obvious that these quantities maximize profit given a firm's belief and the action of its opponent. The decision of firm B to enter is optimal since it makes a net profit of 25.13. Firm A makes a net profit of 24.78. If A would deviate and enter also when x is low, it will optimally produce $(x^L + y^H - 55/6)/2 = 53/12$, yielding an additional conditional expected profit of 9.75 which is not enough to recover entry costs. These strategies, therefore, constitute a Nash equilibrium of the subgame where A is informed about x and B is not informed.

In order to fully describe the strategies of the firms, we would have to specify their actions in each of the other 15 possible information structures. However, in order to check whether those strategies then constitute a Nash equilibrium, we only need to check unilateral deviations. Therefore, it suffices to specify the actions in the subgames reached if one of the firms deviates from the above strategy profile in the information acquisition stage.

Off the equilibrium path: Unilateral deviations by A.

Case 1: A does not learn x or y : Both firms enter and produce $[\alpha\beta \cdot (x^H + y^H) + \alpha(1 -$

$\beta) \cdot (x^H + y^L) + (1 - \alpha)\beta \cdot (x^L + y^H)] / (3 \cdot (1 - (1 - \alpha)(1 - \beta))) = 9$. (Note that when both x and y are low, the price will be equal to zero.) Net profits are now approximately 20.45 for each firm. It is therefore optimal for both firms to enter, and the strategies constitute a Nash equilibrium for the subgame where firms are not informed about x or y .

Case 2: A learns y : A enters when y is high and B enters always. When both firms enter they produce $\alpha \cdot [(x^H + y^H)/3] + (1 - \alpha) \cdot [(x^L + y^H)/3] = 9.6$. When only B enters, it produces $\alpha \cdot [(x^H + y^L)/2] + (1 - \alpha) \cdot [(x^L + y^L)/2] = 11.9$. Net profits for firms A and B are 17.83 and 60.39. If A deviates and enters also when y is low, it would optimally produce $(x^H + y^L - 9.6)/2 = 7.7$, which will yield an additional expected profit of 53.36, which is not enough to recover entry costs. These strategies, therefore, constitute a Nash equilibrium of the subgame where A is informed about y and B is not informed.

Case 3: A learns both variables: A enters only in the high-high state, and B enters always. When both firms have entered, they produce $(x^H + y^H)/3 = 10$. When only B enters, it produces $[\alpha \cdot (1 - \beta) \cdot (x^H + y^L) + (1 - \alpha) \cdot \beta \cdot (x^L + y^H) + (1 - \alpha) \cdot (1 - \beta) \cdot (x^L + y^L)] / (2 \cdot (1 - \alpha\beta)) = 128/11$. Net profits for A and B are approximately 19.58 and 62.97. If A deviates and enters when x is high and y is low, it optimally produces $(25 - 10)/2 = 7.5$, which will yield an additional profit of 56.25, which is not enough to recover entry costs. Other deviations for A are clearly even less profitable. These strategies, therefore, constitute a Nash equilibrium of the subgame where A is informed about x and y and B is not informed.

Off the equilibrium path: Unilateral deviations by B.

Case 4: B learns x : A enters when x is high, and B enters always. When both firms have entered and x is high, they produce $\beta \cdot [(x^H + y^H)/3] + (1 - \beta) \cdot [(x^H + y^L)/3] = 55/6$. When both firms have entered and x is low, they produce $\beta \cdot [(x^L + y^H)/3] + (1 - \beta) \cdot [(x^L + y^L)/3] = 31/6$. When only B enters, it produces $\beta \cdot [(x^L + y^H)/2] + (1 - \beta) \cdot [(x^L + y^L)/2] = 7.75$. Net profits are (as on the equilibrium path) 24.78 and 25.13. If A deviates and enters when x is low, it optimally produces $31/6$, which yields an additional profit of 26.69, which is not enough to recover the entry cost. If firm B deviates and does not enter when x is low, it would forego a net profit of 3.56. These strategies, therefore, constitute a Nash equilibrium of the subgame where A and B are informed about x .

Case 5: B learns y : A enters when x is high and B enters when y is high. When both firms enter they produce $(x^H + y^H)/3 = 10$. When only A enters it produces $(x^H + y^L)/2 = 12.5$, and when only B enters it produces $(x^L + y^H)/2 = 9$. Net profits are 64.46 for firm A and 20.8 for firm B. If A deviates and enters when x is low, it optimally produces $(18 - 10)/2 = 4$ if he meets B, or $(x^L + y^L)/2 = 6.5$ if B does not enter. Additional profits are not sufficient to cover the extra entry costs. If B deviates and enters when y is low, it optimally produces $(25 - 10)/2 = 7.5$ if he meets A, or $(x^L + y^L)/2 = 6.5$ if A does not enter. Once again, the additional profits are not sufficient to recover entry costs. These strategies, therefore, constitute a Nash equilibrium of the subgame where A is informed about x and B is informed about y .

Case 6: B learns both variables: A enters when x is high and B enters when y is high. When both firms enter they produce $(x^H + y^H)/3 = 10$. When only A enters it produces $(x^H + y^L)/2 = 12.5$, and when only B enters it produces $(x^L + y^H)/2 = 9$. If firm A deviates and enters when x is low, it optimally produces $(x^L + y^H)/3 = 6$ if he meets B (because B, who is perfectly informed, will also produce quantity 6 in this case), or $(x^L + y^L)/2 = 6.5$ if he does not meet B. The additional profits are not sufficient to recover the extra entry costs. If B deviates and enters when x is high and y is low, it optimally produces $(25 - 10)/2 = 7.5$. Once again, the additional profits are not sufficient to recover entry costs. Clearly, it is not profitable for B to enter when both x and y are low. These strategies, therefore, constitute a Nash equilibrium of the subgame where A is informed about x and B is informed about x and y .

Note that (A1)—(A4) hold.

It is clear from the above calculations that, given the choices of continuation equilibria, no firm has an incentive to deviate in the information acquisition stage: Firm A is better off learning x , where it expects a payoff of $24.78 - \varepsilon$, than in cases 1, 2, or 3, where it expects payoffs of 20.45, $17.83 - \varepsilon$, and $19.58 - 2\varepsilon$. Firm B is better off not learning about any of the variables, where it expects a payoff of 25.13, than in cases 4, 5, or 6, where it expects payoffs of $25.13 - \varepsilon$, $20.8 - \varepsilon$, and $20.8 - 2\varepsilon$. The above strategies, therefore, constitute a sequential equilibrium of the overt information acquisition and entry game. \square

We see that in the equilibrium no firm learns about y and one firm always enters without gathering information. This means that we will observe excessive entry in the

case of a bad market where both variables are low. Moreover, the production decisions in the Cournot competition are taken without knowing the realization of y , while this realization could have been learned at almost no cost. Firms refrain from learning about y because of the credible threat of more entry and tougher Cournot competition. We interpret these counterintuitive results as evidence that the assumption of overt information acquisition is very dubious and that information acquisition is better modeled as a secret event. This, in turn, reinforces the results of Examples 1 and 2.

4 Conclusion

Our examples show that when potential entrants need to acquire information about the profitability of the market, the number of firms that in fact enter is not necessarily determined by the (almost) zero profit condition, even when information acquisition is almost free. The discrepancy is caused by the fact that the entry of a firm carries information for other firms that have entered. This information may be interpreted incorrectly off the equilibrium path: Demand may be overestimated and the informedness of the entrant may be underestimated by the other firms. This can not happen in a game where many potential entrants are *exogenously* endowed with private information (and do not *endogenously* acquire information), as in Jovanovich (1981). This explains the quote from the introduction to the *Kabalah* at the beginning of this article. When firms endogenously and covertly acquire information, firms have *beliefs* about the informedness of the other firms. These beliefs have to be correct on the equilibrium path but not off the equilibrium path. When firms are exogenously endowed with private information, the informedness of firms is common knowledge, on and off the equilibrium path.

If we would assume that uncertainty about demand is resolved after entry has taken place but before production levels are chosen, things change dramatically. Namely, in this case firms will be informed about demand at the time of the production stage, and this fact is common knowledge. Hence, again, beliefs off the equilibrium path do not play any role. As shown in our companion paper Hurkens and Vulkan (1996), under this additional assumption the number of firms that enter will be equal to the maximal number of firms able to recover entry costs.

The fact that the number of entrants may be less than expected is not only surprising, it may actually be socially desirable. It is well-known (see Mankiw and Whinston (1986)) that the standard model of entry considered in this paper with homogeneous goods and fixed set-up costs leads to excessive entry. An entrant imposes a negative externality on

other firms, since it steals part of their sales. This business-stealing effect dominates the effect of higher consumer surplus from tougher competition. For instance, it is easily verified that in Examples 1 and 2 it is efficient to have only one firm entering in the (x^H, y^L) -state.⁵

We have argued that common knowledge of the information structure is a strong assumption and that it may account for some conclusions that need not hold when information is gathered endogenously. We have shown this only in some examples but it should be clear that our result holds more generally. First of all, the examples are generic, i.e. there exists an open set in the parameter space for which the same conclusions hold. Furthermore, the equilibrium of Example 1 cannot be eliminated by restricting out of equilibrium beliefs. We have assumed Cournot competition in the production stage, but it seems clear that our claim that beliefs may bar entry also holds for other oligopolistic competition forms like price competition with differentiated products. Our examples may also give some insight in other situations where information and competition are important. Consider a model of rent-seeking where agents compete to get some prize. For example, the prize may be the right to be the monopolist in a regulated industry. (See Posner (1975).) Standard theory predicts that free entry implies that the whole rent may be dissipated. However, suppose that the size of the rent is uncertain and that agents have the possibility to learn about it. Entry in the rent-seeking competition may signal to other participants that the prize is high and that they should increase their efforts. This may yield entry in the rent-seeking competition not profitable. As a result fewer agents may engage in rent-seeking behavior which could imply that not the whole rent will be dissipated.

In the real world entry takes places during a long time period and potential entrants can infer information about the profitability of the market from the existing firms. In a dynamic model of entry the existing firms (or early entrants) have the possibility to deter entry by limit pricing (Milgrom and Roberts (1982)). Our model of entry ignores the dynamic aspect of the entry process and the entry deterring behavior by incumbents in order to focus on another aspect of the entry process that has not yet received attention in the literature: Entry in a new market naturally involves uncertainty. Uncertainty about demand can be resolved to some extent by doing market research. However, uncertainty regarding the behavior of other entrants (which will depend on how much information they have collected) after entry costs have been sunk is not so easily resolved. Beliefs are,

⁵When one firm enters total surplus is 131.5 in Example 1 and 183.5 in Example 2, while with two entrants surplus is 115.11 and 165.56, respectively.

therefore, crucial. The beliefs deterring entry in our model are very different in nature than those that deter entry in the limit pricing model. There the incumbent influences the beliefs of the entrant. In our model it works the other way around: By deciding to enter a potential entrant may influence the beliefs of other firms that have entered (incumbents). Our examples are intended to show that entry barriers may arise without incumbent firms creating them and that beliefs may act as barriers to entry. They show that free entry implies zero profits only under the additional assumption that potential entrants' information structure is common knowledge, which is not compatible with a situation in which entrants rely on endogenously acquired information.

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