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Entry Deterrence under Agency Constraints

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Abstract

We study models of signaling and entry deterrence when the incumbent firm is subject to agency restraints and the principal does not have the relevant information to signal to the potential entrant. The informational implications of the dynamic agency relationship are fully identified. A characterization of optimal contracts is given for both the case of deterministic markets as well as stochastic markets. Moreover, the differences between whether incentive contracts are observable or hidden are presented.

We find that one would expect that the study of agency and entry is relevant in many markets, as agency makes entry more lucrative and principals may have reasons to invite entry to alleviate agency costs. We also propose empirically testable hypotheses that are based on the insights of this paper. This study suggests that entry deterrence is more likely to occur in less volatile markets. Also, entry deterrence is found to be more effective when incentives can credibly be made public.

Key words: entry deterrence; agency; financial intermediation; licensing; divisionalization

JEL classification: C73; D8; L1

1. Agency and Entry Deterrence

We consider a manager who operates a firm whose market is threatened by entry. The manager would like to deter entry but is constrained in his actions by an agency relationship with an outside principal. The principal is aware of the potential of entry but has limited information about some aspects of the firm that affect the profitability of entry.

For instance, the manger may be running a start-up company and the principal

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may be a financial intermediary who provides funds or a patent holder who has the exclusive right of the technology. Or the manager may be running a division of a large corporation and central management issues directives and structures compensation schemes.

In each of these cases it is likely that the manager has some private information that affects the firm's profitability. For example, the manager may have private information about his costs or about demand in the market. This information is relevant to both the entrant, who needs to make a (possibly irreversible) entry decision, and the principal, who would like to extract rents from the manager.

Our interest is two-fold. First, to analyze the interplay of entry deterrence and agency from the normative standpoint of optimal contract design. It has been recognized in both the finance and industrial organization literatures that agency relationships directly affect market activity. In particular, most decision-makers in firms are often not principals but agents. That is, managers who make both financial and real decisions on behalf of the firm do so within the bounds of incentive contracts that affect their payoffs.

Our presentation of this issue draws heavily on technical derivations in some of our previous work, much of which is surveyed in Jain et al. (2001). In Jain et al. (2003a), the relationship between a bank and a firm threatened by entry is studied for the case of deterministic markets; in Jain et al. (2002) the issue is studied for a stochastic environment with public contracts; and in Jain et al. (2003b) the same is done for hidden contracts.

This paper extends this work in several ways. First, as outlined above, this paper goes beyond the issue of financial intermediation and applies to more general agency relationships. Second, the focus here is not on the technical derivation of results but rather on the graphical illustration and the interpretation of the findings. This leads to the second purpose of this study.

The second objective is to develop a foundation for the formulation of positive empirical hypotheses for industries in which entry deterrence is relevant and the firm's agency structure is taken into account. To date few, if any, papers on agency in markets have studied the empirical connection between limit pricing and entry. This is especially interesting given the prominence of the policy debate on entry deterrence and limit pricing and the celebrated theoretical works in the area, starting with Milgrom and Roberts (1982) and Matthews and Mirman (1983), and, for the case of predation, Fudenberg and Tirole (1986).

We establish that *ceteris paribus*, entry is more likely to be of concern when agency issues are present (Lemma 2) so that the current study establishes relevant empirical hypotheses concerning entry deterrence. Moreover, it is demonstrated that within the agency framework it is possible to formulate meaningful empirical hypotheses, something that had eluded research based on previous theoretical work that yielded a multiplicity of equilibrium points and relied heavily in their predictions on unobservable or unverifiable data.

In this regard, this study suggests that entry deterrence is a greater issue in less volatile markets. Also, entry deterrence is found to be more effective when incentives can credibly be made public. Finally, principals may actually benefit from the threat of entry as it alleviates some of the costs of agency.

2. The Model

Consider a market that is open for two consecutive periods. Inverse demand for the good in each period is given by $p_t = a - bq_t + \varepsilon_t$, $t = 1, 2$, with a and b representing known parameters. The term ε_t is a random, unobservable noise term that has a zero mean and is distributed independently across the two periods. The random term ε_t, and hence the price, is realized only after output has been supplied. The firm's output is private information. However, the price is observable and thus serves as a signal of the unobserved output.

Suppose that, initially—in period $t = 1$—there is only one firm in the market (the incumbent). In order to commence operations, the incumbent must contract with a principal who provides a critical input into operations. For instance, the principal may be a financial intermediary who provides funds, a patent holder who has the exclusive right of the technology, or central management, e.g., the incumbent is a division of a large corporation.

Assume that payments to the principal can only be based on the observable signal (the market price, p) either because additional information is unobservable, unverifiable, or too costly to verify. The incumbent obtains rents once payment to the principal has been made. In principle, the rents that the incumbent obtains may be of a nonpecuniary nature, such as X-inefficiencies (Leibenstein, 1966) or the like. However, for simplicity, we let the manager be the residual claimant of all profit after having made payment to the principal.

The unit cost of supplying the good is constant. There are two possible levels of the unit cost, denoted c_H and c_L with $c_L < c_H$. The difference in costs may be directly related to differences in the cost of inputs, differences in technologies, or differences in managerial abilities, all of which are private information to the incumbent.

The principal has beliefs ρ that the incumbent's cost is low and $1 - \rho$ that the cost is high. The first-period price observation allows inferences about the incumbent's output and, thus, about the incumbent's type. Consequently, the principal's beliefs are updated after the first period.

In the second period there is a threat of entry. The potential entrant has the same prior beliefs about the incumbent's type as the principal and also updates these beliefs using the first-period price observation. Based on the updated beliefs, the potential entrant decides whether or not to enter. This decision depends on the entrant's expectation of profits, given that if entry occurs there is Cournot competition.

Without an entry threat, it is well known that the principal would like to commit to a two-period contract with the manager to circumvent the so-called ratchet effect (see, e.g., Salanié, 1997). However, there may be an infinite number of possible second-period contingencies in terms of the number of firms in the market (if one allows for more than one potential entrant) and the particulars of rivals' cost structures. Since it is not feasible to anticipate these all in the first period, the principal designs the second-period contract after potential entry has taken place and residual uncertainty about second-period competition is resolved.

Thus, taking account of the dynamic nature of the interaction, as well as the threat of entry, the principal designs short-term contracts in order to maximize the expected payment from the incumbent in the two periods. Let R_H and R_L denote the expected payment by the high cost and the low cost incumbent, respectively. Here the expectation is with respect to the distribution of ε. The principal's per-period expected payoff is $\rho_t R_L + (1 - \rho_t)R_H$, whereas the incumbent's per-period expected payoff is $u_H = \pi_H - R_H$, where π_H is the expected gross profit of the high cost incumbent. Similarly, $u_L = \pi_L - R_L$ for the low cost incumbent.

We differentiate the environment along two dimensions: First, the degree to which the stochastic nature of the observable signal affects learning. In particular, whether full information is obtained in a separating equilibrium (little noise in the environment) or whether, in expectation, asymmetric information persists in the second period (large amount of noise). Second, whether the incentive structure, implemented by the principal, can credibly be revealed to the potential entrant or not. If not, the entry decision must be based on conjectures about the incumbent's (equilibrium) actions in the first period. These conjectures affect the entrant's updating. Hence, the conjectures affect the optimal first-period incentive scheme, and, thus, the equilibrium depends upon whether or not the contract is revealed.

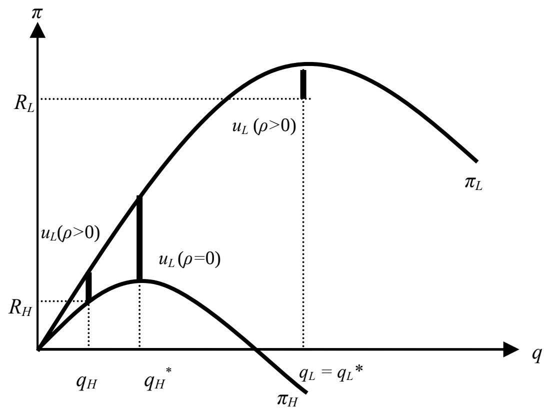
3. The Basic Structure of Optimal Contracts

We begin by establishing some properties of the optimal contract that are invariant both across periods and across the observability of contracts. We focus on the static setting when there is no competitor to consider. Nevertheless, we continue to refer to the firm that is subjected to the agency contract as the incumbent. To be sure, the analysis of this benchmark is the standard treatment of a textbook agency problem (see, e.g., Salanié, 1997).

The main features of the benchmark are illustrated in Figure 1. The concave functions depict the profits of the two types of incumbent. In the case of full information, the principal extracts the maximum profit as payment from the incumbent (that is, all profit in excess of normal profit since the incumbent's opportunity costs of operations are included in the constant unit cost of production). As a consequence, a low cost incumbent produces q_L*, whereas a high cost incumbent produces q_H*.

Under asymmetric information, when the principal's beliefs about the incumbent's type are given by $\rho \in (0, 1)$, in addition to individual rationality constraints (which bind under full information), the principal also considers incentive compatibility constraints. As is well known, in the optimal contract under asymmetric information, the high cost type's individual rationality (participation) constraint binds and the low cost type's incentive compatibility (self-selection) constraint binds. The other constraints are slack.

Figure 1. Profits, First Best and Actual Outputs in Static Monopoly Agency Game



The high cost firm's binding individual rationality constraint implies that, in equilibrium, its payment/output pair lies on its profit function. That is, the high cost firm hands over all its supranormal profit, $R_H = \pi_H(q_H)$, so $u_H(\rho > 0) = 0$. The low cost firm's binding incentive compatibility constraint implies that it obtains an information rent, which is equal to the profit from mimicking the high cost incumbent, i.e., $u_L(\rho > 0) = \pi_L(q_H) - R_H$.

The low cost incumbent is given incentives to produce at the first best (full-information) level of output, $q_L = q_L^*$. However, in order to reduce the information rent, i.e., increase the payment $R_L = \pi_L(q_L^*) - u_L(\rho > 0)$ to the principal, the high cost incumbent's output is distorted below the "first best" level, $q_H < q_H^*$. The exact amount of the distortion of the high cost incumbent's output and the low cost incumbent's payment are increasing functions of the principal's beliefs, ρ.

The following three features are the most important implications from this preliminary discussion. Although derived in the static context, these features are valid across all contracts that arise in our environment, independent of potential entry or entry having occurred and regardless of whether contracts are public or private.

(a) The high cost incumbent does not obtain information rents (the binding individual rationality constraint).

(b) The low cost incumbent retains the same amount of profit as it nets when mimicking the high cost incumbent (the binding incentive compatibility constraint).

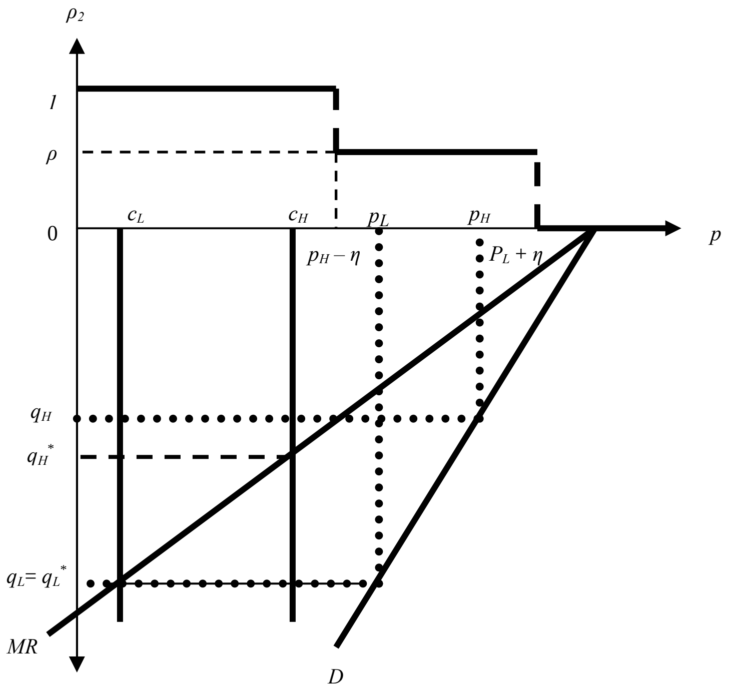
(c) The low cost incumbent produces more than the high cost incumbent ($q_L > q_H$).

A specific feature of the static contract in the monopolistic market that does not hold across all relevant considerations is that the low cost incumbent's output is at the "first best" level. Instead, it is manipulated to affect the information transmission and to account for the entrant's (potential and actual) presence.

4. Information Transmission across Time

On the basis of the contract regularities given in the previous section, some general insights into how information is disseminated from the first period to the second can be gained. To this end, consider Figure 2, which is derived from Figure 1, in output/price space so that the belief function (i.e., posterior beliefs as a function of the observed price) can be constructed.

Figure 2. First Best and Actual Outputs in Monopoly Agency Game with Posterior Belief Function



The diagram's lower portion depicts the expected demand, *D*, expected marginal revenue, *MR*, and the two possible realizations of marginal cost, c_H and c_L. As in the static benchmark analysis of the previous section (and Figure 1), the low cost incumbent's output is determined where marginal cost equals the expected marginal revenue, whereas the high cost incumbent produces less than the first best output.

Given the low cost (high cost) incumbent's output decision, the expected market price is given by p_L (p_H). The actual (observed) price is, of course, determined by the realization of ε. Since only the price is observable, prices are the domain of the belief function that yield posterior beliefs on the basis of Bayes' Rule.

The diagram's top portion depicts posterior beliefs. Since the low cost incumbent always produces more than the high cost incumbent, the belief function is a decreasing function—provided that the distribution of ε has the monotone likelihood ratio property (MLRP).

In the diagram, ε is distributed uniformly on the interval $[-\eta, \eta]$. Given this distributional assumption, in equilibrium, a price below $p_H - \eta$ cannot have resulted from the output of a high cost incumbent, and a price above $p_L + \eta$ cannot have come from a low cost incumbent. For all other prices there remains uncertainty. It follows that if $\eta < (p_H - p_L)/2$, complete learning about the incumbent's type occurs since the sets of equilibrium prices for the high cost and the low cost incumbent are disjoint. Conversely, for η large, the range of prices that yield no additional information dominates all possible first-period price observations, so learning is unlikely to occur. More generally, for any distribution of noise with the MLRP, we have the following.

LEMMA 1: For given actions, the larger the variance of ε is, the less information is transmitted and the less the principal and potential entrant learn in expectation.

For more on information transmission with heteroskedastic noise, see Creane (1994). In our context the following corollary is also relevant.

COROLLARY 1: For given (sufficiently large) variance, the smaller the distance between the first-period equilibrium outputs, the less information is transmitted and the less the principal and potential entrant learn in expectation.

A final remark about information transmission. There are two possible scenarios concerning the first-period contract, each yielding different results. First, the first-period contract is public, and second, the first-period contract is hidden, i.e., the contract is not observed by the potential entrant. If the contract is public, the principal and the entrant both know the correct equilibrium actions. In the case that the contract is hidden, only the principal knows the correct values of the first-period levels of output (and hence the correct specification of the belief function), but the potential entrant does not. Hence, the potential entrant makes a conjecture about the incumbent's actions, upon which his posterior beliefs are based. As a condition of equilibrium, of course, the potential entrant properly anticipates the first-period contract and hence the principal and the entrant have identical posterior beliefs.

5. The Second Period

We turn now to optimal contracts in the second period. We distinguish two cases: continued monopoly in the second period and duopoly after entry has taken place. Note that all possible outcomes in the second period must be studied in order to determine the optimal first-period contract.

The analysis of the former case is straightforward. It is a standard agency setting, so the discussion from Section 3 applies without modification. It should be noted, however, that in equilibrium it is not possible that the principal believes that the incumbent has high cost—such a posterior belief (being shared by the potential entrant) would trigger entry. Indeed, as a technical aside, given the two-type model, any residual uncertainty about the incumbent's type triggers entry (see Jain et al.

2002, and the discussion below), so the only monopoly setting in the second period concerns an incumbent who has been identified as having low cost.

The analysis of entry is somewhat tricky. Not only is there the agency relationship between the principal and the incumbent, but it is also necessary to account for competition in the product market. That is, there are two simultaneous and interrelated games to analyze: agency and imperfect competition. In particular, the principal is dealing with an agent whose payoffs are affected not just by the incentive contract directly but also by a game that is being played with a third party—the Cournot competition game with the entrant (for more on agency and market games, see Jain and Mirman, 2002).

The issue is greatly simplified for the case that the incumbent's cost has been revealed to be high (i.e., full information). While it is possible to construct instances in which agency has economic implications even if costs are known (e.g., along the lines of Fershtman and Judd, 1987, or Katz, 1991), this primarily results in quantitative changes that can be ignored for the purposes of studying entry deterrence. Instead—and given the specifics of our setting—the principal simply extracts from the incumbent the Cournot equilibrium profits that are expected to accrue.

When there is uncertainty about the incumbent's costs, the analysis is analogous. The principal considers the Cournot game (in light of the cost uncertainty) and then determines how much profit can be extracted (again, given the uncertainty about the incumbent's type).

Figure 3. Cournot Reaction Curves with Cost Uncertainty

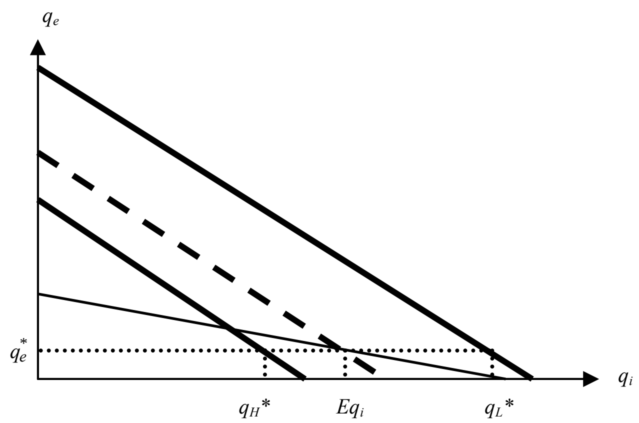
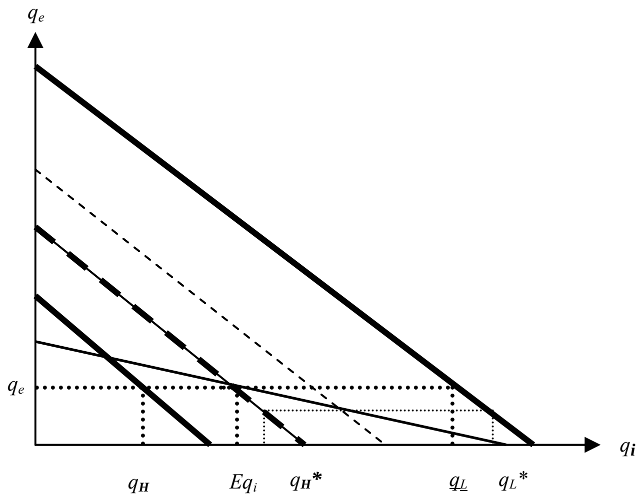


Figure 3 depicts the simple Cournot game with cost uncertainty when the incumbent is free from agency restraints. Here qi denotes the incumbent's output and qe that of the entrant. The heavy-set, steep lines are the incumbent's best-response curves dependent on the cost structure. The dashed line represents the "expected" reaction curve. The flatter thin line is the entrant's reaction curve.

Figure 4 shows how the Cournot game is affected by the agency relationship. As in the static analysis, without a second firm in the market, the high cost incumbent's output is reduced (see Section 3 and Figures 1 and 2). With the second firm present, however, this has the effect of shifting the high cost incumbent's entire reaction curve—the new thick line closer to the origin.

Figure 4. Shifted "Reaction Curves" due to Agency



This shift in the reaction function yields a new "expected" reaction curve—namely, the dashed line shown to coincide with the high cost incumbent's reaction curve when there is no agency. These shifts have repercussions for the low cost incumbent: Although the low cost incumbent's reaction curve stays in place, the distortion created by shifting the high cost incumbent's reaction curve yields an altered response of the entrant and hence a decreased output of the low cost incumbent compared to the Cournot game without agency.

Thus, agency leads to distortions that feed into the market game. The distortion has repercussions for the actions even of the "good" agent, whose best response otherwise remains unaffected. In the particular Cournot equilibrium setting, the high cost incumbent's reduced output leads to an increase in the entrant's output, which, in turn, leads to a reduction in the low cost incumbent's output (see Figure 4)—the case of strategic substitutes. An implication of these distortions, at least for the case of Cournot competition, is thus as follows;

LEMMA 2: An agency relationship between incumbent and principal makes the market more profitable for a potential competitor. In other words, the entrant benefits from the distortions to his rival's output caused by the principal's incentive contract.

Lemma 2 is a rather general insight. For the two-type distribution the incumbent's "expected" best response under agency coincides—as depicted—with the reaction curve of a high cost incumbent who is not constrained by agency (see Figure 4). Thus, competition with cost uncertainty under agency is (in expectation) equivalent to competition with a high cost firm from the standpoint of the entrant. Consequently, the agency relationship benefits the entrant to such a degree that residual uncertainty triggers entry.

6. Informational Considerations in the First Period

It is now clear that learning about the incumbent's cost structure has two main effects. First, it determines whether or not entry occurs, and, second, it determines the structure of the second-period contract between the incumbent and the principal. Both of these factors affect the principal's ability to extract profit from the incumbent firm. So both of these factors must be taken into consideration when contemplating the first-period contract and what that contract implies about the dissemination of information and learning and thus second-period profits and payoffs.

In this section, we briefly discuss the general informational considerations that are made in the first period. In Section 7, we examine how these considerations affect specific first-period incentives given varying degrees of noise in the environment and different levels of public commitment to short-term incentive contracts.

Information and Entry. Given that entry decreases profitability, the amount of expected profit that the principal can extract from either type of incumbent is decreasing in the likelihood of entry. It is not surprising, then, that the principal would like to decrease the probability that the incumbent enters—ideally, engaging in successful entry deterrence.

Thus, the principal designs the first-period contract so that it makes entry less likely, either because it increases the probability that a low cost incumbent's type is revealed or because it increases the potential entrant's expected posterior belief. The latter motivation, while very real, is doomed to failure in equilibrium because the entrant anticipates such attempts and accounts for them when forming posteriors.

The principal's objectives are no different than in the traditional limit pricing literature. The novel twist here (similar to Caillaud and Hermalin, 1993, who ignore the dynamic aspects of agency, however) is that the principal would like to deter (or at least decrease the likelihood of) entry without knowing the incumbent's underlying cost structure and hence without knowing whether, in fact, entry is or is not profitable for the second firm.

Learning—Reducing Inefficiencies and Future Information Rents. In any agency relationship, asymmetric information leads to distortions in actions (inefficiencies) and the retention of information rents by some types of agent. As for the former, output distortions lead the high cost incumbent to produce inefficiently. So efficiency, and, thus, expected profits, is increased with the accuracy of information. As for the latter, the low cost incumbent retains some profit, despite having no bargaining power compared to the principal, so the principal can extract a greater portion of profit as the accuracy of information increases.

Thus, the principal has two reasons to increase the accuracy of the information about the incumbent's cost structure. Indeed, in the limit, if complete information revelation takes place, there are no inefficiencies nor information rents and the principal is able to extract the complete first best level of profit from the incumbent. Consequently, the principal has an incentive to learn about the incumbent's type and has an interest in designing the first-period contract in order to facilitate learning (see Jeitschko and Mirman, 2002, and Figure 5 below). However, there is an opposing incentive that must be accounted for.

Non-Commitment and the Ratchet Effect—Reducing Current Rents. Of the two reasons for the principal's desire to learn, the one that reduces inefficiencies is of no direct concern to the incumbent, who only cares about residual rents after making the payment to the principal. And while the other, namely the principal's desire to reduce future information rents, does not affect the high cost incumbent (who obtains no rents), it is of concern to the low cost incumbent, as the amount of profit that he would otherwise retain is reduced.

Indeed, the low cost incumbent has an incentive to deceive the principal in the first period. If the principal is under the (mistaken) impression that he is dealing with a high cost firm in the second period, he would offer the first best contract for a high cost incumbent to an agent who actually has low costs—yielding a profit of at least $\pi_L(q_H^*)$ and hence a payoff of at least $u_L(\rho = 0)$ (see Figure 1).

Given that the principal wants to learn about the incumbent's type, his only option to prevent deception is to offer up-front the (discounted) gains from deception that would accrue to the low cost incumbent. The reason that this is the only method of preventing deception is because the principal is unable to commit to not exploiting whatever information he gleans about the incumbent's cost structure. This issue, that arises whenever the principal cannot commit to longer-term contracts, is known in the literature as the "ratchet effect" (see, e.g., Freixas et al., 1985, or Laffont and Tirole, 1987).

Since the potential gains from deception are directly related to the amount of learning that takes place—i.e., the more the principal learns, the greater are the gains from deception—and since this determines the up-front payment, the principal's first-period payoffs depend on the amount of information revealed by the first-period contract. Consequently, the principal has an incentive to reduce the informational content of the first-period contract in order to reduce the up-front payments (see Jeitschko and Mirman, 2002, and Figure 5 below).

7. First-Period Contracts

In light of the above discussion, consider the design of the first-period contract. Our primary focus is on distinguishing the case of a deterministic market price or one with little noise (yielding complete learning) from the case of stochastic prices (and incomplete learning). Our second focus is, especially for the case of stochastic market prices, to consider how contracts are structured when they are not observable to the potential entrant in contrast to when contracts are observed.

Little Noise—Complete Learning. When the demand curve is deterministic, if the incumbent firm produces a distinct type-dependent output, his cost structure is fully revealed (see Lemma 1). This is good news for the principal as far as entry deterrence is concerned because it means that entry is always deterred whenever the incumbent has low costs. Indeed, because the principal does not know the incumbent's cost structure—assuming a public contract for the time being—(costly) signalling through limit pricing is not necessary.

Consequently, despite potential entry and the desire to deter entry, the outputs of the static contract of Section 3 can be used just as effectively as any other output combination so that there is no added cost imposed in the first-period contract due to the threat of entry.

Complete learning is also beneficial to the principal since there is no need for inefficiencies in the second period and all rents are transferred to the principal. However, the ratchet effect is a particularly prominent concern since deception by a low cost incumbent is most effective when there is complete learning by the principal. Specifically, in a separating equilibrium, a low cost incumbent is able to fully deceive the principal into believing that the incumbent actually has high cost, yielding a significant information rent in the second period. As a consequence, in equilibrium, the low cost incumbent's up-front rents are quite substantial.

The ratchet effect can lead to problems with the existence of an equilibrium due to countervailing incentives of the high cost firm, i.e., high up-front rents can lead to the so-called take-the-money-and-run strategy (Laffont and Tirole, 1993). However, this issue is less important when dealing with potential entry. Here, if the low cost incumbent takes the equilibrium (separating) action, entry is deterred, whereas the out-of-equilibrium (separating) deceptive action triggers entry. Thus, the low cost firm obtains a smaller information rent when deceiving (compared to the case without entry), so up-front rents are reduced. Thus, potential entry serves as a device to discipline the agent. Indeed, the threat of entry can be so beneficial to the principal, that the principal's overall (two-period) payoff is actually increased when there is the potential of entry (Jain et al., 2003a).

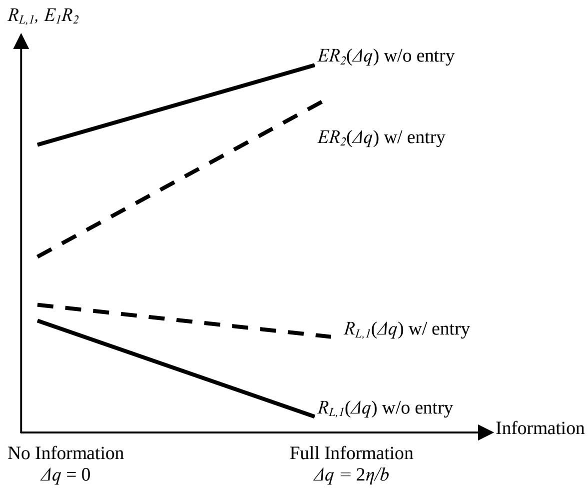
Thus far we considered the case where contracts are credibly conveyed to the potential entrant. When this is not the case, the equilibrium described is no longer unique. However, the issue of hidden contracts and additional equilibrium points is largely of theoretical interest with—we believe—little empirical significance because multiple equilibrium points depend on *ipse facto* unverifiable out-of-equilibrium beliefs, i.e., the equilibrium depends critically on subjects' beliefs in events that have zero probability of occurring (see also Section 8).

Stochastic Prices—Partial Learning. Given sufficiently stochastic prices, complete learning need not take place as many price observations are consistent with the equilibrium outputs of both types of incumbents. In this case, Corollary 1 comes into play. Again, assume for now that the contract between the principal and the incumbent is observable (although much of what follows is true with hidden contracts).

Due to the ratchet effect, the principal has an incentive to reduce the informativeness of the first-period price (the observable signal) in order to increase the first-period payments. Given Corollary 1, this is done by choosing outputs that are closer together (consider the decreasing solid line in Figure 5). This effect is termed signal-dampening.

Of course, this incentive is balanced by the principal's desire to reduce the asymmetric information in the second period. This is termed experimentation and results in the principal wanting to induce the two types of incumbent to take actions that are further apart, so that the incumbent's type is more likely to be revealed (consider the increasing solid line in Figure 5).

Figure 5. Implications of Information on Payments: Signal Dampening and Strategic Experimentation



The net effect of these two incentives, when there is no potential entry, is in favor of signal dampening, so that outputs are chosen closer together than with deterministic prices (Jeitschko et al., 2002). However, potential entry affects both incentives—signal-dampening and experimentation—in favor of learning more. Specifically, signal-dampening is less of a concern because the threat of entry already reduces up-front payments to the low cost incumbent (see the above discussion for the case when there is no noise), and experimentation is more valuable because more information increases the probability that the incumbent's cost is revealed to be low, thus deterring entry (Jain et al., 2002). As a consequence, second-period expected payments, ER_2, are more sensitive, and the low cost incumbent's first-period payment, $R_{L,1}$, is less sensitive to the informativeness of the signal (the dashed lines in Figure 5). Since experimentation specifically incorporates the effect of learning on the potential entrant, it is now referred to as strategic experimentation.

Hidden Contracts—Signal Jamming. Suppose now that contracts are not or cannot be made public. In this case, given any conjecture the potential entrant has regarding equilibrium actions (i.e., the entrant's belief function analogous to Figure 2), the principal has an incentive to increase the probability of prices that deter entry (see the discussion on entry in Section 6). The principal can only manipulate outputs (rather than posterior belief functions) in order to increase the probability of price observations below the critical threshold price that prevents entry. We refer to such attempts to generate misleading price observations as signal jamming.

The derivation of equilibrium configurations that are consistent with private (unobservable) beliefs is rather involved, and existence and uniqueness of equilibrium are not assured (for a full discussion and derivation of equilibrium, see Jain et al., 2003b). However, these complications are basically technical points and do not affect the more general insights.

On the margin, it is better for the principal to increase both equilibrium outputs, rather than decrease them, in order to lower the distribution of market prices and, in turn, increase the potential entrant's posterior beliefs, given his belief function. Loosely speaking, increasing the low cost incumbent's output impacts the entrant's beliefs about whether the incumbent has high cost or whether no learning has occurred. Whereas increasing the high cost incumbent's output impacts the entrant's beliefs between remaining uncertain about the incumbent's cost and the belief that the incumbent actually has low cost. As only the latter affects the entry decision, only the high cost incumbent's output is increased.

However, as the potential entrant can anticipate such manipulation, in equilibrium, entry is actually more likely than when compared to the public contracting case, as the two equilibrium outputs are moved closer together (Corollary 1). In the end, the principal's lack of ability to change the potential entrant's beliefs—i.e., by making the contract public—his mere ability to affect the probability of observing any particular price (which is anticipated in equilibrium) leads to the result of increased entry.

8. Conclusion: Empirical Significance

Despite the theoretical importance of works on entry deterrence in deterministic settings, these results have found little empirical verification. One major reason for this dearth of empirical studies is that the theoretical results provide a multiplicity of equilibrium configurations and therefore empirical predictions are generally hard to make. Indeed, equilibrium configurations, even comparative static results, often hinge on out-of-equilibrium beliefs, which the empirical researcher cannot have access to. Moreover, many if not most markets are actually subject to some random and unobservable shocks, so that the applicability of deterministic models to empirical verification is limited.

Along the latter lines, one can consider the stochastic market given in Matthews and Mirman (1983) as an advancement over the Milgrom and Roberts (1982) model as it captures some unobservable shocks and consequently yields a unique equilibrium. However, empirical hypotheses on the basis of this work would also be hard to verify without a substantial amount of additional information. In particular, the Matthews and Mirman (1983) model yields predictions on differences between first best monopoly pricing and limit (signalling) prices. However, the issue of limit pricing arises precisely because the underlying factors that determine the monopoly price are private information and cannot be credibly revealed. So how would the empirical researcher be able to obtain this information in order to measure the deviation in the firm's pricing policies? This is the inherent difficulty in empirical examinations of theoretical models with asymmetric information and signalling.

The framework we present does not suffer from these problems concerning meaningful empirical verifications. Thus, although there is asymmetric information, empirical hypotheses can be tied to the principal's actions (i.e., contract design), rather than firm behavior. And the information that (by assumption) is readily available to the principal and the entrant alike (the prior beliefs) should be easier to ascertain for the empirical researcher than the hidden information about firm type.

Of course, this raises the question of whether our study on entry deterrence in conjunction with agency is relevant in the real world. There is much casual evidence to suggest that it is relevant.

Examples of managers or owners of a firm, who are subject to outside incentive schemes are ubiquitous. So in cases where entry is an issue one would also expect to find agency concerns. Indeed, agency concerns may be particularly prevalent in markets where entry is an issue, because many entry situations occur in "new" markets (in older and more established markets, much learning may have taken place so that asymmetric information has had a chance to dissipate). Yet, frequently, firms that find these new market opportunities and may be able to establish themselves as incumbents are in the need of proprietary technology or outside funds and thus may become subject to an incentive scheme with a patent holder, a venture capitalist, or a financial intermediary.

Moreover, the analysis of this paper suggests that there are at least three other reasons that entry deterrence is more likely to be an issue when there are agency restraints. First, due to the distortions of the incentive contract, entry is more profitable when there are issues of agency (Lemma 2). Second, entry deterrence is much less costly in this environment because the principal cannot actually engage in costly signalling as he does not have the relevant information. And third, since the principal may actually benefit from the disciplining effect of potential entry in regard to the ratchet effect, potential entrants may actually be sought out by the principal in some circumstances.

In conclusion, we briefly point to some of the more immediate empirical hypotheses that emerge from the analysis. First, although it appears that stochastic environments are the norm rather than a "special case," the less noise there is the more "effective" is entry deterrence. Consequently, one would expect entry deterrence to be more prevalent in environments that are not too noisy, i.e., with relatively stable prices over time, or price fluctuations that are readily explained by economic observables. Thus, one might find principals engaging in efforts to reduce the noisiness of signals—which they would not do absent potential entry due to the ratchet effect.

Also, as entry deterrence is more effective when the parties commit to public contracts, one may expect incentive contracts that are straightforward and do not contain many provisions extraneous to entry to be more likely to account for potential entry (e.g., a simple licensing agreement versus a more sophisticated relationship with a financial intermediary). Similarly, one may observe parties to a contract to incur a cost in order to publicly convey commitment to a particular incentive structure.

As a last example—although slightly removed from the immediate concern of actual entry deterrence—one might find a principal engaged in making potential entrants aware of a possible market opportunity in order to reduce the ratchet effect problem. This can effectively be done in a multi-divisional firm. Corporate headquarters may use a second division to threaten entry, even when under full information it would be costly to allow such intra-firm competition.

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