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Economics working paper 10. February 1992

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Abstract

Entry restrictions are a common form of regulation in markets and occupations, either as a means of limiting the size of a market or affecting the quality of products or services provided by it. This paper analyzes demand, cost and informational characteristics that affect the impact of this type of policies on the quality mix of products provided by an industry and the welfare of its consumers. Selective increases in the costs of entry such as licensing requirements and direct restrictions with competitive bidding for entry rights are considered. We analyze the effects of these policies on entry decisions and also the additional selection effects that are obtained when exit is allowed for and the rights to participate in an industry can be freely traded.

JEL Subject Classification: Rationing; Licensing (D45), Asymmetric information and private information (D82), Information and product quality (L15), Regulation and industrial policy (L50).

*This work was done under NSF grant SES-8911789

1 Introduction

Entry restrictions are a common form of regulation in markets and occupations, either as a means of limiting the size of a market or affecting the quality of products or services provided by it. Such policies are usually implemented through licensing requirements or via direct controls on the number of firms operating in an industry together with a mechanism to allocate the rights to participate in it. The former are most common among some professions and occupations, while the latter have been widely used, for instance, in markets for transportation services[1]. This paper studies the demand, cost and informational characteristics that affect the impact of these two types of policies on the quality mix of products provided by an industry and on the welfare of its consumers.

The imposition of minimum quality standards is studied by Leland (1979), who tried to identify conditions under which a market would benefit from the imposition of direct quality controls. Shapiro (1986) departs from Leland's model by considering indirect controls on the quality level through licensing requirements. In his model entrants are required a minimum standard of investment in order to obtain the licenses. When this minimum standard is only binding for low quality entrants – as in the main case studied by Shapiro – licensing requirements play the role of a selective increase in the cost of entry of low quality producers. This is the first type of policy we consider. Alternatively, direct controls on the number of firms operating in a market with competitive bidding for the rights to participate in it increase symmetrically the costs of all firms. This is the second type of policy we consider.

The basic model we consider is very similar to Shapiro's extended in two ways: i) In our model the size of the market is determined endogenously while in his model it is given. ii) We consider a more general informational structure. The first extension allows us to analyze the effect policies have both on the quality mix of firms and on the total output of the industry. As in Akerlof (1970), the model considered here results in too high a ratio of low quality products. The severity of this adverse selection problem, that arises from the limited information consumers have about entrants, is affected by

[1] This type of regulation existed in the trucking industry until 1977. An interesting empirical study showing the large rents created by this entry restriction is given in Frew (1981). On the other hand, in a cross-city study of the taxi industry for the United Kingdom, Beesley (1973) finds that restrictions in the number of licenses issued combined with fare controls lowers the average quality of the service provided.

the process of diffusion of this information. In Shapiro's model, high and low quality producers cannot be distinguished by consumers up to a certain period and are perfectly separated thereafter. We consider instead a Bayesian learning structure which only for specific values coincides with his. More importantly, while Shapiro finds that an increase in the cost of low quality producers always leads to an increase in the share of high quality products, we show that the reverse is likely to happen in the more general case.

In contrast to the case of licensing considered above, rights are often tradeable in markets where the total number of firms is regulated[2] . The value of these rights has not only an effect on entry decisions but also represents an opportunity cost that may affect exit[3]. Since those firms that have revealed to be low quality are more likely to exit, this selection process could lead to an increase in quality over time. The higher the value of these rights is, the more intense this selection effect may be. By increasing the value of these rights, entry restrictive policies could thus lead to a further effect on quality mix. We also analyze this selection effect and establish that allowing these rights to be transferred is likely to have a positive effect on quality. This provides an equilibrium foundation for the transferability of rights.

It is not the objective of this paper to provide a general theory of quality and entry but rather to discuss the importance of some demand, cost and informational considerations. For that reason we have chosen the simplest setup we could find to illustrate our points. The organization of the paper is as follows. In section 2 we lay out the basic model. The determination of equilibrium and the role of preferences are considered in a model of perfect information in section 3. Section 4 considers the selection effect discussed above and fully characterizes the equilibrium path of entry rights. Finally, the effect of entry restrictions on quality and on social welfare within the general model of imperfect information are analyzed in section 5.

2 Preliminaries

There is a set of infinite identical potential entrants which face the decision to enter an industry. In the entry stage, entrants can choose to remain outside the industry or to enter as a high quality firm (H) or a low quality firm (L).

[2]For instance, the New York Stock Exchange restricts the total number of seats in the exchange. This restriction is reflected in high values for the corresponding rights (see Schwert (1977)).

[3]A general discussion on the importance of the transferability of licenses and barriers to entry can be found in Demsetz (1982) and Lott (1987).

We denote by M the total number of active firms, and by π the proportion of H firms in the market. There is a cost of entry (or production), $C_L < C_H$. Each firm produces a single unit of a product at no extra cost, which other than for quality is homogeneous. Firms behave competitively.

The consumption decision is discrete: each consumer may either consume one unit of output or none. There are N consumers, where N is assumed to be a large number. Of these N consumers only M are served in equilibrium. As in Shapiro, preferences are given by a distribution $F(\theta_H, \theta_L)$ of reservation values, with $0 \leq \theta_H < \bar{\theta}_H$ and $0 \leq \theta_L < \bar{\theta}_L$. Each consumer chooses the product that gives him/her the highest net surplus, or no consumption if the market price for goods of high and low quality are above his/her reservation value.

Let θ_H^i and θ_L^i be the pair of reservation values for consumer i. We assume:

(A1) $\theta_H^i \geq \theta_L^i$, that is, all consumers prefer good H.

(A2) $\theta_H^i > \theta_H^j$ implies $\theta_L^i > \theta_L^j$ for all i, j with $i \neq j$, that is, if one consumer has higher reservation value for one type of product than another consumer, he/she will also have higher reservation value for the other type of product.

Assumptions (A1) and (A2) imply that the distribution of reservation values F will have support on a curve with positive slope above the diagonal in the (θ_H, θ_L) space. In other words consumers are completely ordered with respect to the distribution of reservation values.

In the next two sections we discuss the determination of the equilibrium in models of perfect information.

3 Perfectly observable quality

To begin with we consider a one period model with perfect information. There will be two prices in the market, p_H and p_L for firms of type H and L respectively. Given these prices, let

$$D_H(p_H, p_L) = \{(\theta_H, \theta_L) : \theta_H \geq p_H \quad \text{and} \quad \theta_H - \theta_L > p_H - p_L\}$$

denote the set of consumers that get highest surplus buying an H product and similarly

$$D_L(p_H, p_L) = \{(\theta_H, \theta_L) : \theta_L \geq p_L \quad \text{and} \quad \theta_H - \theta_L \leq p_H - p_L\}$$

the set of consumers that would choose to buy a low quality product.

We can derive the equilibrium prices as follows: if there are M firms in the market, with a proportion π of H firms and a proportion $(1-\pi)$ of L firms, the prices p_H, p_L must satisfy:

$$N \cdot \int_{D_L(p_H,p_L)} dF(\theta_L,\theta_H) = (1-\pi)M$$
$$N \cdot \int_{D_H(p_H,p_L)} dF(\theta_L,\theta_H) = \pi M.$$

Below we provide some assumptions that guarantee that these prices are uniquely determined. We denote them by $p_H(\pi,M)$ and $p_L(\pi,M)$. [4] Since M is the number of active consumers and firms, we will use M interchangeably for consumers or firms.

An *equilibrium* is given by a pair (π, M) such that :

$$p_L(\pi,M) \leq C_L \quad \text{and if} \quad p_L(\pi,M) < C_L \quad \text{then} \quad (1-\pi)M = 0,$$
$$p_H(\pi,M) \leq C_H \quad \text{and if} \quad p_H(\pi,M) < C_H \quad \text{then} \quad \pi M = 0.$$

We now develop some concepts and provide additional assumptions that will be used in the analysis that follows.

Given that by assumption (A2) consumers' reservation values are completely ordered, we can define reservation value curves $\theta_H(M)$ and $\theta_L(M)$ where M is the Mth consumer in descending order of reservation values. More precisely define

$$\theta_H(M) = \sup\{\theta : N \int_{D_H(\theta_H,\bar{\theta}_H)} dF(\theta_H,\theta_L) \geq M\}$$

and similarly for $\theta_L(M)$. Note that these are simply the inverse demand functions for each type of product when the other one is priced out or not available. Figure 1 illustrates these curves for some of the cases analyzed below.

The following assumptions are used to simplify the analysis of the equilibrium:

(A3) $\theta_H(\cdot)$ and $\theta_L(\cdot)$ are continuous.[5]
(A4) $\theta_H(\cdot)$ and $\theta_L(\cdot)$ are strictly decreasing.

We now consider three cases to illustrate how the effect of restrictive entry policies depends on some properties of F.

[4] It is not hard to show that if $0 < \pi < 1$, and if total demand of each type of product is strictly decreasing in the own price, the prices will be unique.

[5] This is equivalent to saying that the marginal distributions of F have densities.

3.1 Case 1: Decreasing quality premium

For this case, we introduce the following extra assumption on the preference structure:

$$\text{(DQP)} \qquad \theta_H(M) - \theta_L(M) \text{ is strictly increasing in } M.$$

Intuitively this says that those consumers that have higher reservation values are less sensitive to quality differentials. For given values of p_H and p_L, the demands for each product are determined as follows: p_H determines the marginal consumer M^* for whom $\theta_H(M^*) = p_H$, and $p_H - p_L$ gives the boundary between the consumers of high and low quality goods $(1-\pi)M^*$, which is defined by $\theta_H((1-\pi)M^*) - \theta_L((1-\pi)M^*) = p_H - p_L$. Total consumption of L goods is $(1-\pi)M^*$ and πM^* is the consumption of H goods (see Figure 1.a). For an interior equilibrium, $p_H = C_H$ and $p_L = C_L$.

The effect of licensing requirements can be studied as in Shapiro (1986) by considering a selective increase ΔC_L in the cost of low quality firms. Since p_H is not affected by this, the size of the market does not change. But since p_L increases by ΔC_L, the boundary between the two markets moves towards the origin, so π increases. In contrast, an increase of both C_L and C_H by ΔC would raise both prices by ΔC, reducing the total market size from M^* to some value M' without changing the boundary between H and L quality markets. As a consequence, the share of L firms would increase. This is the effect of a policy that restricts entry to M', allocating entry rights through competitive bidding. The market price for these rights would be ΔC and the number of L and H firms would be $(1-\pi)M$ and $M' - (1-\pi)M < \pi M$, respectively.

3.2 Case 2: Increasing quality premium

Instead of (DQP) we now assume

$$\text{(IQP)} \qquad \theta_H - \theta_L \text{ is strictly decreasing.}$$

In this case those consumers with higher reservation values are more sensitive to quality differentials. The analysis of this case is similar to the previous one, with the role of H and L reversed. The market size is determined by p_L and the boundary of L and H goods by the difference between p_H and p_L, as illustrated in Figure 1.b. A selective increase in C_L would increase p_L, reducing the total size of the market. For p_H to remain constant, the boundary between the two markets moves to the right, again increasing π.

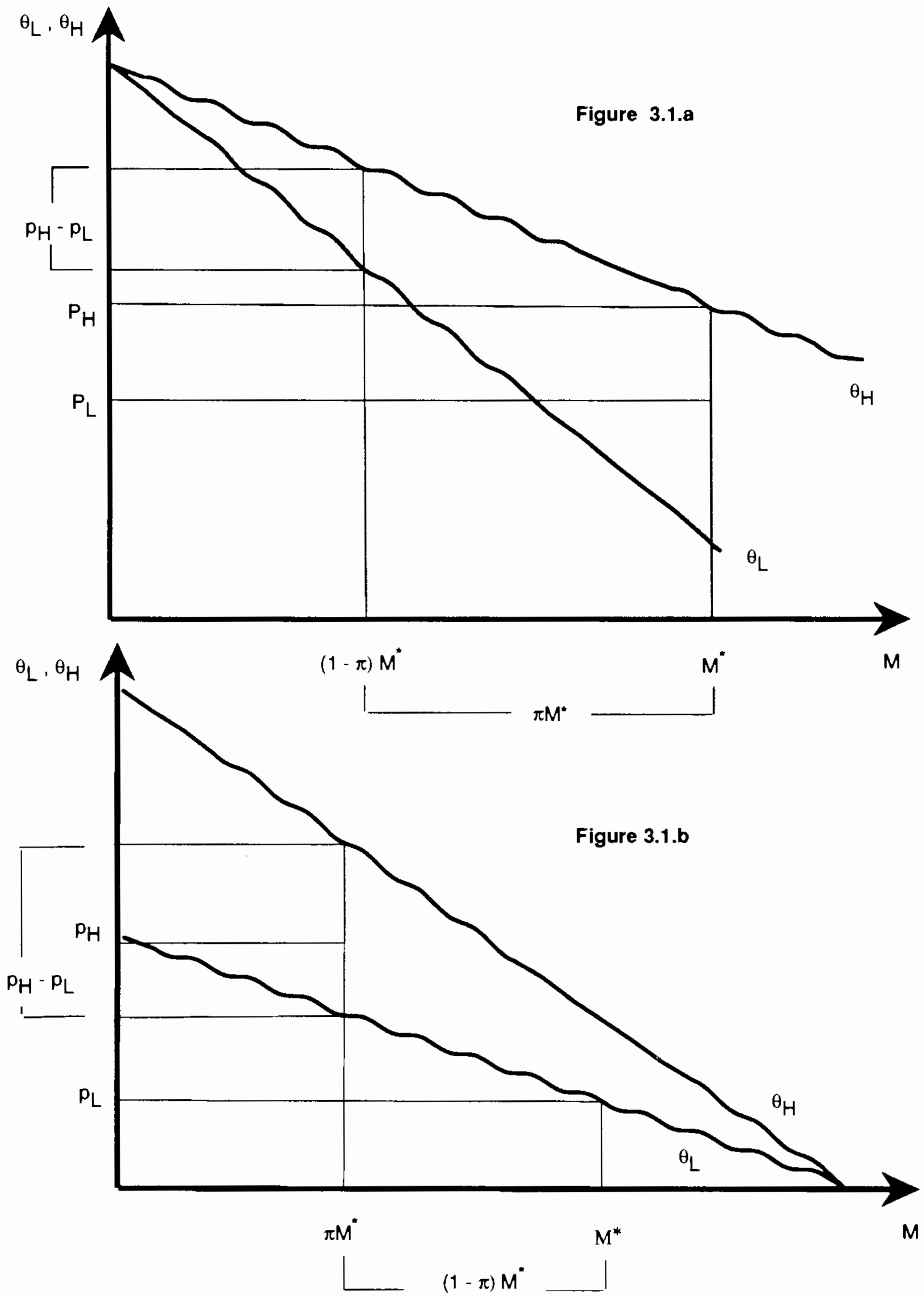

Figure 1: Determination of equilibrium

By an argument symmetric to the one used in the previous case, a restriction in the number of entrants below the equilibrium value will only affect the number of L firms, increasing the average quality offered by the industry. [6]

3.3 Case 3: Constant quality premium

For this case we assume

$$\text{(CQP)} \qquad \theta_H - \theta_L = k > 0.$$

In this case θ_L is parallel to θ_H. If $C_H - C_L > k$ only L firms will enter the industry and if $C_H - C_L < k$ only H firms will enter. Restricting the number of entrants would have no effect on quality.

To summarize, while a selective increase in the cost of entry of low quality firms always results in an increase in the fraction of high quality firms, direct entry restrictions may have the opposite effect. Loosely speaking, the latter will lead to an increase in average quality only if the correlation between reservation values and preferences for quality is positive. The following two propositions summarize the results of this section:

Proposition 1 *Under assumptions* (A1)–(A4) *there exists a unique equilibrium, and if it is interior, a selective increase in the cost of entry of low (high) quality firms increases (decreases) the proportion of high quality firms. The size of the market (M) changes as follows,*

$$\frac{\partial M}{\partial C_L} \leq 0 \quad \text{and} \quad \frac{\partial M}{\partial C_L} < 0 \quad \text{if and only if} \quad p_L = \theta_L(M^*)$$

$$\frac{\partial M}{\partial C_H} \leq 0 \quad \text{and} \quad \frac{\partial M}{\partial C_H} < 0 \quad \text{if and only if} \quad p_H = \theta_H(M^*)$$

where M^* is the number of firms in the original equilibrium.

Proposition 2 *The direct restriction policy has the following effect:*

> *If $\theta_H(M) - \theta_L(M)$ is increasing (decreasing) in M then π decreases (increases).*

[6]In an earlier draft, we provide more general sufficient conditions for quality to increase. An example that satisfies this condition is the case where the distribution F is uniform on $\{(\theta_H, \theta_L) : 0 \leq \theta_L \leq \bar{\theta}_L, \theta_L \leq \theta_H \leq 2\theta_L + k, k > -\theta_L\}$. Details are available from the authors by request.

If $\theta_H(M) - \theta_L(M) = k$ then there is no effect.

In absence of externalities, the equilibria of the model considered in this section are optimal –they maximize total surplus–, so entry restrictive policies are not justifiable from a welfare point of view. Furthermore, it is not hard to see that no consumer would gain with these policies.

4 Exit selection and quality

The idea that making operating rights transferable can enhance efficiency by allowing for entry and exit has been considered by many authors [7]. This section discusses the effect that the transferability of licenses has on quality.

In the model considered in the previous section, even if licenses could be traded after entry, no trade would take place since entry was both ex–ante and ex–post optimal for each firm. Exit could occur if at entry firms face uncertainty about their realized quality.

To analyze this we now consider the case where firms cannot choose their quality at entry, which instead is randomly determined. Assume that each potential entrant faces a prospect of becoming a high quality firm with probability π and a low quality firm with probability $(1-\pi)$, which is observed only after entry. For each period that the firm remains in the industry it produces one unit of output of the realized quality. Obviously in this case restrictive policies cannot affect the mix of firms that enter, but they can affect exit decisions and thus the final quality mix.

Consider first the equilibria without entry restrictions under the preferences given in Case (DQP). The market division is fixed at $(\pi, 1-\pi)$, so given a total number M of firms in the market, p_H and p_L are determined as follows: p_H is equal to the reservation value of the Mth consumer, and p_L is determined from the condition $p_H - p_L = \theta_H\big((1-\pi)M\big) - \theta_L\big((1-\pi)M\big)$, as indicated in Figure 1.a. This gives functions $p_H(\pi, M)$ and $p_L(\pi, M)$ which are decreasing in M. The equilibrium number of entrants M^* is such that,

$$\frac{\pi p_H(\pi, M^*) + (1-\pi)p_L(\pi, M^*)}{1-\delta} = C_e, \tag{1}$$

where the left hand side is the expected discounted profits of an infinitely lived entrant, δ a discount factor and C_e is the unique cost of entry. A similar condition will hold for case (IQP).

[7] For the trucking industry, this point is addressed in Miklius and Casavant (1977).

Now suppose the number of firms is initially restricted to $M' < M^*$. The questions that we will address are:

(1) If the rights to participate in this industry could be freely traded, would they be traded at all?

(2) For how many periods will there be entry and exit and how much selection will there be in the limit, i.e. what will the share of H firms be?

(3) What characteristics will the sequence of entry rights display?

(4) What effect will entry restrictions have on the final quality mix?

This section presents formal answers to these questions, summarized at the end in propositions 3 and 4. However an intuitive answer can be provided for the first question. If no exit occurred, the value of L firms would be $\frac{p_L}{1-\delta}$, while the expected value of a potential entrant would be $\pi\frac{p_H}{1-\delta} + (1-\pi)\frac{p_L}{1-\delta} - C_e$. If the value of L firms exceeded the expected value of a potential entrant, there would be no gains to trade. So a necessary and sufficient condition for exit to occur is that in the first period

$$p_H(\pi, M') - p_L(\pi, M') > \frac{C_e}{\pi}(1-\delta). \tag{2}$$

where M' is the imposed limit on the number of firms. Note that at the original unrestricted equilibrium equation (1) implies that

$$\begin{aligned} p_H(\pi, M^*) - p_L(\pi, M^*) &= \frac{C_e(1-\delta)}{\pi} - \frac{p_L(\pi, M^*)}{\pi} \\ &\leq \frac{C_e(1-\delta)}{\pi} \end{aligned}$$

with strict inequality if $p_L(\pi, M^*) > 0$. In case (DQP) as M is decreased, $p_H(\pi, M) - p_L(\pi, M)$ decreases, so inequality (2) is never satisfied and thus no entry and exit takes place. In contrast, for case (IQP) as M is decreased $p_H(\pi, M) - p_L(\pi, M)$ increases. Provided that $\theta_H(0) - \theta_L(0) > \frac{C_e(1-\delta)}{\pi}$ there exists a critical value $0 < M_c < M^*$ such that a restriction in the number of firms leads to entry and exit if and only if it is below M_c.

We now proceed to a formal definition of equilibrium. Let $p_H(t)$ and $p_L(t)$ denote the price of high and low quality products in period t and $C(t)$ the corresponding price of entry rights. The value of a high quality firm $V_H(t)$ is given by

$$V_H(t) = \sum_{\tau \geq t} \delta^{\tau - t} p_H(\tau). \tag{3}$$

Note that this definition assumes implicitly that high quality firms never exit, which will be true in equilibrium.

In turn, the value of a low quality firm $V_L(t)$ can be defined recursively by

$$V_L(t) = p_L(t) + \max\{\delta V_L(t+1), \delta C(t+1)\}, \tag{4}$$

where the max operator represents the option of staying in the industry or selling the rights and exiting. Using (3) and (4) we can define the expected value of an entrant by

$$V_e(t) = \pi V_H(t) + (1 - \pi) V_L(t). \tag{5}$$

Let $e(t)$ denote the number of firms that exit at the beginning of period t and also the new entrants for that period. Let $\pi(t)$ denote the fraction of high quality firms in the industry at the beginning of period t.

An *equilibrium* with a (binding) maximum of M' firms is given by sequences $\{p_H(t), p_L(t), C(t), \pi(t), e(t)\}$ such that

(C1) $V_e(t) \leq C_e + C(t)$ and $V_e(t) < C_e + C(t)$ implies $e(t) = 0$.

(C2) $e(t) \leq (1 - \pi(t))M'$ and

$V_L(t) < C(t)$ implies $e(t) = (1 - \pi(t))M'$
$V_L(t) > C(t)$ implies $e(t) = 0$,

where V_e and V_L satisfy equations (3)-(5).

(C1) is the standard free entry zero profit condition. (C2) establishes that the number of exiting firms is bounded above by the total number of low quality firms and that the exit decision is optimal.

We now establish that there exists a unique equilibrium and provide a complete characterization of it. Consider first the case where there is entry and exit for a finite number of periods only. Let T denote the last period with positive entry and exit. The following conditions are easily derived from the definition of equilibrium:

Period T.

(i) $p_L(T) \leq C(T)(1-\delta)$

(ii) $\pi p_H(T) + (1-\pi)p_L(T) = C_e(1-\delta) + C(T)(1-\delta)$.

Period $T+1$.

(iii) $p_L(T+1) \geq C(T+1)(1-\delta)$

(iv) $\pi p_H(T+1) + (1-\pi)p_L(T+1) \leq C_e(1-\delta) + C(T+1)(1-\delta)$.

Since there is no entry and exit after period T, $p_H(t) = p_H(T)$ and $p_L(t) = p_L(T)$ for $t \geq T$. Hence (i)–(iv) imply that

$$\begin{aligned} C_e(1-\delta) + p_L(T) &\leq \pi p_H(T) + (1-\pi)p_L(T) \\ &= \pi p_H(T+1) + (1-\pi)p_L(T+1) \\ &\leq C_e(1-\delta) + p_L(T) \end{aligned}$$

and hence

$$p_H(T) - p_L(T) = \frac{C_e(1-\delta)}{\pi}. \tag{6}$$

From our previous discussion it is clear that this condition can only be satisfied in case (IQP), so the remaining analysis is restricted to that case. Of course, for the other cases there will not be entry and exit along the equilibrium path.

Equation (6) implicitly defines $\pi^* = \pi(T)$, the fraction of H firms in the limit by[8]

$$\theta_H(\pi^* M) - \theta_L(\pi^* M) = \frac{C_e(1-\delta)}{\pi}. \tag{7}$$

Equation (7) intuitively states that the gain from replacing a low quality firm by a high quality one $\frac{\theta_H(\cdot)-\theta_L(\cdot)}{1-\delta}$ equals the expected cost $\frac{C_e}{\pi}$. Since by assumption (IQP) the left hand side of (7) is strictly decreasing in π^*, higher costs of entry and lower values of π result in a lower π^*. The higher C_e is and the lower π is, the more costly it is to replace the low quality firms by high quality ones, so less selection takes place.

Since only L firms exit along the equilibrium path, $\pi(t)$ is a nondecreasing sequence and is strictly decreasing in periods where entry and exit occur. Consequently $p_H(t)$ and $V_H(t)$ are nonincreasing and strictly decreasing in periods where entry is positive. In the Appendix we establish that all L firms exit in periods $1, \ldots, T-1$ and that for these periods the price of entry rights

[8] Below we consider the case where no $\pi^* \in [0,1]$ satisfy this equation.

$C(t)$ is strictly increasing. For period T, generically only a fraction $\alpha < 1$ of the low quality firms will exit, so $C(T)$ is determined by

$$p_L = C(T)(1-\delta).$$

For periods $t = 1, \ldots, T-1$, the value of $C(t)$ is obtained recursively from

$$\pi V_H(t) + (1-\pi)[p_L + \delta C(t+1)] = C_e + C(t).$$

To complete the characterization of the equilibrium we need to determine T and α. Equation (7) gives π^* and since all L firms exit in periods $1, \ldots, T-1$

$$T = \min\{t : \pi \sum_{\tau=0}^{t} (1-\pi)^{\tau} > \pi^*\}.$$

and α satisfies

$$\pi \sum_{\tau=0}^{T-1} (1-\pi)^{\tau} + \alpha\pi(1-\pi)^{T} = \pi^*.$$

Under what conditions will there be entry and exit for a finite number of periods only? Again equation (7) provides a clear answer to this, leaving three possibilities:

(i) there exists $\pi^* \in (\pi, 1)$ that satisfies (7).

(ii) $\theta_H(\pi M') - \theta_L(\pi M') \leq C_e(1-\delta)/\pi$

(iii) $\theta_H(M') - \theta_L(M') \geq C_e(1-\delta)/\pi$

In the first case the unique equilibrium is the one described above. In the second case the equilibrium will have no entry and exit and thus $\pi^* = \pi$. In the third case all L firms will exit in every period so $\pi^* = 1$, $p_H(t) \to \theta_H(M')$ and thus $p_H(t) - p_L(t) \to \theta_H(M') - \theta_L(M')$.

Let b be the unique value that satisfies $\theta_H(b) - \theta_L(b) = \frac{C_e(1-\delta)}{\pi}$ or $b = 0$ if $\theta_H(0) - \theta_L(0) \leq \frac{C_e(1-\delta)}{\pi}$. The ranges of M' for which (i), (ii) and (iii) apply are the following:

(i) $\pi M' < b < M'$

(ii) $\pi M' \geq b$

(iii) $M' \leq b$

We now turn to the effect of tighter entry policies. The effects of such policies for values of π in ranges (ii) and (iii) follow from our previous analysis. For values of M' in range (i), note that (6) determines the limiting value $p_H - p_L$, and thus the marginal consumer independently of M'. So if the number of firms were further restricted, ultimately all adjustment would take place by a reduction in the number of L firms. Note that if licenses were not transferable, this would not occur.

The following two propositions summarize the results of this section:

Proposition 3 (A1-A4)

(1) An equilibrium exists and it is unique.

(2) The equilibrium involves entry and exit only for case (IQP). *If the limiting value π^* is such that $\pi < \pi^* < 1$ then there exists a $T < \infty$ such that for periods $1, \ldots, T-1$ all L firms exit and for period T a fraction $\alpha \in [0,1]$ exit. No entry or exit occurs after T. The limiting value π^* is the one defined by equation* (7).

(3) The price of entry rights $C(t)$ will be decreasing.

Proposition 4 (A1-A4, IQP) *The lower the binding number of firms is, the higher the limiting value π^* will be and the longer will the period over which entry and exit occur (T) be.*

Sections 3 and 4 considered the effect of entry restrictions on the equilibrium mix of firms when qualities are observable. Our analysis illustrates the importance that demand considerations have in order to assess this effect. By restricting the size of the market, the pool of consumers that end up buying a product changes. The relative desire for low or high quality goods of this new pool compared to the original one, will affect the final mix of products.

The next section considers the case of asymmetric information, where consumers cannot perfectly observe the qualities of products. There are two reasons that make the analysis of this case particularly interesting. First, it is a case where one may expect that the type of policies considered could potentially result in welfare gains[9]. On the other hand, there are some qualitative differences in the role of preferences for that case.

[9] In the cases considered above all equilibria were originally Pareto optimal.

5 Privately observed quality

In this section we consider a model with the same structure as before, except that the quality of a firm is not perfectly observable by the market. The quality of a good is realized after purchase, and depends on the type of firm producing it according to the following: firms of type H produce a high quality good with probability 1, while firms of type L produce a high quality good with probability λ and and a low quality good with probability $1 - \lambda$. We assume that the previous realizations of quality of all firms in the market are public knowledge. Note that low quality firms are either indistinguishable from high quality ones or perfectly distinguished, depending on their history of realized qualities. Firms make a choice about entering as an L or H firm, which involves paying entry costs C_L or C_H as before, and if entry occurs they produce one unit for T periods thereafter, drawing independently each period the quality from its corresponding distribution.

In order to define preferences consistent with the previous ones, we will assume that consumers are risk neutral and value a product according to its expected reservation value. These expectations are taken with respect to the updated prior at the time of purchase, updated by consumers according to Bayes rule. This update can be summarized by a sufficient statistic q_t denoting the probability that a given firm is of type H. If the prior at entry is denoted by π, q_t can be defined as:

$$q_t = \frac{\pi}{\pi + \lambda^t(1-\pi)}$$

and if there has been any observation of low quality,

$$q_t = 0.$$

From now on we will consider only two periods, though all results extend naturally to arbitrary T.

To illustrate the way preferences translate into prices, consider the case where reservation values are as given in Case 2, with the obvious adjustment for uncertainty indicated above. In Figure 2 we represent the preferences for this case.

$\theta(M|\pi)$ represents the reservation value curve for the first period, when all firms firms are perceived as identical. $\theta(M|H)$ is the reservation value for goods offered by firms that have produced high quality products in period 1,

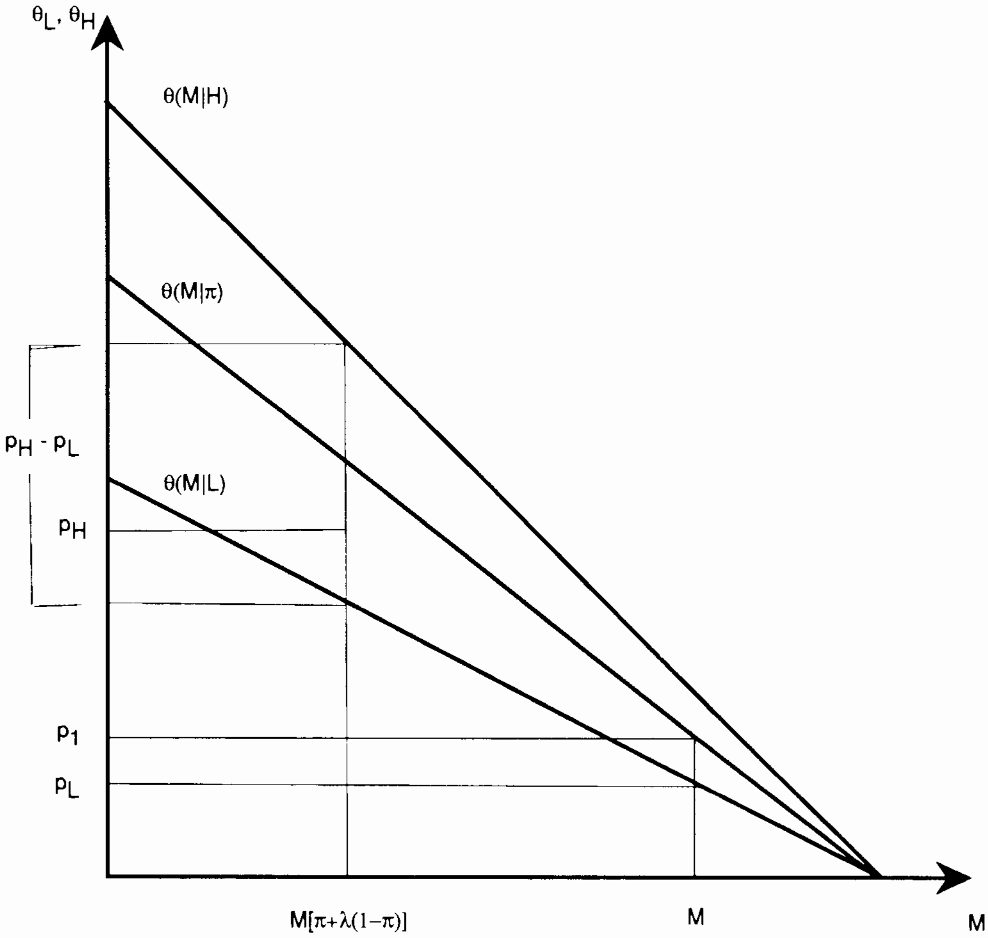

Figure 2: Reservation value curves for private information

while $\theta(M|L)$ is the reservation value for firms that have revealed their low quality[10].

Market clearing prices are determined each period in an analogous way to Section 3. In the first period firms are indistinguishable, so they obtain the same price p_1 for their products, while in the second period some L firms will have revealed their low quality. We denote by p_H the second period price a firm gets if it had a good realization in the first period and p_L if it produced a low quality good in the first period. Let V_L and V_H denote the expected discounted profits at entry of an L and H firm, respectively. If δ is the discount factor

$$\begin{aligned} V_H(\pi, M) &= p_1 + \delta p_H, && (8)\\ V_L(\pi, M) &= p_1 + \delta\lambda p_H + \delta(1-\lambda)p_L. && (9) \end{aligned}$$

where the dependence of the prices on (π, M) is as described in section 3.

We now define an equilibrium as a pair (M^*, π^*), such that

$$\begin{aligned} &V_H \le C_H, \quad \text{and if} \quad V_H < C_H, \quad M^*\pi^* = 0,\\ &V_L \le C_L, \quad \text{and if} \quad V_L < C_L, \quad M^*(1-\pi^*) = 0. \quad (10) \end{aligned}$$

Note that as part of our definition of equilibrium we impose the condition that consumers' initial priors are consistent with the distribution of entrants.

It is convenient to rewrite (9) as follows:

$$V_L = p_1 + \delta p_H - \delta(1-\lambda)(p_H - p_L). \quad (11)$$

For an interior equilibrium, conditions (10) must be satisfied with equality. Hence the equilibrium is given by the pairs (π, M) that make (8) and (9) equal to C_H and C_L, respectively. Each of these equations thus defines an implicit map $M_H(\pi)$ and $M_L(\pi)$ by

$$\begin{aligned} V_L\Big(\pi, M_L(\pi)\Big) &= C_L,\\ V_H\Big(\pi, M_H(\pi)\Big) &= C_H. && (12) \end{aligned}$$

[10] In terms of the original reservation value functions, these expected reservation values can be written as:

$$\theta(M|\pi) = \pi\theta_H(M) + (1-\pi)\lambda\theta_H(M) + (1-\pi)(1-\lambda)\theta_L(M),$$

$$\theta(M|H) = q\theta_H(M) + (1-q)\lambda\theta_H(M) + (1-q)(1-\lambda)\theta_L(M),$$

$$\theta(M|L) = \lambda\theta_H(M) + (1-\lambda)\theta_L(M).$$

where $q = \frac{\pi}{\pi+\lambda(1-\pi)}$.

In Figure 3 we draw a set of implicit functions to illustrate the possible equilibria. [11]

At $\pi = 0$, all prices are equal: $p_1 = p_L = p_H$. [12] Hence the values $M_L(0)$ and $M_H(0)$ satisfy

$$p_L(M_L(0))(1+\delta) - C_L = 0,$$

for L firms, and

$$p_L(M_H(0))(1+\delta) - C_H = 0,$$

for H firms. Given that $C_H > C_L$, it follows that $M_L(0) > M_H(0)$.

For an interior solution to exist these two functions must intersect for a value of $\pi \in (0,1)$. A necessary condition for this to occur is that $\frac{\partial M_H}{\partial \pi} > \frac{\partial M_L}{\partial \pi}$ for some values of M. Generically there will be an odd number of equilibria, the number of which depends on how many times the functions M_H and M_L intersect. To analyze what equilibria can arise we now turn to two cases, illustrated in Figure 3.

The first case is represented by the curves (M_L, M_H). Since both V_H and V_L are decreasing with respect to M , the pairs (π, M) lying below the curves M_L and M_H satisfy $V_L > C_L$ and $V_H > C_H$ respectively, while the pairs above these curves satisfy $V_L < C_L$ and $V_H < C_H$. The only equilibrium corresponds to point A where only L firms enter the market. At this point, no H firms would enter since $V_H < C_H$. Also note that point B on curve M_H, where $\pi = 1$, cannot be an equilibrium, since at this point $V_L > C_L$, and some L firms would find it profitable to enter. The second case is represented by the curves (M_L, M'_H), that only intersect once. There are now three equilibria: 1) point A; 2) an equilibrium corresponding to point C, where only H firms enter the market. At this point no L firms would enter the market since $V_L < C_L$; the third possible equilibrium corresponds to point D. In the Appendix we show that under assumptions (IQP) or (CQP) these equilibria are Pareto ranked.

The following proposition easily follows from the previous analysis:

Proposition 5 (A1-A4)

(1) An equilibrium with $\pi^* = 0$ always exists.

---

[11]Continuity of these curves follows from the fact that V_L and V_H are jointly continuous and strictly decreasing in M. In the Appendix we give conditions under which these curves are increasing.

[12]The usual discontinuity arises when $\lambda = 0$ and all information is revealed after one period. In that case $p_L \neq p_H$. For the remainder, we will assume that $\lambda = 0$. Section 5.3 is devoted to the case $\lambda = 0$.

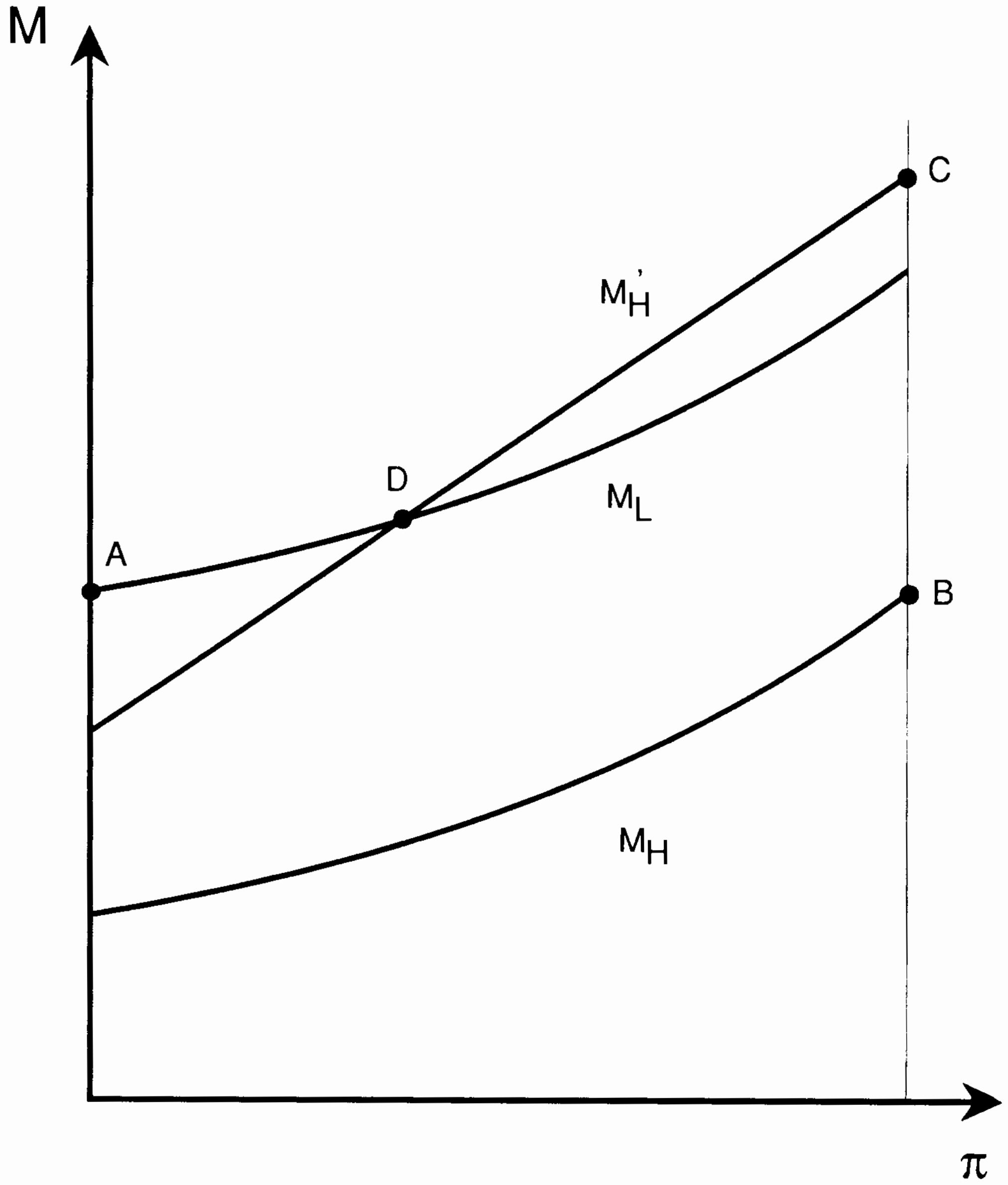

Figure 3: Possible equilibria with imperfect information

(2) If there exists and equilibrium with $\pi^* = 1$, then there will also be an interior equilibrium, i.e. with $\pi^* \in (0,1)$

(3) If there is a unique interior equilibrium, then there is one with $\pi^* = 1$.

Notice that proposition 5 implies that if there exist interior equilibria, at least one will have the property that the M_H curve cuts the M_L curve from below, or $\frac{\partial M_H}{\partial \pi} > \frac{\partial M_L}{\partial \pi}$. We will refer to this as the lower interior equilibria. This has particular relevance to evaluate policies that selectively increase C_L, such as licensing requirements as considered in Shapiro (1986). An increase in C_L moves the M_L curve downward. The value of π at the lower interior equilibria decreases. So for this Bayesian learning environment there are always equilibria where licensing requirements decrease the level of quality!

The effect of direct entry restrictions will now be analyzed. Two questions will be addressed:

1. Can a restriction in the number of firms be supported by a competitive market for entry rights?

2. If so, what effect will such policy have on quality?

An answer to the first question can be obtained by evaluating the effect of a simultaneous increase in the cost of entry on the equilibrium number of firms. A necessary condition for such policy to work is that the number of firms decreases.

Our analysis of these two questions will be restricted to the comparative statics of the lower interior equilibria, which is the unique one for cases (DQP) and (CQP).

For convenience from now on we strengthen assumption (A3):

(A3′) $\theta_H(\cdot)$ and $\theta_L(\cdot)$ are continuously differentiable.

This assures that the functions M_H and M_L are continuously differentiable.[13] With these assumptions,

$$\frac{\partial M_H}{\partial \pi} = -\frac{\frac{\partial V_H}{\partial \pi}}{\frac{\partial V_H}{\partial M}}, \qquad \frac{\partial M_L}{\partial \pi} = -\frac{\frac{\partial V_L}{\partial \pi}}{\frac{\partial V_L}{\partial M}}.$$

The results are given in the following proposition, proved in the Appendix:

[13]This follows from the implicit function theorem.

Proposition 6 . (A1,A2,A3′,A4) *The lower interior equilibrium has the following comparative statics properties:*

(1) (DQP) $\frac{\partial M^*}{\partial C} < 0,\ \frac{\partial \pi^*}{\partial C} > 0$

(2) (IQP) *If* $\frac{\partial V_H}{\partial \pi} > 0$ *then* $\frac{\partial M^*}{\partial C} < 0,\ \frac{\partial \pi^*}{\partial C} < 0$

Thus in case (DQP) direct entry restrictions can always be supported through competitive bidding for rights while for case (IQP) they can provided $\frac{\partial V_H}{\partial \pi} > 0$. Note also that with this information structure the effects on quality are opposite to the ones obtained for the perfect information case analyzed in section 3.

What makes the asymmetric information case qualitatively different is that the mix of firms that enter the market (π) has a direct effect on the expected profits of entrants. Still, whether entry restrictions lead or not to lower average quality depends on some specific characteristics. Three of these were critical to the result obtained in our last case. First, at $\pi = 0$ *net* expected profits for low quality firms were higher than for high quality firms. This obviously extends to other models whenever there are substantial differences in the costs of entry. Secondly, higher costs of entry shift the M_L curve down more than the M_H curve. This will occur if (and only if) changes in M affect the expected discounted profits of high quality firms more than those of low quality firms. Note that under these two conditions, if there are interior equilibria there will be at least one where entry restrictions can result in lower average quality. Other models that share these two characteristics will lead to similar conclusions. Finally, for an interior equilibrium to exist it was necessary for M_L to have smaller slope than M_H in some region. This requires that, relative to changes in M, higher π benefits high quality firms the most.

Section 5.1 will consider the case of (CQP). Section 5.2 discusses in more detail a class of (IQP) preferences, provides a condition so that $\frac{\partial V_H}{\partial \pi} > 0$ and develops welfare considerations. Finally section 5.3 discusses the special case in which all information is revealed after one period ($\lambda = 0$), relating our results to those in Shapiro (1986).

5.1 Constant quality premium.

This corresponds to preferences under assumptions (A1), (A2), (A3′), (A4) and (CQP). For these preferences, note that $p_H - p_L$ will not depend on M

Table 1: Parameter values for numerical computations

Parameters	Case 1	Case 2
α	0.2	0
δ	1	0.8
λ	0.6	0.32
C_L	9.5	30
C_H	10	50
b	30	50

(though it will increase with π), so using (8) and (11) $\frac{\partial V_L}{\partial M} = \frac{\partial V_H}{\partial M}$. It is also clear that $\frac{\partial p_H}{\partial \pi} > 0$, so from (11) it follows that $\frac{\partial V_L}{\partial \pi} < \frac{\partial V_H}{\partial \pi}$. From these two results, it is easy to check that $\frac{\partial M_L}{\partial \pi} < \frac{\partial M_H}{\partial \pi}$, which implies that there will be at most one point of intersection. This will occur provided that the difference $C_H - C_L$ is not large. Note the contrast to the corresponding case of perfect information, where at equilibrium only one type of firm entered the market.

Consider now the effect of entry restrictive policies that increase equally C_L and C_H by ΔC. Since $p_H - p_L$ is independent of M and p_L and p_H are strictly decreasing in M at constant π, both curves shift down by the same magnitude. The new equilibrium has the same π but a lower number of entrants. It follows that as in the case of perfect information, with these preferences this type of entry restrictive policies is neutral with respect to π.

5.2 Results for a class of (IQP) preferences

In this section we consider a special class of (IQP) preferences with $\theta_H(M) = b/M$ and $\theta_L(M) = \alpha\theta_H(M)$.[14] For illustrative purposes, in Figure 4 we plot numerical estimates for the implicit functions $M_H(\pi)$ and $M_L(\pi)$ for two cases.

The parameter values for the two cases considered are given in Table 1.

In the Appendix we show that $\frac{\partial V_L}{\partial \pi} > 0$ and $\frac{\partial V_H}{\partial \pi} > 0$ if $\lambda \geq \pi(1-\lambda)$. This implies that the implicit functions M_L and M_H are upward sloping.

In case 1, there is a unique interior equilibrium, denoted by point E. Notice that M_H intersects M_L from below, so this implies that at this point $\frac{\partial M_H}{\partial \pi} > \frac{\partial M_L}{\partial \pi}$. A selective increase in C_L has the same consequences as in

[14]In the Appendix we show that these preferences are equivalent to a more common separable class closely related to those in Shaked and Sutton (1982).

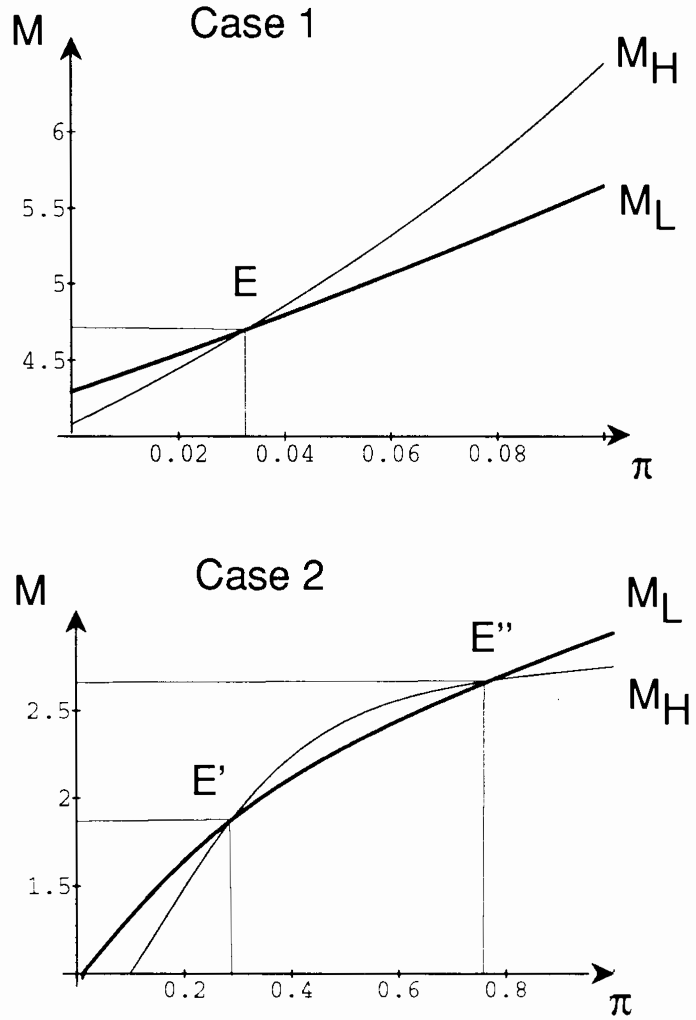

Figure 4: Equilibria for numerical computations

the (CPQ) case. Consider now the experiment of increasing C_L and C_H by ΔC. By proposition 6 π^* decreases and if $\frac{\partial V_H}{\partial \pi} > \frac{\partial V_L}{\partial \pi}$ then M^* decreases. In the Appendix we show that a sufficient condition for the latter is that $\lambda \geq \pi(1-\lambda)$. In the Appendix we also show that this simultaneous increase in entry costs reduces social welfare.

In case 2, there are two equilibria, denoted by points E' and E''. Point E' has the same properties as point E of case 1, while for point E'' the comparative statics results are reversed. Note however, that at the latter point it would be necessary that $\Delta C < 0$ for M to decrease. Since entry rights must have nonnegative price, this point could not be supported by the type of policy considered but rather by subsidies to entry.

5.3 All information revealed after one period

The results described in the previous section contrast to the ones obtained by Shapiro (1986). As for this matter, the main difference between his model and ours is on the learning environment. Shapiro assumes that high and low quality producers cannot be distinguished for a fixed number of periods but are perfectly separated thereafter.

Suppose that in the first period firms are indistinguishable, but in the second period the types of the firms are revealed. This is clearly the case when $\lambda = 0$. The values of the firms in this case are:

$$V_H = p_1 + \delta p_H,$$

$$V_L = p_1 + \delta p_L.$$

There is a single price in the market in the first period, and it is determined by the expected reservation value curve $\theta(M|\pi)$, when consumers have prior π for the proportion of H firms. Assuming $\lambda = 0$

$$p_1(\pi, M) = \pi\theta_H(M) + (1-\pi)\theta_L(M).$$

In the second period all L firms will have revealed their low quality [15], so $p_L(M) = \theta_L(M)$ and $p_H(\pi, M) = p_L(M) + \theta_H(\pi M) - \theta_L(\pi M)$. From these equations it follows that

$$\frac{\partial V_H}{\partial \pi} = \frac{\partial V_L}{\partial \pi} + \delta M[\theta'_H(\pi M) - \theta' L(\pi M)] < \frac{\partial V_L}{\partial \pi}$$

[15]We proceed under assumptions (A1), (A2), (A3′), (A4) and (IQP).

$$\frac{\partial V_H}{\partial M} = \frac{\partial V_L}{\partial M} + \delta\pi[\theta'_H(\pi M) - \theta' L(\pi M)] < \frac{\partial V_L}{\partial M} < 0$$
$$\frac{\partial V_L}{\partial \pi} > 0$$

where the two first inequalities follow from $\theta'_H(\pi M) - \theta'_L(\pi M) < 0$. [16]

As for the M_H and M_L functions, this implies $\frac{\partial M_L}{\partial \pi} > 0$ and leaves two possibilities for M_H: either the M_H curve cuts the M_L curve from above or it is downward sloping, i.e.

(i) $\frac{\partial M_L}{\partial \pi} > \frac{\partial M_H}{\partial \pi} > 0$

or (ii) $\frac{\partial M_H}{\partial \pi} < 0.$

We now discuss the comparative statics properties for an interior equilibrium, leaving the existence issue for later. An increase in C_L shifts M_L down, which in either case increases π. This coincides with Shapiro's result. The total number of firms and consumers increases in case (i) while it decreases in case (ii). Consider now the effect of a simultaneous increase in both C_L and C_H by ΔC. Since $|\frac{\partial V_L}{\partial M}| < |\frac{\partial V_H}{\partial M}|$, M_L moves down more than M_H, increasing π. In both cases the number of firms and consumers decreases.

We now turn to the issue of existence of an interior equilibrium. A necessary condition in case (i) is that the M_H curve intersects the M axis above of the M_L curve. This requires that at $\pi = 0$ profits be higher for H firms. For $\lambda > 0$ and a degenerate prior at $\pi = 0$ this is not possible. However for $\lambda = 0$, consumers learn from the first observation the true quality of a firm, so second period profits are higher for H firms. If the difference in profits is sufficiently large relative to the difference in entry costs, this condition will be satisfied. In that case, if no intersection occurs, the only equilibrium is one with $\pi = 1$; if they do intersect, the unique equilibrium will be the interior one. Similar results apply in case (ii). As before, if M_L cuts the M axis above M_H the unique equilibrium will have $\pi = 0$.

What makes this case so different is that there is no externality associated to the process of transmission of information, so the "lemons" effect plays a role only in the first period, where it affects both types of firms equally. This makes it possible for the value of low quality firms to be more sensitive to changes in π. In contrast, when $\lambda > 0$ a lower value of π reduces the informational value of the first period realization, affecting more negatively second period profits of H firms.

[16]This is true in general.

6 Conclusions

This paper analyzed the effects of entry restrictions on the quality mix of firms and the welfare of consumers. Despite the fact that the analysis has been kept deliberately simple our results are suggestive on how the effects of policies that restrict entry depend on characteristics of the economic environment. The overall effect on quality and welfare of these kind of policies depends on demand, cost and informational characteristics of each specific market.

On the demand side, the relationship between reservation values and preferences for quality plays an important role. By restricting the size of the market, the pool of consumers that end up buying a product changes. The relative desire for low or high quality goods of this new pool compared to the original one, will affect the final mix of products. For the case of perfect information we show, loosely speaking, that if the correlation between the two is positive entry restrictions result in higher average quality. For policies of direct regulation, our analysis suggests that making operating rights transferable and thus allowing selection to operate through entry and exit of firms, results in higher average quality. Our model also predicts that the equilibrium value of these rights will decrease through time.

The case of asymmetric information brings in additional considerations. When the quality of producers cannot be perfectly observed, our analysis suggests that the effect of entry restrictive policies cannot be determined without detailed knowledge of the process by which information about quality is diffused in the market. Our analysis of the Bayesian learning case shows that, in contrast to previous results, these policies are likely to have negative rather than positive effects on average quality and welfare.

Appendix

A Exit and Selection

Claim: All L firms exit and $C(t+1) < C(t)$ for periods $1, \ldots, T-1$.

Proof: (C1) implies that

$$\begin{aligned} C_e + C(T-1) &\geq \pi V_H(T-1) + (1-\pi)(p_L + \delta C(T)) \\ &\geq \pi V_H(T-1) + (1-\pi)\frac{p_L}{1-\delta} \end{aligned}$$

$$
\begin{aligned}
&> \pi V_H(T) + (1-\pi)\frac{p_L}{1-\delta} \\
&= C_e + C(T).
\end{aligned}
$$

This implies that $C(T-1) > C(T)$ so $V_L(T-1) = p_L + C(T) < C(T-1)$ and thus all L firms exit at the beginning of period $T-1$, i.e. $e(T-1) = (1-\pi(T-2))M'$. It also implies that $p_H(T-2) > p_H(T-1)$ and $V_H(T-2) > V_H(T-1)$. A simple inductive argument will now show that the same will occur for all periods $t < T$. As an inductive hypothesis for $t \leq T-1$ assume $C(t) > C(t+1) > \ldots > C(T-1) > C(T)$ and $C(t) > V_L(t)$. This implies that all L firms exit in period t, so $p_H(t-1) > p_H(t)$ and $V_H(t-1) > V_H(t)$. Hence

$$
\begin{aligned}
C_e + C(t-1) &\geq \pi V_H(t-1) + (1-\pi)(p_L + \delta C(t)) \\
&> \pi V_H(t) + (1-\pi)(p_L + \delta C(t+1)) \\
&= C_e + C(t).
\end{aligned}
$$

This proves that $C(t-1) > C(t)$. To complete the argument we will show that $V_L(t-1) < C(t-1)$, so all L firms exit in period $t-1$:

$$
\begin{aligned}
V_L(t-1) - C(t-1) &= p_L + \delta C(t) - C(t-1) \\
&< p_L - (1-\delta)C(t) \\
&\leq p_L - (1-\delta)C(T) \\
&\leq 0.
\end{aligned}
$$

This completes the proof.

B Related preferences

To relate the preferences of section 5.2 to other models in the literature, for instance Shaked and Sutton (1982), consider the following type of preferences: consumers face the choice to buy one unit of a product with expected quality $E(s)$. Quality takes only two values $s_H > s_L$. Preferences are represented by

$$
U = \begin{cases} \theta E(s) - p & \text{if purchase,} \\ 0 & \text{otherwise.} \end{cases}
$$

Assuming that θ is distributed over the population according to a distribution function $F(\theta)$ the inverse demand function can be written as

$$
p = \Phi(M)E(s),
$$

where $\Phi(M) = F^{-1}(1 - M/N)$, M is the number of products and N is the number of consumers. Adopting the same information structure as in section 5, we arrive to the following demand functions:

$$\begin{aligned} p_1 &= \Phi(M)\big[\pi s_H + (1-\pi)s_L\big], \\ p_L &= \Phi(M)\big[\lambda s_H + (1-\lambda)s_L\big], \\ p_H &= \Phi(M')\big[q s_H + (1-q)s_L\big]. \end{aligned}$$

Defining $s_H = 1$, $s_L = \lambda + (1-\lambda)\alpha$ and $\Phi(M) = \theta_H(M)$ we arrive to the formulation used in the text.

C Proof of Proposition 6

(1) For the case (DQP) $\frac{\partial V_H}{\partial \pi} > \frac{\partial V_L}{\partial \pi}$, $\frac{\partial V_H}{\partial \pi} > 0$ and $\frac{\partial V_L}{\partial M} < \frac{\partial V_H}{\partial M} < 0$. This implies that the M_H curve is upward sloping. If $\frac{\partial V_L}{\partial \pi} > 0$, then an increase ($\Delta C$) in the cost of entry shifts the M_L curve to the right more than the M_H curve, decreasing the equilibrium value of M. If $\frac{\partial V_L}{\partial \pi} < 0$, then the original equilibrium is at a point where $\frac{\partial M_L}{\partial \pi} < 0$ and the M_L curve shifts to the left. This also results in a decrease of M.

(2) This result follows the same argument as in (1).

(3) For case (DQP) $\frac{\partial V_L}{\partial M} < \frac{\partial V_H}{\partial M} < 0$, which implies that as a consequence of an increase ΔC in the cost of entry, the M_H curve shifts down more than the M_L curve. Since at the interior equilibrium $\frac{\partial M_L}{\partial \pi} < \frac{\partial M_H}{\partial \pi}$, the conclusion follows. For the case of (IQP) $\frac{\partial V_H}{\partial M} < \frac{\partial V_L}{\partial M} < 0$, so the opposite result is obtained.

D Conditions for M_L and M_H to be increasing

We develop conditions under which M_L and M_H are increasing in M, for the preferences considered in section 5.2. Differentiating implicitly:

$$\frac{\partial M_H}{\partial \pi} = -\frac{\frac{\partial V_H}{\partial \pi}}{\frac{\partial V_H}{\partial M}}, \qquad \frac{\partial M_L}{\partial \pi} = -\frac{\frac{\partial V_L}{\partial \pi}}{\frac{\partial V_L}{\partial M}}.$$

V_H and V_L are clearly decreasing in M. Given that $\frac{\partial p_1}{\partial \pi} > 0$ and $\frac{\partial p_L}{\partial \pi} = 0$, it suffices to show that $\frac{\partial}{\partial M}\Big(\theta(M'|H) - \theta(M'|L)\Big) > 0$. We write this expression as

$$\theta(M'|H) - \theta(M'|L) = \frac{1}{M[\pi + \lambda(1-\pi)]}\big[q(1-\lambda)(1-\alpha)\big] = k\frac{q^2}{\pi},$$

where k is a constant that does not depend on π. Differentiating the last term

$$\frac{\partial}{\partial \pi}\Big(\frac{q^2}{\pi}\Big) = q^2\Big(\frac{2\lambda}{\pi + (1-\pi)\lambda} - 1\Big),$$

which is positive if $\lambda > \pi(1-\lambda)$.

E Ranking of multiple equilibria

We show that under assumptions (A1), (A2), (A3′), (A4) and (IQP) or (CQP) and if $\frac{\partial M_L}{\partial \pi} > 0$ the equilibria are Pareto ranked. We consider the case where there is a unique interior equilibria as depicted in Figure 3, though the arguments extend to the general case. The three equilibria corresponding to the curves M_L, M_H are A, C and D, with $1 = \pi_C > \pi_D > \pi_A = 0$ and $M_C > M_D > M_A$.

Under assumptions (IQP) or (CQP) if $n_1 < n_2$

$$\big(\theta_H(n_1) - p_H\big) - \big(\theta_L(n_1) - p_L\big) > \big(\theta_H(n_2) - p_H\big) - \big(\theta_L(n_2) - p_L\big). \quad (13)$$

We will use the following remark:

Remark: Assume that θ' and θ'' are two reservation value curves with $\theta' < \theta''$ and that the corresponding equilibrium prices and quantities satisfy $p' < p''$ and $M' < M''$. Then the equilibrium with (p'', M'') is Pareto superior. To establish this, note that all consumers in the interval (M', M'') will be strictly better off in the latter case. Applying (13) this will also be the case for all consumers in $[0, M']$.

Let p_A and p_C be the prices in equilibria A and C respectively, p_1 be the first period price in D and p_L, p_H the second period prices in D. It is easy to check that

$$p_L < p_A < p_1 < p_C < p_H.$$

Since $\pi_A < \pi_D < \pi_C$ and $M_A < M_D < M_C$, the remark implies that for all first period consumers $C \succ D \succ A$. For the second period, since $p_L < p_A$ all consumers prefer D to A. Let θ_H denote the high reservation curve for the second period in case D. Then all consumers in the interval (M_D, M_C) are strictly better off in C since $\theta_H > p_C$. It now follows from (13) that all second period consumers will be strictly better off at C.

F Welfare effects of changes in entry restrictions

In the case analyzed in section 5.2. the effect of increasing C_H and C_L by ΔC is a reduction in π and M. We now show that the original equilibrium is

Pareto superior. Call the original equilibrium (M_A, π_A) and the equilibrium after changing the cost of entry (M_B, π_B).

In the first period, we have that $p'_B < p'_A$ and $M_B < M_A$, therefore by (13), all first period consumers are better off at A.

Let $M'_A = \pi_A M_A$ and $M'_B = \pi_B M_B$. M'_A and M'_B are the number of consumers that consume high quality products in A and B, respectively. Note that $M'_B < M'_A$. It is easy to show that $p^A_L < p^B_L < p^B_H < p^A_H$. All consumers in $[M'_B, M_B]$ are strictly better off at A, since $p^A_L < p^B_L$. By the remark, the same is true for consumers in $[0, M'_B]$. Finally the rest of the consumers that participate in A consume zero in B and are hence better off at A.

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