Entry Regulation in a Linear Market[1]

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This work performs a comparative welfare analysis of two types of entry regulation in a duopolistic retail market: number of licenses and minimum distance between stores. In a linear (Hotelling) market we show that, using minimum distance rules, the regulator may get higher consumer and social surplus than with the concession of licenses. The optimal distance rule is one quarter of the market under which firms will be located at the quartiles. This happens both with simultaneous and sequential entry and those location are also optimal under regulated prices. This analysis, which is not yet considered in the literature, is motivated by a change of entry regulation in the drugstore market in the Spanish region of Navarre.

Key Words: Entry, Regulation, Welfare Analysis, Hotelling

JEL Classification: D43, D60, L43, L51

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1. Introduction

Some retail markets, such us drugstores in many countries, have regulations with respect to entry into the market. The most popular of those regulations are the concession of a number of licenses and a minimum distance between stores. This paper performs a comparative welfare analysis of these two types of regulation in two models of competition in a linear market: one with simultaneous entry and the other with sequential entry.

This analysis is motivated by a regulation change in the drugstore market of the Spanish region Navarre. While before 2001, the main restriction to entry into the drugstore market was a fixed number of licenses, in 2001, the conditions to obtain a license were significantly liberalized. As a consequence, in many parts of Navarre, from 2001 on, the minimum distance between drugstores became the binding restriction to open a new store. In this paper, our goal is to study theoretically the impact of this change of regulation on the equilibrium outcome and welfare.

The linear market describes competition between products horizontally differentiated along a single dimension. Hotelling (1929) pioneered the analysis of competition with horizontally differentiated products and predicted minimum product differentiation in equilibrium. Some of the original Hotelling assumptions have been relaxed by posterior works showing a tendency towards maximum or, at least, intermediate degree of differentiation.[2]

The present paper analyses a modified version of Hotelling's model by considering minimum distance conditions and sequential entry into a market with two firms. The literature on sequential entry in a linear market has been focused mainly on the prediction of the equilibrium locations of firms by comparing the case of a fixed number of firms with the one that considers free entry and fosters entry deterrence strategies. One of the goals of those works is to analyse whether all earlier entrants get a higher profit than later ones.[3] The number of firms in equilibrium with free entry is typically determined by the entry deterrence strategies in combination with the level of fixed costs (see Lane (1980), Neven (1987) and Economides et al. (2004)).[4]

[2] A noteworthy contribution is that by d'Aspremont et al. (1979), who find a subgame perfect equilibrium with maximum product differentiation considering quadratic, rather than linear, transportation costs.
[3] Which follows the literature on *first mover advantages*, see Gal-Or (1985).
[4] Götz (2005) analyses a modified version of Neven (1987)'s work by considering changes in market size for given levels of fixed costs.

In our model the number of firms in the case of free entry depends on the combination of entry deterrence activities of incumbent firms with the minimum distance fixed by the regulator. We show that minimum distance rules may reach a higher level of both consumer and social surplus than the number of licenses rules as firms in a market regulated with minimum distance tend to locate closer to the market centre.

The remainder of this paper is organised as follows: in Section 2, we present the model of horizontal product differentiation. In Section 3, we perform the comparative analysis of entry regulation with regulation through number of licenses and minimum distance under simultaneous entry of firms. In Section 4, we repeat the analysis for the case of sequential entry. In Section 5, we compare and discuss the implications of both types of regulation. Section 6 analyses the optimal minimum distance rule when prices are regulated. Conclusions are presented in Section 7.

2. The Model

In this section we present a modified version of Hotelling's original model in which transportation costs are quadratic in distance. Consumers are evenly distributed along a linear city of length 1 (see Figure 1).

Figure 1: Linear market

The utility of consumer located at point ω when she buys from firm j, located at x_j, is:

$$u_\omega(x_j, p_j) = k - p_j - (x_j - \omega)^2,$$

where $k > 0$ is her reservation price, which is assumed to be equal for all consumers, and $j = \{1,2\}$. As it is customary in the literature, we assume that the reservation price is high enough so that all consumers in the linear city end up buying one unit of the good. When entry is simultaneous, the game is played in two stages: in the first stage firms simultaneously choose locations and, in the second stage, firms simultaneously fix prices. When entry is sequential, the game is played in three stages: in the first stage firm 1 chooses its location, in the second stage firm 2 chooses its location and in the third stage both firms simultaneously fix prices.

The game is solved by backward induction. Let us define the marginal consumer, located at z, who is indifferent between buying from firm 1 or 2, as the one who gets the same utility from the consumption of either good (see Figure 2, where the locations are represented in the horizontal axis and the delivered prices – mill prices plus transportation costs – are represented in the vertical axis):

$$u_z(x_2, p_2) = k - p_2 - (x_2 - z)^2 = u_z(x_1, p_1) = k - p_1 - (x_1 - z)^2$$

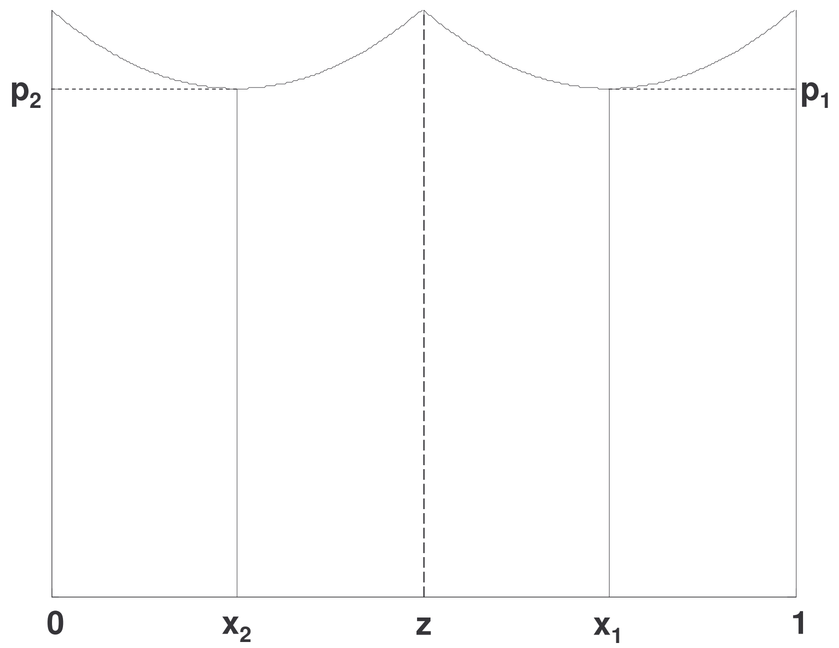

Figure 2: Mill and delivered prices and location of the marginal consumer

Assuming that $0 \leq x_2 \leq x_1 \leq 1$, the position of the marginal consumer determines the firms' demand functions:

$$D_2(p,x) = z = \frac{p_1 - p_2}{2(x_1 - x_2)} + \frac{x_1 + x_2}{2}$$

$$D_1(p,x) = 1 - z = 1 - \frac{p_1 - p_2}{2(x_1 - x_2)} - \frac{x_1 + x_2}{2},$$

where $p = (p_1, p_2)$ is the vector of firms' prices and $x = (x_1, x_2)$ is the vector of firms' locations.

Maximising the profit function $\Pi_j(p|x) = p_j D_j(p|x)$ with respect to p_j leads to the price reaction functions:

$$p_2(p_1, x) = \frac{p_1 + (x_1 - x_2)(x_1 + x_2)}{2}$$

$$p_1(p_2, x) = \frac{p_2 + (x_1 - x_2)(2 - x_1 - x_2)}{2}.$$

This system of equations yields the equilibrium prices $p_j^*(x)$ and demands $D_j^*(x)$ as a function of the vector of locations x:

$$p_2^*(x) = \frac{(x_1 - x_2)(2 + x_1 + x_2)}{2}$$

$$p_1^*(x) = \frac{(x_1 - x_2)(4 - x_1 - x_2)}{2}$$

$$D_2^*(x) = \frac{2 + x_1 + x_2}{6}$$

$$D_1^*(x) = \frac{4 - x_1 - x_2}{6}.$$

Equilibrium locations are computed depending on the nature of the entry game (simultaneous or sequential) and on the type of regulation (with restrictions, in the case of a minimum distance, or without, in the case of the concession of two licenses –). Let us denote as $\Pi = \Pi_1 + \Pi_2$ the resulting value of the profits earned by the firms in this market.

In order to complete the welfare analysis of each type of regulation analysed in the following sections we need to define consumer surplus. Figure 3 illustrates the welfare analysis for a particular case in which the two firms charge equal prices. The total firms' profit is the dashed area below the price, consumer surplus is the area above the delivered prices and the blank area corresponds to consumer surplus loss, the difference between the whole box of area k and total surplus.

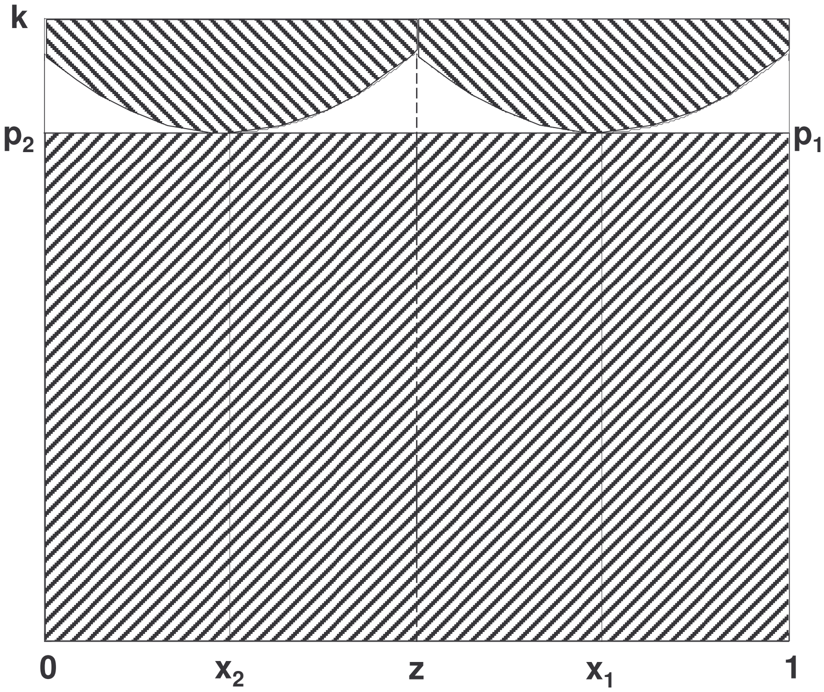

Figure 3: Profits, consumer surplus and consumer surplus loss

Consumer surplus loss is associated with the transportation costs incurred by consumers. When x_1 and x_2 take interior values, the consumer surplus loss (CSL) is

$$CSL = \int_0^{x_2} s^2 ds + \int_0^{z-x_2} s^2 ds + \int_0^{x_1-z} s^2 ds + \int_0^{1-x_1} s^2 ds .$$

The maximum level of surplus that could be reached in this market is equal to the reservation value k , that is the height of the total rectangular surplus area, with 1 (the mass of consumers) as the base of that rectangle. That area of value k is divided into three components: profits, consumer surplus and consumer surplus loss. Therefore consumer surplus (CS) is equal to $CS = k - \Pi - CSL$ and social surplus (SS) is defined as $SS = CS + \Pi = k - CSL$.

In order to calculate the total level of consumer and social surplus numerically, we need to make an assumption about the value of the consumer's reservation value k , that takes the same value for all the consumers. We assumed in the beginning of this section that k is high enough so that it induces all the consumers in the market to purchase the good. Without loss of generality, we assume that the reservation value is the lowest value so that all the consumers consume the good in equilibrium for any number of firms. In our model with quadratic transportation costs and mass of consumers equal to 1, the minimum reservation value is 1.25, as in Götz (2005).

3. Simultaneous entry

We start this section considering the case in which the regulator concedes two licenses. Firms choose their locations in order to maximise their first-stage profit functions:

$$\Pi_1(x)=\frac{(x_1-x_2)(4-x_1-x_2)^2}{12} \text{ and } \Pi_2(x)=\frac{(x_1-x_2)(2+x_1+x_2)^2}{12}.$$

Locations are $x_2=0$ and $x_1=1$ (see Figure 4). Prices are monopoly prices, $p_1=p_2=1$, and each firm gets half of the market, so $D_1=D_2=1/2$. The level of surpluses are also equal to those in monopoly, with total profits $\Pi=1$, $CS=0.1667$ and $SS=1.1667$.

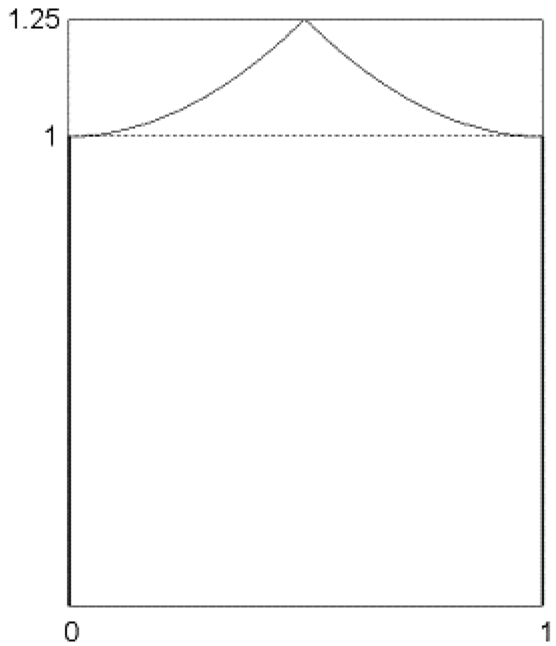

Figure 4: Regulation with two licenses under simultaneous entry

Let us now consider the case where the regulator wants to reach a market with two firms by stating a minimum distance between stores. Let us define a value D such that the distance between the two stores has to be higher than that level. When $D\geq 0.5$ we have a legal monopoly with only one firm located in the middle of the market, as in Figure 5.

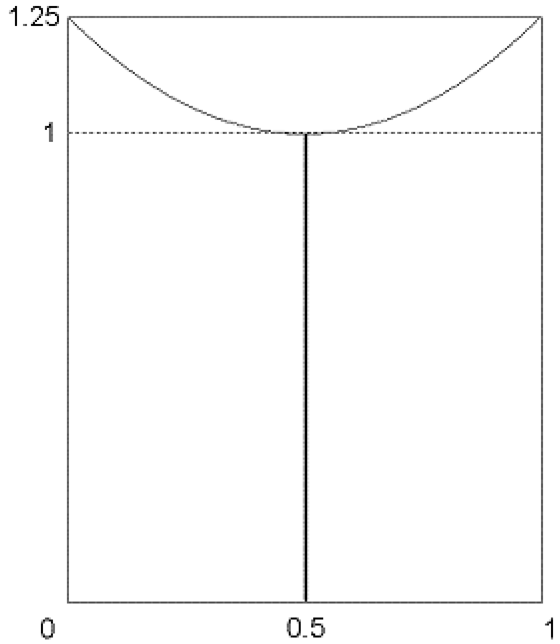

Figure 5: Monopoly

When $0.25 \leq D < 0.5$, we have a duopoly with locations $x_2 = \frac{1}{2} - D$ and $x_1 = \frac{1}{2} + D$, prices $p_1 = p_2 = 2D$, outputs $D_1 = D_2 = 1/2$ and profits $\Pi_1 = \Pi_2 = D$. Total profits are $\Pi = 2D$, $CS = \frac{7}{6} - \frac{3}{2}D - D^2$ and $SS = \frac{7}{6} + \frac{1}{2}D - D^2$.

Figure 6 represents the locations of the firms as a function of the minimum distance. The vertical axis represents the locations of firms in the segment $[0,1]$ and the horizontal axis represents the minimum distance and is measured from left to right. The continuous line represents the location of firm 1, while the dashed line represents the location of firm 2. When $D \geq 0.5$ we have a legal monopoly with firm 1 located in the middle of the market. When $0.25 \leq D < 0.5$, we have a duopoly with locations $x_2 = \frac{1}{2} - D$ and $x_1 = \frac{1}{2} + D$. When $D = 0.25$, firms are located at the quartiles, at locations $x_2 = \frac{1}{4}$ and $x_1 = \frac{3}{4}$. In those cases where there is a duopoly, firms' locations are always symmetric. Prices, profits and sales are therefore equal for both firms.

Consumer and social surplus are both maximised when $D = \frac{1}{4}$. In that case, locations are $x_2 = \frac{1}{4}$ and $x_1 = \frac{3}{4}$, prices are $p_1 = p_2 = \frac{1}{2}$, outputs are $D_1 = D_2 = 1/2$, profits are $\Pi_1 = \Pi_2 = \frac{1}{4}$, $CS = 0.7292$ and $SS = 1.2292$.

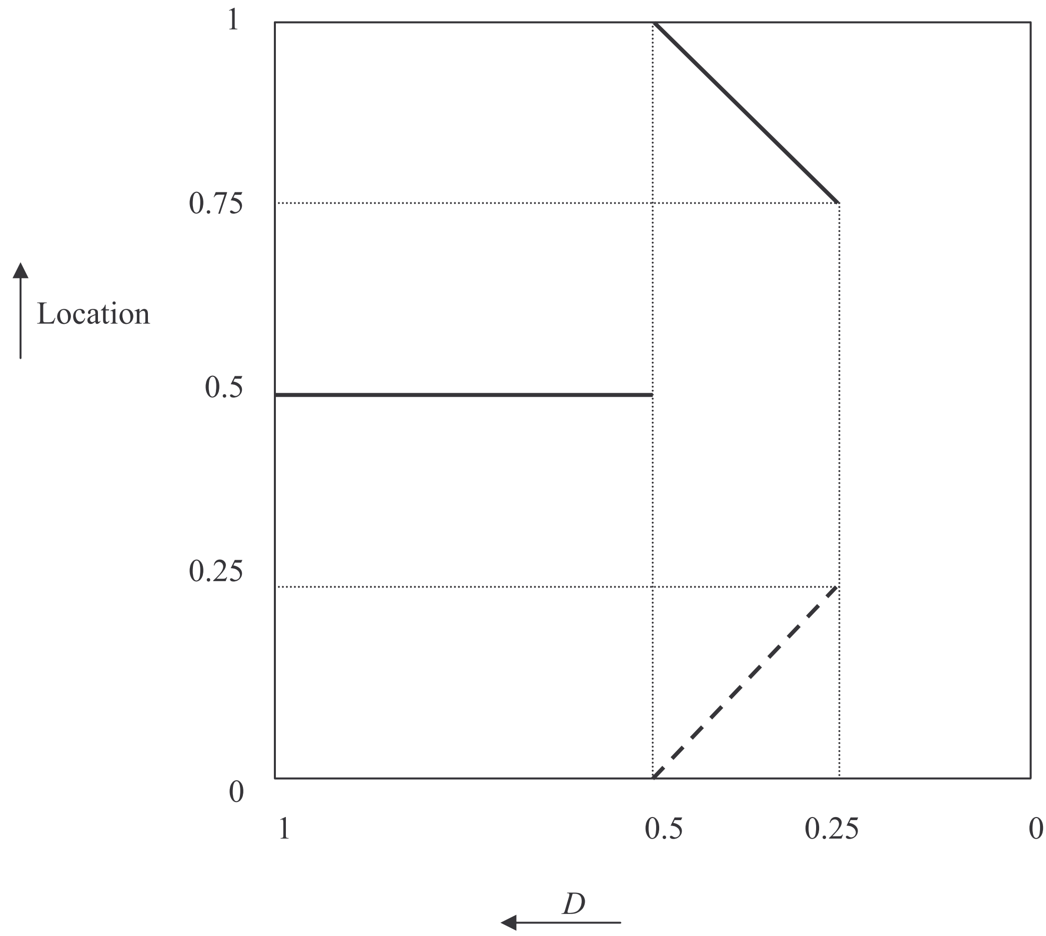

Figure 6: Firms' locations as a function of minimum distance under simultaneous entry

4. Sequential entry

In this section, we present the model of sequential entry into the market described in Section 2. In this case the first entrant will choose its location anticipating the location reaction of the second entrant.

As in the previous section, we start with the case of regulation through a number of licenses and thus the number of firms in the market is fixed. If the market is a legal monopoly (with a number of firms equal to 1), the only firm will be located again at the centre and would charge a price equal to 1. If the number of licenses is 2, the first entrant, firm 1, will be located at the end of the market ($x_1 = 1$) anticipating that the second entrant, firm 2, will locate at the other end of the market ($x_2 = 0$). The second entrant will do this in order to relax price competition as much as possible even though it would gain a higher market share if it located closer to the first entrant. As the price effect dominates the market share effect, firm 2 locates at the opposite end of the market. The price will still be equal to 1 and the consumer and social surplus will take the same values as in the legal monopoly case and as in the case of simultaneous entry.

Let us now analyse the case where the regulator states the minimum distance that there must be between the two firms. The locations chosen by the firms for the different values of minimum distance are depicted in Figure 7.

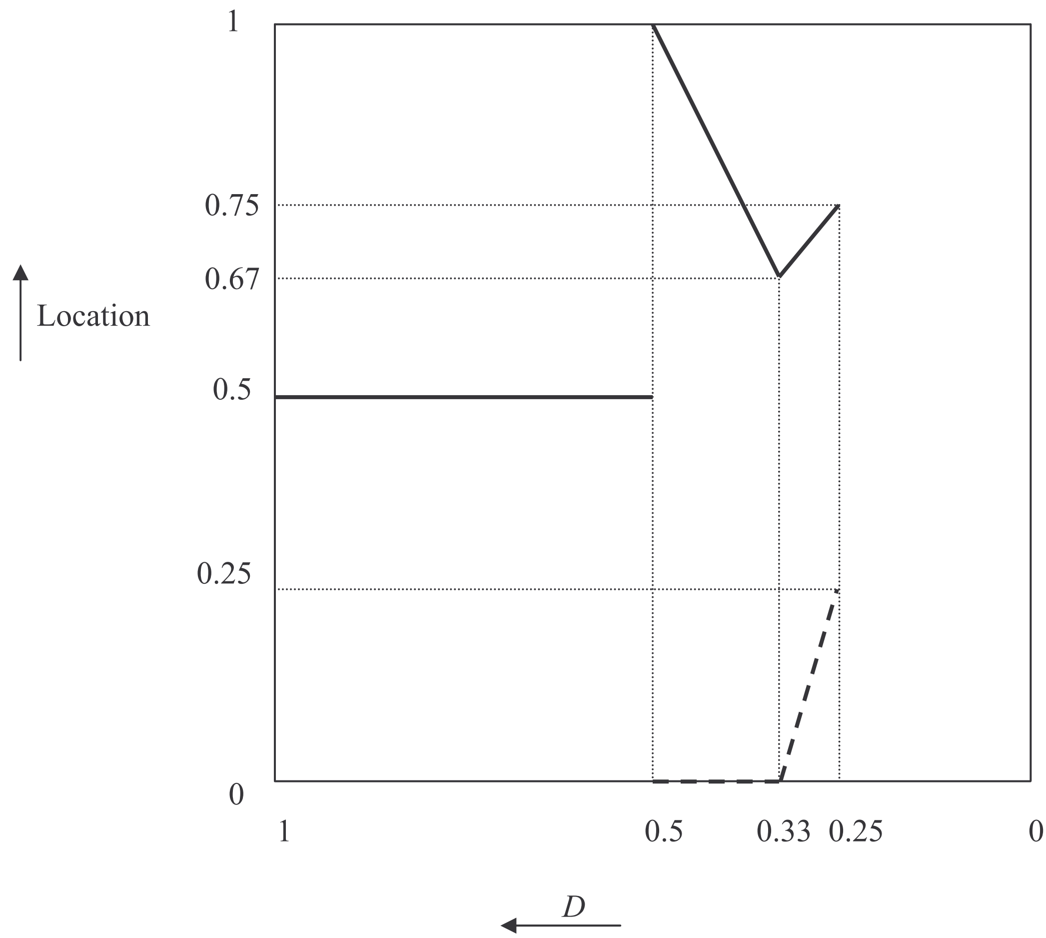

Figure 7: Firms' locations as a function of minimum distance under sequential entry

When the distance between firms is higher than 0.5, then the market will be a legal monopoly again.

If the minimum distance between locations is some value between $1/3$ and $1/2$, then firm 1 will take some location between 1 and $2/3$ and firm 2 will be located at 0. By using these strategies the firms deter the entry of a third firm both in the segment between them and in the segment between firm 1 and its closer end.

The equilibrium in this segment is characterised by:

locations $x_1 = 2D$, $x_2 = 0$,

prices $p_1 = \frac{4}{3}D(2-D)$, $p_2 = \frac{4}{3}D(1+D)$,

quantities $D_1 = \frac{2-D}{3}$, $D_2 = \frac{1+D}{3}$,

profits $\Pi_1 = \frac{4}{9}D(2-D)^2$, $\Pi_2 = \frac{4}{9}D(1+D)^2$, $\Pi = \frac{4}{9}D\left(5-2D+2D^2\right)$

and surpluses $CS = 1.25 - \frac{4}{9}\left(5-2D+2D^2\right) - \frac{(1+D)^3}{81} - \frac{(5D-1)^3}{81} - \frac{(1-2D)^3}{3}$,

$SS = 1.25 - \frac{(1+D)^3}{81} - \frac{(5D-1)^3}{81} - \frac{(1-2D)^3}{3}$.

As we can observe from this analysis, when minimum distance is lower than 0.5, firm 1 accepts the entry of one rival but acts in order to deter the entry of an additional rival. It chooses location in a way as to allow only one rival and this rival, firm 2, will choose the farthest possible location, that is, the edge of the market segment.

In the limit when $D = 1/3$, the equilibrium is depicted in Figure 8.

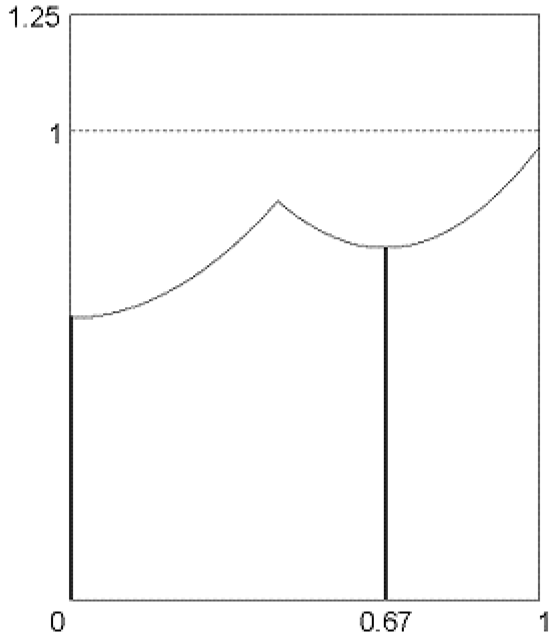

Figure 8: Equilibrium with $D = 1/3$

Equilibrium values are reported in Table 1.

Firm number	Location	Price	Output	Profits	Consumer surplus	Social surplus
1	0.67	0.7407	0.5555	0.4115		
2	0	0.5926	0.4444	0.2634		
TOTAL				0.6749	0.5298	1.2047

Table 1: Equilibrium with $D = 1/3$

Let us now analyse the case where D is between $1/4$ and $1/3$. In this case, entry is not blockaded if firm 2 remains at the edge. So it has to move towards the middle of the market segment. Firm 1 will move towards its end of the market in order to be farthest from firm 2 but keeping on avoiding the entry of an additional firm.

In this segment, the equilibrium is characterised by the following values:

locations $x_1 = 1 - D$, $x_2 = 1 - 3D$,

prices $p_1 = \dfrac{2D(2+4D)}{3}$, $p_2 = \dfrac{2D(4-4D)}{3}$,

quantities $D_1 = \dfrac{2+4D}{6}$, $D_2 = \dfrac{4-4D}{6}$, profits $\Pi_1 = \frac{D(2+4D)^2}{9}$, $\Pi_2 = \frac{D(4-4D)^2}{9}$, $\Pi = \frac{4}{9}D(5-4D+8D^2)$

and surpluses $CS = 1.25 - \frac{4}{9}D(5-4D+8D^2) - \frac{(1-3D)^3}{3} - \frac{(7D-1)^3}{81} - \frac{(1-D)^3}{3} - \frac{D^3}{3}$,

$SS = 1.25 - \frac{(1-3D)^3}{3} - \frac{(7D-1)^3}{81} - \frac{(1-D)^3}{3} - \frac{D^3}{3}$.

In the limit, when $D = 0.25$, firms are located at the quartiles as shown in Figure 9. The results of the equilibrium are the same as under the same distance rule with simultaneous entry and are reported in Table 2.

Firm number	Location	Price	Output	Profits	Consumer surplus	Social surplus
1	0.75	0.5	0.5	0.25		
2	0.25	0.5	0.5	0.25		
TOTAL				0.5	0.7292	1.2292

Table 2: Equilibrium with $D = 1/4$

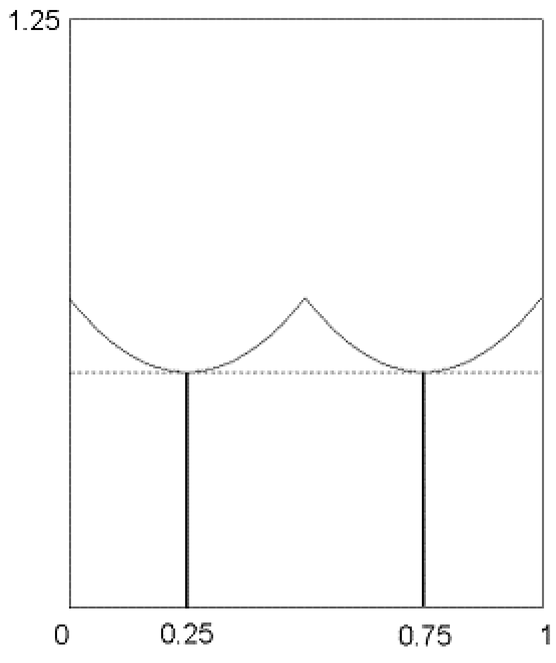

Figure 9: Equilibrium with $D = 1/4$

5. Comparison of policies

In this section we compare the results obtained in the two previous sections and reach some conclusions about the implications of the two types of regulations analysed (number of licenses and minimum distance) and the entry procedure (simultaneous or sequential).

When the minimum distance is higher than 0.5, we have a legal monopoly under both rules with the single firm located at the centre and charging a price equal to 1. When the minimum distance is between $1/2$ and $1/4$, we have a duopoly. We can compare the duopoly that emerges under minimum distance with the one that results from the concession of two licenses. In the case of two licenses, firms are located at the opposite ends and charge the monopoly price. The overall level of profits and consumer surplus is the same with one and with two firms, as the average distance that consumers have to travel to purchase the good is 0.25 in both cases. However, in the case of a minimum distance lower than 0.5, firm 1 will come closer to firm 2's location, reducing prices and increasing consumer surplus. At the limit when the distance between firms needs to be higher than $1/4$, the average distance travelled by consumers is only $1/8$ and consumer surplus is increased by more than 4 times.

Let us now compare the welfare that is reached under simultaneous entry with the one that is reached under sequential entry. In the range between $1/2$ and $1/3$, simultaneous entry yields higher social surplus if $\frac{7}{6}+\frac{D}{2}-D^2>1.25-\frac{(1+D)^3}{81}-\frac{(5D-1)^3}{81}-\frac{(1-2D)^3}{3}$, which holds for the whole range of minimum distance between $1/2$ and $1/3$ except for $D=1/2$. In the range between $1/3$ and $1/4$, simultaneous entry yields a higher social surplus if $\frac{7}{6}+\frac{D}{2}-D^2>1.25-\frac{(1-3D)^3}{3}-\frac{(7D-1)^3}{81}-\frac{(1-D)^3}{3}-\frac{D^3}{3}$, which holds for the whole range except for $D=1/4$. Consumer and social surplus are maximised when minimum distance is $1/4$ so that firms are located at the quartiles. This happens both for simultaneous and sequential entry. Firms' profits are maximised when the regulator concedes two licences or when minimum distance is $1/2$.

We can conclude from this analysis that, when a regulator intends to limit the number of firms operating in a market, the welfare effects may be different by stating a minimum distance rule rather than by allocating a number of licenses. Consumers are better off when the minimum distance rule is used with a minimum distance lower than $1/2$ and they are best off when the minimum distance is $1/4$ so that firms are located at the quartiles.

6. Entry regulation with regulated prices

In some sectors, such as medical products, prices are regulated so that competition in prices does not take place. In these cases firms only choose locations. Let us now analyse what is the minimum distance rule that maximises social welfare under fixed prices. In the equilibrium without distance restrictions, both firms would locate at the centre of the market segment. Consider again the linear market of length 1 in which the regulator needs to define the locations of the two firms. See Figure 10.

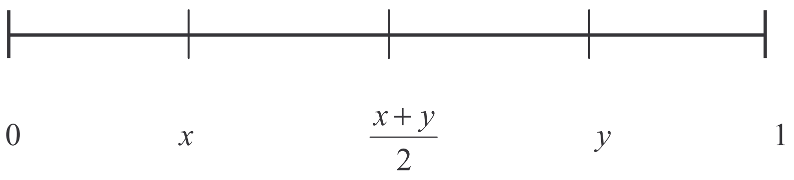

Figure 10: Linear market

By choosing a minimum distance rule, the regulator decides the locations of the firms: x and y. The marginal consumer who gets the same utility from the consumption of either good is located at $\frac{x+y}{2}$. The regulator acts to minimise the average distance travelled by the consumers of this market. There are four sets of consumers in the market:

(1) Those located between 0 and x. They buy from the firm located at x, the average distance travelled by them is $\frac{x}{2}$ and their weight in the total market is x.

(2) Those located between x and $\frac{x+y}{2}$. They buy from the firm located at x, the average distance travelled by them is $\frac{1}{2}\left(\frac{x+y}{2}-x\right)=\frac{y-x}{4}$ and their weight in the total market is $\frac{x+y}{2}-x=\frac{y-x}{2}$.

(3) Those located between $\frac{x+y}{2}$ and y. They buy from the firm located at y, the average distance travelled by them is $\frac{1}{2}\left(y-\frac{x+y}{2}\right)=\frac{y-x}{4}$ and their weight in the total market is $y-\frac{x+y}{2}=\frac{y-x}{2}$.

(4) Those located between y and 1. They buy from the firm located at y, the average distance travelled by them is $\frac{1-y}{2}$ and their weight in the total market is $1-y$.

The average distance function that the regulator needs to minimise in order to get the locations of the firms that maximises welfare is:

$$\frac{1}{2}x^2+\frac{(y-x)^2}{4}+\frac{1}{2}(1-y)^2.$$

Optimising that function with respect to x and y yields the locations: $x=1/4, y=3/4$, which are reached when minimum distance is $D=1/2$. By issuing a minimum distance of one half, firms will be located at the quartiles as each of the firms loses part of the market in detriment of the other firm if it moves towards the edge.

We can conclude that a minimum distance that induces firms to be located at the quartiles maximises social welfare also when prices are regulated.

7. Conclusions

In this work, we have performed a welfare analysis for two types of entry regulation in a duopolistic linear market, number of licenses and minimum distance, under two types of entry games, simultaneous and sequential. With two licenses, firms are located at the edges of the market and charge the monopoly price. This is the best scenario for the firms. When locations are regulated through minimum distance, firms move closer to each other in order to avoid the entry of an additional firm. Prices are reduced and both consumer and social surplus are increased. The optimal minimum distance rule is a minimum distance of $1/4$, with which firms will be located at the quartiles both with simultaneous and sequential entry. When prices are regulated, so that firms only compete in locations, the minimum distance rule is $1/2$ with firms located at the quartiles again.

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