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Competition in Multiple Characteristics: An Empirical Test of Location Equilibrium

Javier Elizalde
Facultad de Ciencias Económicas y Empresariales
Universidad de Navarra

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ABSTRACT

With products differentiated in multiple dimensions, the location equilibrium for a duopolistic market exhibits maximum differentiation in one dimension and minimum differentiation in all the other dimensions. This paper analyses whether this equilibrium arises using real data for the Spanish movie theatre exhibition market where the firms (cinemas) are differentiated along two dimensions (their geographical location and the set of movies exhibited). Data not only shows a trade-off such that closer theatres tend to choose a higher proportion of different movies but also there is a tendency towards either max-min or min-max product differentiation.

Javier Elizalde
Universidad de Navarra
Depto. Economía
Campus Universitario
31080 Pamplona
jelizalde@unav.es

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Javier Elizalde[♣]
Universidad de Navarra

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With products differentiated in multiple dimensions, the location equilibrium for a duopolistic market exhibits maximum differentiation in one dimension and minimum differentiation in all the other dimensions. This paper analyses whether this equilibrium arises using real data for the Spanish movie theatre exhibition market where the firms (cinemas) are differentiated along two dimensions (their geographical location and the set of movies exhibited). Data not only shows a trade-off such that closer theatres tend to choose a higher proportion of different movies but also there is a tendency towards either max-min or min-max product differentiation.

Key Words: Spatial competition, Horizontal product differentiation, Multiple dimensions, Equilibrium
JEL Classification: L13, L82, R39

1. Introduction

Harold Hotelling pioneered the address approach to horizontal product differentiation analysis. His acclaimed "principle of minimum product differentiation" (H. Hotelling (1929)) has been tackled by economists by relaxing some of the original assumptions.[1] Unlike in H. Hotelling's original model, where there didn't exist a price equilibrium for

[♣] Campus Universitario. Ed. Bibliotecas, Entrada Este. 31080 Pamplona, Spain. E-mail: jelizalde@unav.es

[1] H. Hotelling's model assumed a linear market where products were differentiated in a single dimension.

some set of firms' locations, C. d'Aspremont, J.-J. Gabszewicz and J.-F. Thisse (1979) reached a subgame perfect equilibrium with products maximally differentiated under the assumption of quadratic transportation costs, thus raising the so-called "principle of maximum product differentiation".[2] When goods are differentiated in multiple dimensions, T. Tabuchi (1994), E. Veendorp and A. Majeed (1995), A. Ansari, N. Economides and J. Steckel (1998) and A. Irmen and J.-F. Thisse (1998) find that goods in equilibrium are maximally differentiated in one dimension and minimally differentiated in all the other dimensions, what has been called the "max-min-min principle of product differentiation".[3] With products differentiated by two characteristics, either the max-min or the min-max equilibrium hold depending on whether the characteristic that is most highly valued by consumers is the first or the second one, respectively. If both characteristics are similarly valued by consumers, then both the max-min and the min-max equilibria hold.[4]

The theoretical prediction that firms tend to maximally differentiate in one characteristic if it is highly valued by consumers is supported by empirical evidence. E. Glaeser, G. Ponzetto and J. Shapiro (2005) show that the Republican and Democratic parties in the United States before the November 2004 elections took extreme positions in religious related issues as attitudes towards those issues defined in a big deal the core constituents of the voters of each party.[5] S. Mullainathan and A. Shleifer (2005) show that newspapers take extreme positions on topics where reader beliefs diverge, such as political divisive issues.

In this paper I analyse whether the location equilibrium in a two-dimensional model of horizontal product differentiation, such that firms maximally differentiate in one dimension and minimally differentiate in the other, is supported by empirical evidence. The data used corresponds to the movie theatre exhibition market in Spain and takes all those towns that have had two first-run cinemas during at least forty weeks in at least one of four different years: 1998, 2001, 2004 and 2008. I consider the geographical location of theatres and the set of movies exhibited as the two dimensions of cinema differentiation. Anecdotal evidence shows that, under duopolistic setup, cinemas located

[2] The game is played in two stages, where the two firms simultaneously choose locations (i.e. product specification) in the first stage and price in the second stage.

[3] A. Ansari, N. Economides and J. Steckel (1998).

[4] With products defined by two dimensions, max-min differentiation means that products are maximally differentiated in the first dimension and minimally differentiated in the second dimension. Analogously, min-max differentiation means that products are minimally differentiated in the first dimension and maximally differentiated in the second dimension.

[5] With regards to other issues, parties tend to take similar positions in order to attract the median voter.

further apart exhibit a higher proportion of same movies and vice versa. Using a probit model of estimation, I find that not only this trade-off exists but there is also a tendency towards both the max-min and min-max equilibria as predicted by theoretical work. The key variable that determines which of the two settings arises in a particular town is town size. The bigger the town, the more important geographical distance becomes for moviegoers, so competition in the movies exhibited becomes less important and both cinemas may show the same, most popular, films. For small towns, theatre location is a less important issue so the bundle of movies shown in each venue becomes the dominant characteristic and cinemas try to coincide in a lower number of titles.

The reminder of this work is organised as follows: Section 2 examines the theoretical work on competition with multi-dimensional product differentiation. Previous applied works are reviewed in Section 3. Section 4 presents the data and main empirical facts. Section 5 presents the test of location equilibrium and the results obtained and Section 6 concludes. Tables and graphs are reported in the appendix in Section 8.

2. Theory

In this section I review the relevant theoretical literature on competition with differentiated products, mainly focused on multidimensional product differentiation. The section is completed with an explanation of the application of the theoretical model in A. Irmen and J.-F. Thisse (1998) to competition between movie theatres.

The so-called "principle of minimum product differentiation" predicted by H. Hotelling (1929) has been tackled by economies in a different number of ways. Some of Hotelling's original assumptions (mainly: linear transportation costs, completely inelastic demand, one-dimensional product differentiation and duopolistic setup) have been relaxed by economists who have predicted a tendency towards either maximum or at least intermediate degree of product differentiation.[6]

With one-dimensional product differentiation and linear transportation costs, C. d'Aspremont, J.-J. Gabszewicz and J.-F. Thisse (1979) show that a noncooperative price equilibrium fails to arise for close locations of symmetric firms. By contrast, with products differentiated in two dimensions, N. Economides (1986) found that a price equilibrium exists for all pairs of symmetric locations.

[6] See, among others, C. d'Aspremont, J.-J. Gabszewicz and J.-F. Thisse (1979), D. Neven (1985), N. Economides (1984, 1989), S. Salop (1979) and S. Brenner (2005).

The search for the subgame perfect equilibrium was approached by using a quadratic transportation cost rather than a linear one. As found by T. Tabuchi (1994) and E. Veendorp and A. Majeed (1995), for the case of two dimensions, and by A. Ansari, N. Economides and J. Steckel (1998) and A. Irmen and J.-F. Thisse (1998), for the case of n dimensions ($n > 1$), the equilibrium exists with products maximally differentiated along one dimension and minimally differentiated along all the other dimensions. With n characteristics, when consumers' preference for one of them is significantly higher than for the other $n-1$ characteristics, an equilibrium exists with products maximally differentiated along the most preferred characteristic and minimally differentiated along the others.[7] In the opposite extreme, when all the n dimensions are similarly valued by consumers, there exist n equilibria each with products maximally differentiated in one characteristic and minimally differentiated along all the other ones.

The explanation for this result is given in T. Tabuchi (1994) and E. Veendorp and A. Majeed (1995) for the case of two-dimensional product differentiation. With products defined by two characteristics, if the first characteristic is dominant, the max-min equilibrium arises with products maximally differentiated in the first characteristic and minimally differentiated in the second one. The rationale for this equilibrium comes from the incentive of the firms to relax price competition as much as possible. A longer distance in the dominant characteristic increases the degree of differentiation and reduces price competition, as the one-dimensional differentiation literature had proved. Additionally, by minimising differentiation in the dominated characteristic, firms reduce the number of marginal consumers. The lower the number of marginal consumers, the less sensitive is a firm's demand to prices charged by its opponent and thus the less severe is price competition in the second stage.

Let us now highlight the main items in A. Irmen and J.-F. Thisse (1998)'s model: Products are differentiated along n dimensions, so a product is defined by a firm's location in $\Re^n$. Let us consider a market with two firms A and B located respectively at $\mathrm{a} = (a_1,...,a_n)$ and $\mathrm{b} = (b_1,...,b_n)$. Consumers are uniformly distributed along a unit hypercube $C = [0,1]^n$ according to a continuous nonnegative density function $g(\mathrm{z})$, where $\mathrm{z} = (z_1,...,z_n)$ is a consumer's location. Consumer located at z has a conditional indirect utility function $V_i(\mathrm{z})$ that represents the satisfaction obtained from the

[7] As we shall see below, the characteristic in which the firms maximally differentiate in the only equilibrium is called by A. Irmen and J.-F. Thisse (1998) the *dominant characteristic*.

consumption of good $i = A, B$. Under the assumption of a quadratic transportation cost, consumer's utility from the consumption of good A is equal to

$$V_A(\mathrm{z}) = S - p_A - \sum_{k=1}^{n} t_k (z_k - a_k)^2$$

where S is the gross utility that a consumer obtains when consuming either product and p_A is the price of product A. The last term in the right-hand side of the equation represents the disutility of the consumer from consuming variant A instead of her ideal variant. $|z_k - a_k|$ is the Euclidean distance between consumer's ideal amount of characteristic k and the amount of that characteristic contained in A. t_k is the salience coefficient of characteristic k. Irmen and Thisse thus allow characteristics to be differently weighted by consumers, who are assumed to be homogeneous in their weights for each characteristic. By taking the assumption that S is large enough so that all consumers purchase one unit of the good, the demand for good A is the mass of consumers who weekly prefer good A to good B:

$$D_A = \int_{\{\mathrm{z}; V_A(\mathrm{z}) \geq V_B(\mathrm{z})\}} g(\mathrm{z}) d\mathrm{z}$$

In order to reach a unique perfect equilibrium in both the location and price stages, Irmen and Thisse take the assumption that one of the characteristics is strongly dominant. The nth characteristic strongly dominates when

$$t_n(b_n - a_n) > \sum_{k=1}^{n-1} t_k (b_k - a_k).$$[8]

The first order conditions for profit maximisation in the second-stage price equilibrium, given first-stage locations $\mathrm{a} = (a_1, ..., a_n)$ and $\mathrm{b} = (b_1, ..., b_n)$, yield equilibrium prices

$$p_A^*(\mathrm{a}, \mathrm{b}) = \frac{2t_n(b_n - a_n) - \sum_{k=1}^{n-1} t_k (b_k - a_k) + \sum_{k=1}^{n} t_k (b_k^2 - a_k^2)}{3}$$

$$p_B^*(\mathrm{a}, \mathrm{b}) = \frac{4t_n(b_n - a_n) + \sum_{k=1}^{n-1} t_k (b_k - a_k) - \sum_{k=1}^{n} t_k (b_k^2 - a_k^2)}{3}.$$

These equilibrium prices have the following static properties:

$$\frac{dp_A^*}{da_i} > 0 \quad \text{for} \quad a_i < \frac{1}{2} \qquad i = 1, ..., n-1$$

[8] Authors assume, without loss of generality, $t_n(b_n - a_n) \geq t_{n-1}(b_{n-1} - a_{n-1}) \geq ... \geq t_1(b_1 - a_1)$.

$$\frac{dp_B^*}{db_i} < 0 \quad \text{for} \quad b_i > \frac{1}{2} \qquad i = 1,...,n-1.$$

$$\frac{dp_A^*}{da_n} < 0 \quad \text{for} \quad 0 \le a_n \le 1$$

$$\frac{dp_B^*}{db_n} > 0 \quad \text{for} \quad 0 \le b_n \le 1$$

From the above equations, we conclude that: first, both equilibrium prices rise as the products become more similar in the dominated characteristics; and, second, equilibrium prices fall when products become more different in the dominant characteristic.

Given the second-stage equilibrium prices just described, the equilibrium locations that maximise the first-stage profit functions are:

$$\mathrm{a}^* = (1/2, 1/2, ..., 1/2, 0), \quad \mathrm{b}^* = (1/2, 1/2, ..., 1/2, 1)$$

that is a global equilibrium under the assumption that the last characteristic is strongly dominant.

Irmen and Thisse show that, assuming that $t_k = t \quad \forall k = 1,...,n$ (which is the opposite extreme case where no characteristic dominates nor even weakly), there are n local equilibria characterised by locations

$$\mathrm{a}^* = (1/2, 1/2, ..., 0, ..., 1/2, 1/2), \quad \mathrm{b}^* = (1/2, 1/2, ..., 1, ..., 1/2, 1/2)$$

where 0 and 1 are the kth component of the two vectors. Hence, firms maximise differentiation along one dimension in order to relax price competition and minimise differentiation along all the other dimensions in order to reduce the number of marginal consumers and thus the degree of competition required to get them.

The work in Section 5 applies the model just highlighted to our particular case of competition between movie theatres. It analyses competition by two products 1 and 2, defined by two characteristics m and d (where m stands for *movies* and d for *distance*). Each product is defined by a vector of characteristics: (m_1, d_1) for product 1 and (m_2, d_2) for product 2. The equilibrium in the location subgame is defined by the set of vectors $\{(m_1^*, d_1^*), (m_2^*, d_2^*)\}$. Assuming $m_1 \le m_2, d_1 \le d_2$ without loss of generality, the max-min equilibrium is defined by vectors $\{(0, 1/2), (1, 1/2)\}$ and the min-max equilibrium is defined by values $\{(1/2, 0), (1/2, 1)\}$. Graph 1 and Graph 2 illustrate the max-min and min-max equilibria respectively.

3. Applied works

This section reviews the applied literature to competition between products differentiated in multiple dimensions. There are three types of applied works of competition with multi-dimensional product differentiation: empirical works using real industry data, experimental works and those that perform numerical simulations.

With regards to numerical simulations, E. Veendorp and A. Majeed (1995) take two firms A and B that play the two-stage location-then-price game on a rectangular market of sides of length $(h,1)$. Using the customary backward induction process for solving this game, authors allow the firms to make pricing decisions by considering all prices (with increments of 0.01) that yield positive profits, given the price choice of the other firm and the fixed locations of both firms. This price game is repeated for all possible locations and the equilibrium is taken to be the set of prices and locations that maximise the profits of both firms. The computation is repeated for different values of $h = \{1,\ 1.2,\ 1.4,\ 1.6,\ 1.8,\ 2\}$. Veendorp and Majeed find that firms locate at the midpoints of the opposite sides with both $\{(a_1,a_2)=(0,1/2),(b_1,b_2)=(h,1/2)\}$ and $\{(a_1,a_2)=(h/2,0),(b_1,b_2)=(h/2,1)\}$ location equilibria if $h=\{1,\ 1.2,\ 1.4\}$ and only $\{(a_1,a_2)=(0,1/2),(b_1,b_2)=(h,1/2)\}$ if $h=\{1.6,\ 1.8,\ 2\}$. Veendorp and Majeed's numerical simulations thus support the theoretical prediction such that both max-min and min-max equilibria exist if the difference in the consumers' weight for each dimension is low and only the max-min equilibrium exists if the weight given to the first dimension is considerably higher than the weight given to the second dimension.[9]

Theoretical predictions are also confirmed by computer simulations when Veendorp and Majeed extend the analysis to three dimensions. In a different work, A. Larralde, P. Jensen and M. Edwards (2006) use a logit demand function for consumers' choices and find, both analytically and with numerical simulations, that firms tend to locate closer and even though charge higher prices when the distortion introduced by the logit function increases.

With regards to experimental works, A. Mangani and P. Patelli (2001) designed an experimental analysis to test whether participants in the experiment would make price and location choices consistent with the max-min equilibrium of horizontal product differentiation in two dimensions. Sixty students at University of Trento were paired

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[9] The weights to the dimensions are represented here by the length of the longer side, i.e. the value of h.

with another student playing the two-stage location-then-price game under three types of treatments repeating the choices for a number of times. The goal of the experiment was to find whether individuals' choices converged to the max-min location equilibrium predicted by previous theoretical works. Experiment's results were unsatisfactory as most students tried to minimise differentiation in both dimensions.

With regards to empirical work, there are no previous works properly devoted to test for the theoretical equilibrium in a multi-dimensionally differentiated-product duopoly market. In spite of this, some works have empirically analysed some of the features of the equilibrium: E. Glaeser, G. Ponzetto and J. Shapiro (2005) analyse the conditions under which one product characteristic is dominant so that it leads duopolists to maximally differentiate products along that dimension. J. Netz and B. Taylor (2002) study whether it is in firms' interest to choose either maximum or minimum spatial differentiation in a market with a high number of firms. Finally, R. Thomadsen (2007) tests for the location equilibrium of asymmetric duopolists.

Duopolists in E. Glaeser, G. Ponzetto and J. Shapiro (2005) are the two major political parties in the United States in the November 2004 presidential elections (Republican and Democratic parties). They perform a cross-sectional estimation of the determinants of right-wing voting both across countries and across states in the U.S.. Regular church attendance is a significant factor that explains right-hand voting and this effect is highest when around half of the population attends church. So they conclude that religious related issues are a key degree of differentiation when church attendance is around the U.S. levels and that is why Republicans and Democrats tend to choose extreme positions on some issues such as abortion or gay marriage.

J. Netz and B. Taylor (2002) follow J. Pinske and M. Slade (1998) in considering that, when firms choose locations, there are two counterbalancing effects: the market share effect, that provides firms with an incentive towards minimum differentiation in order to gain a higher number of consumers, and the market power effect that creates an incentive to maximise differentiation in order to relax price competition. Which effect dominates determines the optimal location strategy of firms. J. Netz and B. Taylor (2002) use data from gasoline stations in Los Angeles area and estimate spatial differentiation between gasoline stations in Euclidean geographic distance using as independent variables a set of station characteristics as well as three measures of competition: the total number of stations, the proportion of stations that are independent and the proportion of stations that carry the same brand name as the centre station.

Evidence shows that a higher degree of competition in each of those variables leads to greater differentiation in physical location.

J. Netz and B. Taylor (2002) look for evidence towards the max-min differentiation hypothesis by analysing the sign of the coefficients of some station attributes, such as repair service, car wash, convenience store or credit card acceptance. Most of those coefficients have positive sign and J. Netz and B. Taylor (2002) interpret this as evidence against max-min equilibrium as “firms increase spatial differentiation as differentiation in other attributes increases”, suggesting a kind of max-max differentiation. As the prediction of max-min product differentiation was found in a theoretical model of duopolistic competition with differentiated products under simultaneous location and pricing decisions, I consider that the market analysed by J. Netz and B. Taylor (2002) does not provide the framework for testing for the max-min equilibrium as some of the model conditions do not apply to their industry, particularly the duopolistic setup. Therefore their results should not be taken as evidence against the max-min equilibrium.

Finally, R. Thomadsen (2007) studies the location equilibrium for a duopoly with asymmetric firms, McDonald’s and Burger King, in the fast food industry. Asymmetry is considered by using a logit utility function with McDonald’s providing consumers with a higher inherent utility than Burger King. Consumers are assumed to be spread over a two-dimensional geographic space whereas firms are assumed to be located on a line, so minimum differentiation along one of the dimensions is imposed ex-ante. R. Thomadsen (2007) solves for the equilibrium backwards, first studying duopolists’ prices and profits as a function of distance between restaurants and as a function of rival’s prices and finally analysing firms’ location best-response functions. Asymmetry of firms’ inherent utility leads to asymmetric equilibrium locations. Firms’ incentive to differentiate pretty much depends on market size. In larger markets, firms increase their profits by moving towards the edges of the market, whereas they increase profits by moving towards the market centre in small markets. This evidence is consistent with the finding explained in Section 5 below that big town size favours maximum location differentiation and small town size favours minimum location differentiation. R. Thomadsen (2007) also simulates the location equilibrium if both duopolists were symmetric competitors, finding that firms would locate apart and away from the centre (both under simultaneous and sequential entry games) thus giving support to the max-min equilibrium.

4. Data

I start this section by briefly summarising the main trends in the Spanish movie theatre market. The exhibition industry has renovated: some old cinemas have been closed and new cinemas have been opened with a higher number of screens and a smaller number of seats in each theatre. Table 1 shows a decrease in the number of cinemas since 2001 and an increase in the number of screens per cinema and in the number of seats per screen.

Let us now present the data used to test for the location equilibrium. I use data for 100 duopolies that correspond to those towns in Spain where there have been two movie theatres exhibiting first-run films for at least 40 weeks in the years 1998, 2001, 2004 and 2008.[10] Each duopoly is taken just once, and year fixed effects are controlled for.[11,12] Table 2 reports the 100 duopolies analysed.[13] The dependent variable in the analysis is the number of movies shown in the two cinemas in town the same week over the number of movies screened in the smaller cinema. We have 4,000 observations of that variable (40 per duopoly). The averages of the values of that variable for each duopoly are reported in the last column of Table 2.

There are four sources of data in the estimation work: The data for the titles screened in each theatre have been provided by Entertainment Data Inc. (EDI). I observe all the titles exhibited in every cinema in Spain every week. EDI's data also contains information about the circuit that runs each theatre and the number of screens in each cinema. Data about cinema's address were obtained from the Census of Movie Theatres published by the Association for Media Research (AIMC). With those location data, the distance between theatres is calculated using the distance calculator in Google Maps. Finally, data on town's population are obtained from the Census of Population published by the National Statistics Institute (INE).

Summary statistics of the variables are displayed in Table 3.[14] Duopolists screen on average roughly one-third of the movies screened by rival exhibitor and towns with two

[10] The dataset also includes the two cinemas in the Principality of Andorra.

[11] There are 87 towns in the dataset. Those 13 towns that are included twice contain data about two different pairs of cinemas, so no duopoly is taken more than once.

[12] In those cases where a duopoly existed for more than one period, data were used for the first year in which both cinemas were showing first-run movies for at least forty consecutive weeks.

[13] The names of towns in Table 2 are the official names, in some cases they are not in Spanish but in the local languages.

[14] With regards to percent of movies in both theatres, figures in Table 3 are calculated from the average values for each duopoly.

firms are primarily medium size towns, with an average population of 86,348 inhabitants. The figures reported also show some of the facts of the evolution of the Spanish movie theatre industry that has taken place in the last decade and is still going on. Duopolies are evolving towards bigger towns with bigger theatres, more distant from each other, that screen a higher share of identical movies.[15] We can also observe the effect of cinema ownership. Cinemas that belong to the same circuit as the other cinema in town tend to be smaller and closer located and show a considerably lower share of identical movies. This is an interesting finding as there are no works to my knowledge that have analysed the equilibrium for a market with two firms belonging to a monopolist in multiple dimensions. The results in this work show a tendency towards the max-min equilibrium, with firms minimally differentiated in location and maximally differentiated in the bundle of movies.[16] We can also observe the evolution of ownership during the years analysed. We see that the share of duopolies with both cinemas of the same group have considerably decreased over the decade, as new theatres of big national chains have replaced old theatres of local chains.

One feature of the data that is specially significant for the location equilibrium analysis is the trade-off between the distance between theatres and the percentage of movies exhibited in both venues. This trade-off is observed in Graph 3 for the 4,000 observations (where the unit of observation is duopoly-week) and also in Graph 4 for the average percent of movies in each duopoly (where the unit of observation is duopoly).

Let us now analyse minimum and maximum differentiation in each of the dimensions considered: geographical location and set of movies screened. A main difference between the location choices of duopolists in the theory reviewed in Section 2 and the

[15] Data shows two discontinuities in the mentioned evolution. With regards to the percent of same movies in both cinemas, the figure for 1998 is higher than that for 2001 due to the effect of the movie "Titanic", by far the most widely distributed motion picture in my database. It was released in January 9th 1998, a year when the average number of weekly movies exhibited in a theatre (the denominator of the ratio) was significantly lower than in posterior years.

The second discontinuity takes place in the variable of population. The population of towns with two first-run movie theatres have considerably increased over the last decade but the high figure in 1998 is due to the fact that some of the old-fashioned cinemas with a very low number of screens (in many cases, with only one screen) that operate in small towns were not regular first-run exhibitors but became as such in the early 2000s when the distributors increased significantly the number of film copies in order to be released in a higher number of theatres. This happened in some places such as Vielha e Mijaran, Sitges, Andorra la Vella or Barbastro, thus decreasing the average population of duopolists in 2001 relative to that in 1998.

[16] With differentiation in one dimension, two firms run by a monopolist will locate in equilibrium at the quartiles, so it may be interesting to test for the equilibrium in two dimensions as one would expect that location at the quartiles should remain for one of the dimensions.

choices of real firms is that, in a real market, location does not often take continuous values but it rather takes discrete values.[17] We can think in terms of physical location: movie theatres that want to fully minimise distance may not have an available venue next door to an existing cinema but some yards or even a few miles away.

With regards to the set-of-movies dimension, as we can observe in Table 3, minimum differentiation does not mean to be strictly 100% of movies screened in both cinemas. There are two main reasons why two theatres that try to show the same movies all the time do not necessarily yield a value of 100%. First, some films are shown in both theatres but one of them usually screen it for a higher number of weeks, so some weeks the movie is shown just in one of them even though both cinemas hired the same movie. The second reason is that some distributors may have a high degree of bargaining power over the exhibitors, so they can impose a cinema to show a movie that it would not choose otherwise as it may not be interesting enough. From the aforementioned reasons and from the figures in Table 3, any share of identical movies between two-thirds and one should be a reasonable measure for minimum differentiation in the set-of-movies dimension. On the other hand, a 0% of identical movies is quite more realistic for maximum movie differentiation. But, similarly to what happened with minimum differentiation, two movie theatres may be interested in differentiating their sets of movies as much as possible but not necessarily screen no identical movies at all. Again, some movies are imposed by distributors, and also exhibitors are interested in very popular movies even if their rivals also screen them. This is more acute when both cinemas have many screens as it is much more difficult not to coincide at all. This can be observed in Table 4 and Table 5, that describe the distribution of number and percent of movies in both theatres for different values of the number of screens in the smallest cinema. We can thus take maximum movie differentiation to be between 0 percent and one quarter allowing duopolies with two big cinemas to reach a value of one-third.

With regards to the location dimension, as we have towns of quite different sizes, we should be flexible enough when considering both minimum and maximum differentiation. Table 6 reports distribution statistics of the distance between venues for different values of town sizes. From those figures, it seems reasonable to consider as

[17] And this fact can be more important in this case, as it may be much more difficult to find a location for a cinema with twelve theatres than for a small café, whose decision can be thought of as being roughly continuous.

minimum location a distance lower than 1-1.5 kilometres and maximum differentiation a distance higher than 3.5-4 kilometres.

5. Empirical results

In this section, I explain the different methods I use to test for the location equilibrium in a dupolistic product differentiation model and I report the results of each test performed.

5.1. Trade-off distance-percent of movies

The trade-off between the distance between theatres and the percent of movies exhibited in both venues observed in Graphs 3 and 4 is corroborated using a tobit model of estimation. Results are reported in Table 7. The dependent variable is the percent of movies exhibited in the two cinemas of each duopoly every week.[18] The trade-off is represented by the positive and significant coefficient of the variable of distance (measured in kilometres). We can also see the effect of the other variables: year fixed effects show an increasing pattern in the proportion of movies during the decade.[19] The higher the number of screens in each theatre, the higher the proportion of movies in both. The negative sign in the coefficient of joint ownership of both cinemas reflects an incentive of local monopolists to increase the variety and thus decrease the degree of competition between the cinemas of same circuit.[20]

The variable population has been included in the analysis as a proxy for town size. As explained in the Introduction, I expect town size to be a key factor to determine the dominant characteristic in this market. In equilibrium, firms chose maximum differentiation along the dominant characteristic and minimum differentiation along the dominated characteristic(s). The larger the town size, the more important is the trip towards the venue for consumers and so location becomes the dominant characteristic. In small towns, distance is a minor issue and therefore the set of movies becomes the dominant characteristic. When towns have a similar density of population, population is

[18] As explained above the percentage is calculated as the number of movies in both theatres divided by the number of movies in the cinema showing the lowest number of movies. The unit of observation is duopoly-week.

[19] The negative coefficient in the dummy for 2001 with respect to that for 1998 is due to the movie "Titanic" that caused a higher value of the percent of movies in both cinemas in 1998 that would have otherwise taken place.

[20] In this regression and the subsequent ones, the symbol the asterisk means a 95% degree of significance, whereas the double asterisk means a 99% degree of significance.

a good proxy for town size. In this work, as towns in the dataset are mostly medium size, similar density of population is a realistic assumption, so population can be regarded as a valid proxy for town size. The positive and significant coefficient in the regression backs our conjecture that cinemas in bigger towns tend to screen a higher proportion of identical movies, as competition in those towns is more important in the location dimension and less important in the set-of-movies dimension.

5.2. Test of location equilibrium

The next step in the analysis is to test whether there just exists a trade-off such as more distant cinemas show a more identical set of movies or whether, in addition to this, data resembles the max-min and/or min-max equilibrium predicted by the theory.

The test for max-min (min-max) equilibrium is performed by estimating a probit model. The dependent variable is a binary variable that takes the value 1 when the percent of movies shown in both cinemas is below a threshold level (implying maximum differentiation in the set-of-movies dimension) and 0 otherwise. An independent binary variable is used taking value 1 when the distance between theatres is below a threshold level (implying minimum differentiation in the location dimension) and 0 otherwise. The econometric model also includes the same control variables used in the tobit model presented above: year fixed effects, number of screens in the smaller cinema and in the bigger one, town population and a dummy for joint ownership of both cinemas. Table 8 reports the results of the estimation for different values of maximum movie differentiation and minimum location differentiation, with duopoly-week as the unit of observation. In the regressions with a threshold value of 0% for maximum movie differentiation, the coefficient of minimum location differentiation is not significant for a threshold value of 1 km, but it is significant for a threshold value of 1.5 km and for all other combinations of movie and location differentiation variables. The positive sign gives support to the max-min equilibrium, as minimum location differentiation implies maximum movie differentiation. We can observe that the result is robust to changes in the threshold value of maximum movie differentiation up to $1/3$ and to changes in the threshold value of minimum location differentiation up to 2.5 km. So we can conclude that data in this industry supports the max-min equilibrium. Table 8 also reports the number of duopoly-week observations and of average duopoly observations that fit in those threshold levels. We can observe that, in the most restrictive scenario, there are 6 duopolies that fit in the corresponding degrees of differentiation, while there are 43 duopolies fitting the max-min equilibrium in the most relaxing scenario.

Let us now proceed to test for the min-max equilibrium, with products minimally differentiated along the set-of-movies dimension and maximally differentiated along the location dimension. A probit model of estimation is again used to test for the equilibrium. The dependent variable is a binary variable that takes the value 1 when the percent of movies shown in both cinemas is above a threshold level (implying minimum movie differentiation) and 0 otherwise. An independent binary variable is used taking value 1 when the distance between theatres is higher than a threshold value (implying maximum location differentiation). Estimation includes the same control variables as in the test of max-min equilibrium. Results are reported in Table 9. The positive and significant coefficients for all the pairs of threshold values of minimum movie differentiation and maximum location differentiation analysed give support to the min-max equilibrium. The number of duopoly-week observations and of duopolies fitting the different combinations of threshold values are smaller than for the max-min equilibrium. I will shortly discuss about this issue.

5.3. Robustness checks

To check for the robustness of the results just estimated and discussed, let us perform the same analysis to test for both max-min and min-max equilibria using alternative measures of both movie and location differentiation. As a particular value of distance between theatres can imply proximity in big towns and farness in small towns, the next analysis is performed by using relative distance regarding town size. All the towns in the dataset are assumed to have a circular shape with a constant density of population equal to 5,000 inhabitants per squared kilometre. Highest distance between two places in a town is equal to the diameter of that town thus calculated. The two cinemas in a town are considered as maximising or minimising differentiation in location by comparing its distance in kilometres with the diameter of that town. Different threshold values for minimum and maximum differentiation in the location dimension are used. Results are reported in Table 10, for max-min equilibrium, and Table 11, for min-max equilibrium. The coefficients of minimum location differentiation in the test for max-min equilibrium are not significant, but the coefficients of maximum location differentiation in the test for the min-max equilibrium are positive and significant. Therefore max-min equilibrium is not supported using relative measures of distance whereas min-max equilibrium is supported and robust to changes in both movie and location differentiation.[21]

Finally, the test is performed by using not only raw measures of percent of movies and of distance in kilometres but also comparing the observed values of distance and percent of movies in both venues with those predicted by the model. Tables 12 and 13 report the estimated coefficients for the independent variables used in the estimation of the percent of movies and distance, respectively. The percent of movies in both cinemas is estimated with a tobit model using as regressors the same variables as in the original model reported in Table 7 except the distance between theatres. All the signs and the levels of significance do not change. Distance between theatres is estimated using the OLS method of estimation and using population and the joint ownership of both cinemas as independent variables. Coefficients of both variables are significant. As expected, the bigger the town the more distant theatres are. Additionally, cinemas are opened at a higher distance from each other if they are run by a different entity.

Two regressions are performed to test for the max-min equilibrium using this mixed form of both absolute and relative measures of variables.[22] In the first one, the binary variable for maximum movie differentiation takes value 1 when the percent of movies shown in both venues is higher than 25% or the observed percent value is 20% lower than the predicted one. The binary variable of minimum location differentiation used in that regression takes value 1 when the observed distance between stores is lower than 1.5 km or 1.5 km shorter than the predicted value. In the second regression, maximum movie differentiation is defined as a percent of movies in both venues higher than $1/3$ or 15% higher than predicted and minimum location differentiation is defined as a distance lower than 2.5 km or 1 km lower than predicted. As reported in Table 14, coefficients give support to the max-min equilibrium. The min-max equilibrium is analogously tested in two regressions. Minimum movie differentiation is defined by a percent of identical movies higher than $43/60$ or 20% higher than expected, in the first regression, and by a percent higher than $2/3$ or 15% higher than expected in the second regression. Maximum location differentiation is assumed to take place when distance is higher than 4 km or 1.5 km larger than predicted, in the first regression, and a distance higher than 3.5 km or 1 km larger than predicted in the second regression. As reported

[21] The number of observations and duopolies fitting the equilibria in this case is smaller than in the original case.

[22] The latter are relative with respect to the values predicted by the models just described.

in Table 15, coefficients of both regressions are positive and significant so they give support to the min-max equilibrium. Considering this mix of absolute and relative measures of differentiation, the duopolies that fit in the max-min equilibrium do not change with respect to the original case, whereas the number of duopolies in the min-max equilibria increase significantly.

5.4. Duopolies fitting the equilibria

In order to understand the pattern of each type of equilibrium, let us look at the list of duopolies fitting the max-min and the min-max equilibria. Table 16 reports all the duopolies that fit the max-min equilibrium in the most relaxing scenario analysed in each case and the population of each town in the corresponding year.[23] Figures in the last raw report the number of towns fitting the equilibrium, the median of the year and the average population. We can observe that duopolies fitting this equilibrium are very diverse in terms of town size and period, but there is some domination from small towns in the early years analysed. Table 17 reports the duopolies that fit the min-max equilibrium also in the most conservative scenario of each case.[24] While the number of duopolies fitting this equilibrium is lower than for the max-min equilibrium, the features of those duopolies are interesting to understand the equilibrium. Towns in min-max equilibrium are considerably bigger in size and more recent in time. This result shows that there may be a tendency towards this type of equilibrium. Whereas movie theatre duopolies have traditionally been small towns with two small cinemas in the town centre, duopolies are more and more big towns with two cinemas with many screens located at the opposite ends of the town and showing a high proportion of similar (most popular) movies. This gives support to our previous conjecture that town size is a relevant feature to explain which characteristic dominates.

The dominant characteristic is the one that, when there is a unique equilibrium, firms maximise differentiation in that dimension and minimise differentiation in the others. The dominant characteristic is the most highly valued characteristic by consumers. In

[23] In both the “abs-abs” and the “abs-rel” columns the threshold value for minimum movie differentiation is $1/3$ while it is $1/3$ or 15% over predicted in the “mix-mix” column. The threshold value for minimum location differentiation is 2.5 km in the “abs-abs” case, $1/3$ of diameter in the “abs-rel” and 2.5 km or 1 km below predicted in the “mix-mix” case.

[24] In both the “abs-abs” and the “abs-rel” columns the threshold value for maximum movie differentiation is $2/3$ and while it is $2/3$ or 15% over predicted in the “mix-mix” column. The threshold value for maximum location differentiation is 3.5 km in the “abs-abs” case, $2/3$ of diameter in the “abs-rel” and 3.5 km or 1 km above predicted in the “mix-mix” case.

the case of cinemas, we expected that the set of movies was the dominant characteristic in small towns whereas the location dimension was the dominant characteristic in big towns.

This conjecture is contrasted with three types of analysis. First, in the original tobit regression, population had a positive and significant coefficient thus meaning that in bigger towns theatres tend to screen a higher percent of same movies. Second, in the different binomial probit models for min-max equilibria the coefficient of population was significant and positive while it was negative when significant in the models for max-min equilibria.

5.5. Multinomial probit estimation

An additional analysis confirms the determinant role of town size and, at the same time, it gives support to the robustness of both the max-min and min-max equilibria obtained from the binomial probit models reported above. A multinomial probit model is performed for each of the three cases analysed (abs-abs, abs-rel and mix-mix). In each case, the variable "max-min" takes value 1 when the duopoly fits the max-min equilibrium and 0 otherwise, the variable "min-max" takes value 1 when the duopoly fits the min-max equilibrium and 0 otherwise, whereas the variable "none" takes value 1 when neither max-min nor min-max equilibria fit the data for that duopoly.[25] Tables 18 to 20 report the coefficients for the length of town (approximated by the diameter calculated as explained above) and the constant term. The values of the coefficient of diameter confirm the determinant role of town size to determine which equilibrium holds.

A final robustness check is done using as dependent variable the percent of movies in both cinemas over the sum of the number of movies screened in each venue. All our previous findings are backed by the evidence of this analysis, with statistics and results reported in Tables 21 to 23.

6. Conclusions

This work has developed a test of the location equilibrium in a horizontally differentiated-product duopoly with multiple characteristics.

[25] The duopolies included in each equilibrium in each case are those reported in Tables 16 and 17.

The industry for which the analysis is performed, the movie-theatre exhibition industry in Spain, shows a trade-off between the two main dimensions of differentiation: the distance between venues and the set of movies exhibited in each of them. Our test of the max-min (min-max) equilibrium predicted by theory, such that products are maximally differentiated in one dimension and minimally differentiated in the other dimensions, tries to prove that not only the mentioned trade-off exists, but an evidence in favour of the equilibrium may also exist. Using a probit model of estimation for different definitions of the binary variables describing maximum and minimum differentiation in both movie and location dimensions, we find support for both max-min and min-max equilibria (taking set of movies as first dimension and geographical location as second dimension). We find that the key variable to determine which characteristic is dominant, so that products are maximally differentiated along that dimension, is town size. In bigger towns, moviegoers are more concerned about the distance to travel and, in smaller towns, travelling is a minor issue and moviegoers base their choice of venue on the set of movies exhibited in each venue. We observe a trend in the features of movie theatre duopolies. They had traditionally been small towns with two small cinemas in the town centre and they are now turning towards big towns with two cinemas with many screens located at the opposite ends of the town and showing a high proportion of similar movies.

This application of location equilibrium with goods differentiated in the place where it is sold and in product's attributes suggests that more geographical proximity may imply more product variety.

One interesting feature of the empirical findings reached in this work is that local monopolies (with the two cinemas in town run by the same circuit), resemble the max-min equilibrium, whereas in one dimension, they chose not maximum nor minimum differentiation. Therefore an interesting work for future research may be the search for the theoretical equilibrium in a local monopoly with two products differentiated in multiple dimensions.

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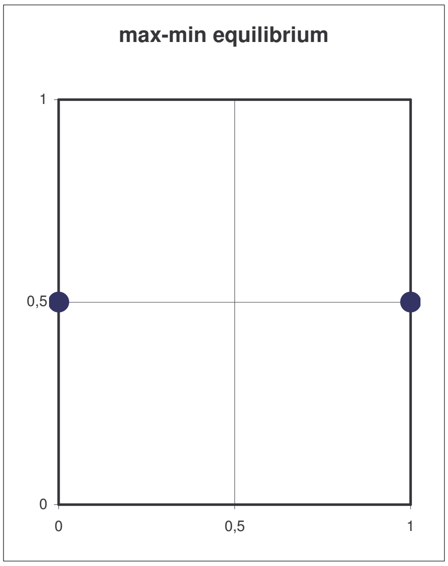
Appendix: Graphs and Tables

Graph 1: Max-min equilibrium (location in the movie dimension in the x-axis and in location dimension in the y-axis)



Graph 2: Max-min equilibrium (location in the movie dimension in the x-axis and in location dimension in the y-axis)

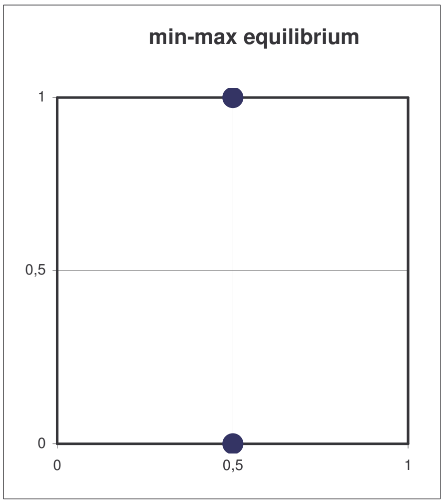


Table 1: Evolution of the Spanish movie theatre exhibition market (1998-2008). (Source: General Media Study (EGM), published by the Research Media Association (AIMC))

Year	Cinemas	Screens	Capacity	Screens per cinema	Capacity per screen
1998	794	2,197	738,739	2.77	336
1999	952	2,691	835,593	2.83	311
2000	1,007	3,000	894,422	2.98	298
2001	1,018	3,241	912,653	3.18	282
2002	968	3,488	918,446	3.60	263
2003	974	3,769	955,969	3.87	254
2004	963	4,029	998,890	4.18	248
2005	941	4,136	995,561	4.40	241
2006	899	4,120	983,250	4.58	239
2007	848	4,133	965,934	4.87	234
2008	785	4,016	926,573	5.12	231

Table 2: Description of the duopolies analysed (town and year, population, main features of cinemas, distance between them and the average percentage of movies in both theatres).

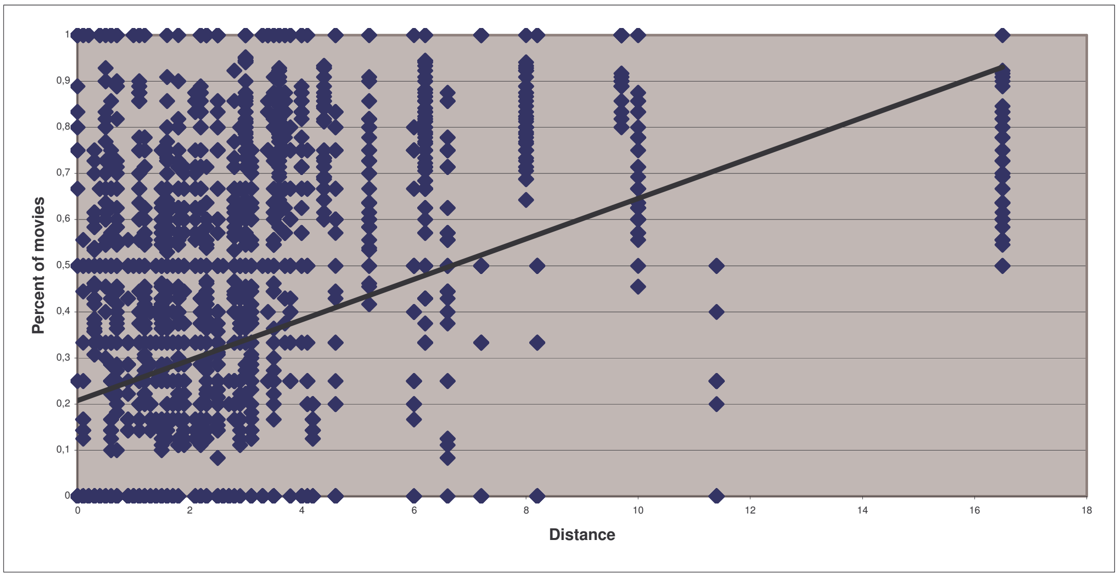
Town	Year	Cinema 1			Cinema 2			Population	Distance	Percent
		Name	Circuit	Screens	Name	Circuit	Screens		(in km)	of movies
A Coruña	2008	Filmax A Coruña	ACEC	11	Rosales	Yelmo	13	245,164	4.4	0.77
Alcalá de Guadaira	2004	Alcalá Plaza Cinemas	UCC	8	Los Alcores	Ramade	12	61,063	1.5	0.47
Alcalá de Henares	2008	Cisneros	Independent	3	La Dehesa Cuadernillos	La Dehesa	19	203,645	11.4	0.12
Alcobendas	2004	Ábaco Alcobendas	Abaco	12	Cinesa La Moraleja	Cinesa	8	100,307	3.6	0.81
Alcorcón	2004	Cinebox Opción	Abaco	23	Yelmo Tres Aguas	Yelmo	15	156,592	3.0	0.79
Algeciras	1998	Las Palomas	UCC	7	Magallanes	Independent	2	101,972	2.2	0.13
Almería	2008	Cervantes	Asensio	1	Monumental	Asensio	10	187,521	2.3	0.30
Alzira	1998	Colón	Sanz	4	Reyno	Sanz	4	40,390	0.7	0.05
Alzira	2008	Colón	Sanz	4	El Punt-Alzira	ACEC	10	43,892	2.5	0.70
Andorra la Vella	2001	Moderno	Independent	4	Principat	Independent	1	20,845	0.1	0.09
Aranjuez	2001	Aranjuez	Independent	3	Berlanga	Rodríguez	6	40,113	0.3	0.00
Arrecife	1998	Atlántida	Independent	5	Buganvilla	Independent	3	40,770	1.1	0.03
Ávila	1998	Ávila	Independent	3	Tomás Luis de Victoria	Independent	2	47,650	1.1	0.00
Ávila	2008	Estrella Ávila	Ezquerra	6	Tomás Luis de Victoria	Independent	2	56,144	4.1	0.27
Avilés	1998	Almirante	Arango	4	Marta	Clarín	4	84,835	1.0	0.00
Avilés	2004	Cinebox Parque Astur	Abaco	10	Marta	Clarín	4	83,899	4.6	0.58
Badalona	2004	Cinesa Montigalà	Cinesa	7	Picarol	ACEC	6	214,874	3.7	0.74
Barbastro	2001	Principal	Barrena	1	Argensola	Urgellene	1	14,382	0.5	0.03
Basauri	2001	Bilbondo	Beitia	8	Sozial Antzokia	Independent	1	46,669	2.5	0.19
Benidorm	2008	Colci	Colomer	5	Colci Rincón	Colomer	6	70,280	3.1	0.17
Burgos	2008	Cinebox El Mirador	Ábaco	7	Van Golem Arlanzón	Golem	6	177,879	1.9	0.38
Cáceres	1998	La Dehesa	La Dehesa	5	Cáceres	Heras J	7	78,614	1.7	0.00
Cádiz	2004	Bahía de Cadiz	Ramade	10	Centro	Al Andalus	9	133,242	2.3	0.42
Calafell	2004	Iris	MCB	1	MCB Cinemas	MCB	8	17,277	3.5	0.11
Castelldefels	2004	Metropol	Independent	2	Plaza	Independent	1	53,964	0.7	0.05
Castell-Platja d'Aro	2001	Avinguda	Independent	1	Iván	Independent	1	7,112	0.1	0.01
Ceuta	2004	Al Andalus Ceuta	Al Andalus	7	Marinas Cinema	UCC	7	74,654	1.8	0.29
Ciudad Real	1998	Castillo	Independent	3	Cristina	Mayoral	3	61,138	2.1	0.00
Collado Villalba	2001	Estrella	Ezquerra	8	Villalba	Yelmo	5	44,872	1.3	0.14
Collado Villalba	2004	Estrella	Ezquerra	8	Planetocio Cineplex	Yelmo	9	50,695	1.2	0.35
Cornellà de Llobregat	1998	Llobregat	ACEC	14	Pisa	ACEC	4	80,329	0.0	0.90
Coslada	1998	Coslada	Barral	3	La Rambla	Barral	5	73,732	1.7	0.14
Cuenca	2004	Ábaco Cuenca	Ábaco	8	Cuenca	Macho	5	47,862	1.6	0.24
Eivissa	2008	Eivissa	Porto Pí	5	Serra	Independent	5	46,835	2.2	0.51
El Escorial	2001	Variedades	CSTA	3	Escorial	PRIM	4	11,209	2.6	0.01
Ferrol	2008	Dúplex	Coruña Films	2	Cinebox Narón	Ábaco	12	74,696	3.5	0.05
Figueres	2001	Cinemes Figueres	ACEC	8	Savoy	ACEC	1	34,493	1.0	0.08
Fuengirola	2008	Alfil	Al Andalus	8	Miramar	Ramade	12	68,646	0.7	0.51
Fuenlabrada	1998	Fuenlabrada	Independent	10	Las Provincias	Macho	6	167,458	2.1	0.53
Gandía	2008	ABC Gandía	Pechuán	10	Cinebox Gandía Palace	Ábaco	8	79,958	5.2	0.69
Getafe	2001	Cinebox Getafe	Ábaco	6	Cinesa Bulevar	Cinesa	7	150,532	6.2	0.59
Getafe	2008	Cinesa Bulevar	Cinesa	7	UGC Cine Cité Getafe	UGC	20	164,043	9.7	0.96
Gijón	2008	Centro	Clarín	5	Yelmo Ocimax	Yelmo	13	275,699	4.0	0.77
Granollers	2004	Oscar Granollers Centre	ACEC	5	Oscar Granollers Nord	ACEC	11	56,456	1.8	0.43
Huesca	1998	Avenida	Barrena	1	Olimpia	Barrena	1	45,485	0.9	0.00
Huesca	2004	Al Andalus Cinemundo	Barrena	6	Avenida	Barrena	1	47,923	1.2	0.04
Igualada	1998	Kursaal	ACEC	3	Salón Rosa	ACEC	1	32,526	0.4	0.03
Irún	2004	Cinebox Mendibil	Ábaco	6	Oscar	ACEC	11	58,899	6.6	0.54
Jerez de la Frontera	1998	Jerez	UCC	15	Jerezano	UCC	1	181,602	4.0	0.07
Jerez de la Frontera	2001	Ábaco	Ábaco	9	Jerez	UCC	15	185,091	0.5	0.67
Las Rozas de Madrid	1998	Burgocentro	Independent	6	Las Rozas	PRIM	5	47,922	6.0	0.44
Leganés	2008	Cinesa Parque Sur	Cinesa	12	Yelmo Avenida M-40	Yelmo	12	184,209	8.0	0.81
León	2008	Cinebox Espacio León	Ábaco	9	Van Gogh	Independent	6	135,119	3.1	0.51
Linares	2001	Bowling Linares	UCC	6	Linares	Chiclana	5	57,796	2.2	0.08
Logroño	1998	Astoria	Independent	2	Golem	Golem	11	125,617	0.4	0.32
Lugo	2008	As Termas	Independent	8	Multicines Centro	Coruña Films	7	95,416	1.8	0.55
Majadahonda	1998	Centro Oeste	Independent	6	Renoir Majadahonda	Macho	4	41,642	2.5	0.30
Majadahonda	2004	Cinesa Equinoccio	Cinesa	12	Renoir Majadahonda	Macho	4	58,377	2.5	0.16
Manresa	2001	Atlántida	ACEC	3	Bages Centre	ACEC	12	63,929	2.8	0.27
Marbella	1998	Alfil	Reyes	3	Gran Marbella	Gran Marbella	7	98,377	7.2	0.48
Marbella	2004	Cinesa La Cañada	Cinesa	8	Gran Marbella	Gran Marbella	7	117,353	10.0	0.69
Mataró	2004	Cinesa Mataró Parc	Cinesa	12	Oscar Mataró	ACEC	4	114,114	3.0	0.58

Medina del Campo	1998	Coliseo	Independent	4	Lope de Vega	Independent	1	20,023	0.9	0.00
Melilla	2008	Multicines El Real	Independent	3	Perelló	Hernavi	1	71,448	1.5	0.00
Mérida	2001	Cinesa El Foro	Cinesa	6	Mérida	Independent	3	51,056	4.6	0.02
Móstoles	1998	Dos de Mayo	La Dehesa	5	Iviasa	Independent	5	195,311	1.8	0.39
Oviedo	2008	Cinesa Parque Principado	Cinesa	12	Yelmo Los Prados	Yelmo	14	220,644	6.2	0.83
Palamós	2001	Arinco	Independent	3	Kiton	Independent	3	15,203	0.1	0.10
Petrer	2004	Cinemax Petrer	Moro	10	Yelmo Vinalopó	Yelmo	10	31,919	0.3	0.47
Pontevedra	2004	ABC	Vigo	3	Cinebox Vialia Pontevedra	Ábaco	8	78,715	1.4	0.12
Pozuelo de Alarcón	1998	Pozuelo	Yelmo	5	Torreón	Yelmo	7	62,010	4.2	0.10
Puerto de la Cruz	2004	Chimisay	Independent	4	Timanfaya	Independent	1	30,088	0.0	0.08
Puerto de Santa María	1998	El Paseo	Chiclana	9	Macario	Independent	1	73,728	3.3	0.57
Puerto de Santa María	2004	Bahía Mar	UCC	14	El Paseo	Chiclana	9	80,658	3.5	0.12
Reus	1998	Lauren Reus	Lauren	9	Reus Palace	ACEC	8	89,034	2.3	0.38
Rivas Vaciamadrid	2008	Parque Rivas	Yelmo	10	Yelmo Rivas Futura	Yelmo	13	64,808	2.8	0.59
Sabadell	2001	Cineart	ACEC	5	Eix Macià	ACEC	9	18,5170	2.2	0.67
Sabadell	2008	Eix Macià	ACEC	9	Imperial	ACEC	11	203,969	1.6	0.64
Sagunt	1998	Alucine	Colomer	7	Capitol	Colomer	2	56,607	8.2	0.26
San Cristóbal de la Laguna	2001	Aguere	Macho	4	Cinebox La Laguna	Ábaco	18	133,340	3.8	0.53
San Fernando	2004	Ábaco San Fernando	Ábaco	9	Bahía Sur	Cinesa	6	90,178	1.1	0.77
Sant Cugat del Vallès	1998	Cinesa Sant Cugat	Cinesa	4	Yelmo Sant Cugat	Yelmo	9	50,529	3.4	0.80
Sant Feliu de Llobregat	1998	Guinart	Independent	6	Yelmo Sant Feliu	Yelmo	8	35,958	0.9	0.27
Santa Cruz de Tenerife	2008	Renoir Price	Macho	6	Yelmo Meridiano	Yelmo	11	221,956	1.5	0.24
Santa Lucía de Tirajana	2001	Vecindario Multicines	Dorestes	6	Yelmo Vecindario	Yelmo	11	47,161	0.6	0.32
Santiago de Compostela	2008	Cinesa Área Central	Cinesa	7	Valle Inclán	Yelmo	6	94,339	1.2	0.51
Segovia	2004	Cinebox Luz de Castilla	Ábaco	8	Miró	Rodríguez	3	55,586	2.9	0.37
Segovia	2008	Artesiete Segovia	Chiclana	7	Cinebox Luz de Castilla	Ábaco	8	56,858	3.0	0.55
Sitges	2004	Prado	Independent	1	Retiro	Independent	1	23,172	0.2	0.09
Soria	1998	Avenida	Santorun	1	Rex	Santorun	1	33,882	0.3	0.00
Talavera	2001	Calderón	Macho	3	Cinebora	Macho	6	76,011	2.7	0.01
Terrassa	1998	Principal	ACEC	2	Rambla	ACEC	3	165,654	0.7	0.01
Teruel	1998	Maravillas	Independent	1	Marín	Independent	1	29,320	1.6	0.00
Toledo	1998	Cristina	Mayoral	4	Mayoral	Mayoral	4	66,989	1.1	0.01
Toledo	2008	Luz del Tajo	Ramade	10	Real Cinema Olías	Independent	10	80,810	16.5	0.71
Torrejón de Ardoz	1998	Cinebox Parque Corredor	Ábaco	17	El Círculo	Barral	2	91,186	0.6	0.62
Vielha e Mijaran	2001	Agrupació	Independent	1	Cinemes Agrupació	Urgellene	1	4,233	0.1	0.00
Vilafranca del Penedès	2008	Casal La Principal	Independent	2	Kubrick	Independent	1	37,364	0.3	0.01
Vilanova i la Geltrú	2004	Bosque	JUNC	5	Lauren Garraf	Lauren	12	59,409	2.5	0.23
Zamora	2008	Valderaduey	Fuentes	4	Zamora	Independent	5	66,672	1.1	0.19

Table 3: Data's summary statistics

Variable	Observations	Mean	Std. Dev.	Min	Q1	Median	Q3	Max
Percent of movies	100	32.5	28.0	0.0	5.8	27.1	54.6	96.3
Screens small	100	4.5	3.0	1	2	4	6	15
Screens big	100	8.2	4.4	1	5	8	11	23
Population	100	86,348	60,301	4,233	46,752	66,831	108,043	275,699
Distance	100	2.7	2.65	0.0	1.0	2.1	3.5	16.5
Distance (in km)								
Year 1998	30	2.2	2.0	0.0	0.9	1.7	2.5	8.2
Year 2001	19	1.8	1.7	0.1	0.3	1.3	2.7	6.2
Year 2004	25	2.6	2.1	0.0	1.2	2.3	3.5	10.0
Year 2008	26	4.0	3.7	0.3	1.6	2.9	4.4	16.5
Same circuit	33	1.6	1.7	0.0	0.4	1.1	2.3	8.2
Different circuit	67	3.2	2.9	0.1	1.4	2.5	3.8	16.5
Percent of movies (in %)								
Year 1998	30	22.7	26.3	0.0	0.0	11.6	39.1	89.7
Year 2001	19	20.1	24.1	0.0	1.3	8.8	32.0	67.3
Year 2004	25	38.1	25.6	3.8	12.0	36.5	58.3	81.4
Year 2008	26	47.5	27.7	0.0	24.2	51.2	70.2	96.3
Same circuit	33	16.1	23.1	0.0	1.3	7.5	17.1	89.7
Different circuit	67	40.6	26.8	0.0	16.0	42.1	59.5	96.3
Screens small								
Year 1998	30	3.2	1.8	1	1	3	4	8
Year 2001	19	3.4	2.2	1	1	3	5	9
Year 2004	25	5.5	3.4	1	3	5	8	15
Year 2008	26	6.1	3.3	1	4	6	8	12
Same circuit	33	2.7	2.3	1	1	1.5	3.5	10
Different circuit	67	5.5	3.0	1	3	5	7	15
Screens big								
Year 1998	30	6.5	4.0	1	4	6	9	17
Year 2001	19	7.1	4.6	1	4	6	9	18
Year 2004	25	9.4	4.3	1	8	9	12	23
Year 2008	26	9.8	4.3	2	7	10	12	20
Same circuit	33	5.9	4.1	1	3	5	8	15
Different circuit	67	9.3	4.2	1	7	9	12	23
Population								
Year 1998	30	77,343	47,052	20,023	41,642	64,500	91,186	195,311
Year 2001	19	62,590	58,045	4,233	15,203	46,669	76,011	185,170
Year 2004	25	75,891	44,722	17,277	50,695	59,409	90,178	214,874
Year 2008	26	124,154	73,234	37,364	66,672	87,575	187,521	275,699
Same circuit	33	65,835	54,605	7,112	32,526	47,923	70,280	203,969
Different circuit	67	96,451	60,783	4,233	51,056	78,715	133,242	275,699
Same circuit								
Year 1998	30	0.50	0.51	No. 0's:	15	No. 1's:	15	
Year 2001	19	0.37	0.50	No. 0's:	12	No. 1's:	7	
Year 2004	25	0.24	0.44	No. 0's:	19	No. 1's:	6	
Year 2008	26	0.19	0.40	No. 0's:	21	No. 1's:	5	

Graph 3: Effect of distance between theatres and the percent of movies shown in both cinemas (unit of observation: duopoly-week)



Graph 4: Effect of distance between theatres and the average percent of movies shown in both cinemas (unit of observation: duopoly-week)

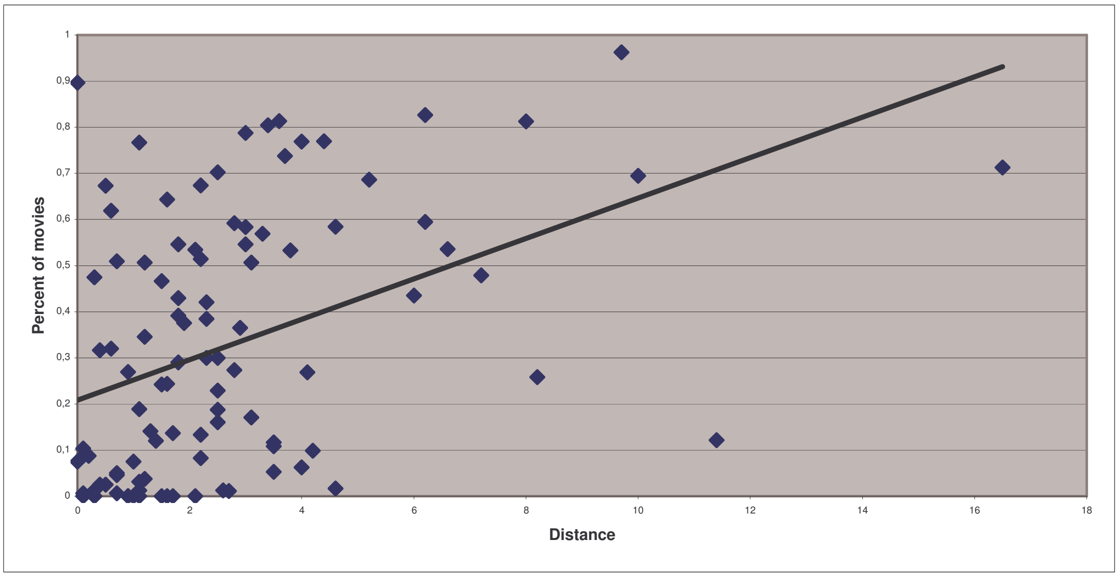


Table 4: Distribution of number of movies in both cinemas (for different values of screens in the smallest cinema, unit of observation: duopoly-week)

Screens small	Observations	Mean	Std. Dev.	Min	10%	Q1	Median	Q3	90%	Max
1	840	0.08	0.32	0	0	0	0	0	0	2
2-3	840	0.52	0.88	0	0	0	0	1	2	5
4-5	1000	2.10	1.90	0	0	0	2	3	5	9
6-7	640	4.35	2.45	0	2	3	5	8	9	12
>7	680	7.74	3.65	1	3	5	7	10	13	20

Table 5: Distribution of percent of movies in both cinemas (for different values of screens in the smallest cinema, unit of observation: duopoly-week)

Screens small	Observations	Mean	Std. Dev.	Min	10%	Q1	Median	Q3	90%	Max
1	840	5.98	22.42	0.0	0.0	0.0	0.0	0.0	0.0	100.0
2-3	840	15.76	26.16	0.0	0.0	0.0	0.0	25.0	50.0	100.0
4-5	1000	35.95	32.34	0.0	0.0	0.0	28.6	60.0	83.3	100.0
6-7	640	52.68	26.39	0.0	25.0	41.4	60.0	72.7	88.9	100.0
>7	680	61.66	20.65	10.0	33.3	45.5	61.5	78.6	90.0	100.0

Table 6: Distribution of distance between cinemas (for different values of town population, unit of observation: duopoly)

Population	Observations	Mean	Std. Dev.	Min	10%	Q1	Median	Q3	90%	Max
<45,000	23	0.94	0.97	0.0	0.1	0.2	0.7	1.3	2.5	3.5
45,000-70,000	29	2.62	1.86	0.6	0.7	1.2	2.2	3.0	6.0	8.2
70,000-110,000	23	3.11	3.34	0.0	1.0	1.4	2.2	3.5	5.2	16.5
>110,000	25	3.91	3.04	0.4	0.7	1.9	3.0	4.4	9.7	11.4

Table 7: Results of tobit estimation (trade-off between distance and movie differentiation, unit of observation: duopoly-week)

	Percent of Movies
Year 2001	-0.0716**
Year 2004	0.0478*
Year 2008	0.0457*
Screens Small	0.0585**
Screens Big	0.0359**
Population	7.86E-07**
Same Circuit	-0.1272**
Distance	***0.0124****
Constant	-0.4562**
No. of Observations	4000
No. of 0's	2140
No. of 1's	211

Table 8: Results of probit model for max-min equilibrium (with distance measured in km)

	Percent of Movies					
	0%	0%	below 16.67%	below 16.67%	below 25%	below 33.33%
Year 2001	0.0345	0.0380	0.0610*	0.0617*	0.0957**	0.0636*
Year 2004	-0.1013**	-0.0995**	-0.1076**	-0.1093**	-0.0811**	-0.0762**
Year 2008	-0.0699**	-0.0677**	-0.0424	-0.0473	-0.0161	-0.0600*
Screens Small	-0.1591**	-0.1595**	-0.1381**	-0.1386**	-0.1262**	-0.1012**
Screens Big	-0.0386**	-0.0374**	-0.0430**	-0.0411**	-0.0304**	-0.0290**
Population	-2.48E-08	7.78E-08	-2.75E-07	-1.78E-07	-9.97E-07**	-1.06E-06**
Same Circuit	0.0208	0.0109	0.0481*	0.0391	0.0460	0.0469*
Distance<1 km	0.0084	--	0.0542*	--	--	--
Distance<1.5 km	--	0.1025**	--	0.1429**	--	--
Distance<2 km	--	--	--	--	0.1289**	--
Distance<2.5 km	--	--	--	--	--	0.1713**
Pseudo R-squared	0.5192	0.5239	0.4486	0.4558	0.4007	0.3656
Observations fitted	710	971	740	1033	1269	1711
Duopolies fitted	6	8	18	25	31	43

Table 9: Results of probit model for min-max equilibrium (with distance measured in km)

	Percent of Movies					
	above 75%	above 75%	above 71.67%	above 71.67%	above 66.67%	above 66.67%
Year 2001	-0.0560**	-0.0593**	-0.0614**	-0.0565**	-0.0252	-0.0353
Year 2004	-0.0037	-0.0096	-0.0120	-0.0098	0.0075	-0.0153
Year 2008	-0.0136	-0.0151	-0.0082	-0.0063	0.0274	0.0236
Screens Small	0.0090**	0.0096**	0.0128**	0.0139**	0.0204**	0.0218**
Screens Big	0.0162**	0.0162**	0.0165**	0.0166**	0.0176**	0.0162**
Population	5.34E-07**	5.35E-07**	5.55E-07**	4.50E-07**	8.29E-07**	7.78E-07**
Same Circuit	-0.0082	-0.0048	0.0021	-0.0061	-0.0195	-0.0141
Distance>5 km	0.1159**	--	--	--	--	--
Distance>4.5 km	--	0.1149**	0.1173**	--	--	--
Distance>4 km	--	--	--	0.0814**	0.1180**	--
Distance>3.5 km	--	--	--	--	--	0.1257**
Pseudo R-squared	0.1949	0.1966	0.2110	0.2055	0.2273	0.2317
Observations fitted	187	201	210	262	333	423
Duopolies fitted	3	3	3	5	8	10

Table 10: Results of probit model for max-min equilibrium (with distance measured proportionately to town's diameter)

	Percent of Movies		
	below 16.67%	below 25%	below 33.33%
Year 2001	0.0577*	0.0794**	0.0545
Year 2004	-0.1156**	-0.0847**	-0.0832**
Year 2008	-0.0513	-0.0298	-0.0799**
Screens Small	-0.1382**	-0.1216**	-0.0961**
Screens Big	-0.0429**	-0.0341**	-0.0338**
Population	-3.45E-07	-1.04E-06**	-1.13E-06**
Same Circuit	0.0508*	0.0659**	0.0482*
Distance<1/5*Diameter	0.0284	--	--
Distance<1/4*Diameter	--	-0.0092	--
Distance<1/3*Diameter	--	--	0.0176
Pseudo R-squared	0.4481	0.3938	0.3529
Observations fitted	514	614	985
Duopolies fitted	12	15	25

Table 11: Results of probit model for min-max equilibrium (with distance measured proportionately to town's diameter)

	Percent of Movies		
	above 75%	above 71.67%	above 66.67%
Year 2001	-0.0530**	-0.0523**	-0.0331
Year 2004	-0.0030	-0.0076	0.0035
Year 2008	-0.0177	-0.0072	0.0030
Screens Small	0.0106**	0.0139**	0.0197**
Screens Big	0.0156**	0.0160**	0.0152**
Population	6.21E-07**	6.76E-07**	1.29E-06**
Same Circuit	-0.0008	0.0084	-0.0128
Distance>4/5*Diameter	0.1227**	--	--
Distance>3/4*Diameter	--	0.0932**	--
Distance>2/3*Diameter	--	--	0.1415**
Pseudo R-squared	0.2037	0.2106	0.2385
Observations fitted	240	268	405
Duopolies fitted	4	4	9

Table 12: Results of tobit model of estimation of the percent of movies in both cinemas

	Percent of Movies
Year 2001	-0.0778**
Year 2004	0.0454**
Year 2008	0.0570**
Screens Small	0.0592**
Screens Big	0.0375**
Population	8.29E-07**
Same Circuit	-0.1369**
Constant	-0.4419**
No. of Observations	4000
No. of 0's	1649
No. of 1's	211

Table 13: Results of the OLS estimation of the distance between cinemas

	Distance
Population	1.22E-05**
Same Circuit	-1.1967**
Constant	2.0093**
No. of Observations	4000

Table 14: Results of probit model for max-min equilibrium (including both observed and predicted values of variables)

	Percent of Movies	
	25%/20%	33.33%/15%
Year 2001	0.0945**	0.0692**
Year 2004	-0.0856**	-0.0995**
Year 2008	-0.0484	-0.0899**
Screens Small	-0.0573**	-0.0379**
Screens Big	-0.0191**	-0.0168**
Population	-4.92E-07**	-6.45E-07**
Same Circuit	0.1387**	0.1193**
1.5 km/1.5 km	0.0793**	--
2.5 km/1 km	--	0.0849**
Pseudo R-squared	0.2370	0.1931
Observations fitted	1152	1759
Towns fitted	27	43

Table 15: Results of probit model for min-max equilibrium (including both observed and predicted values of variables)

	Percent of Movies	
	71.67%/20%	66.67%/15%
Year 2001	-0.0667**	-0.0744**
Year 2004	0.0349	0.0173
Year 2008	0.0011	0.0096
Screens Small	0.0116**	0.0190**
Screens Big	0.0134**	0.0096**
Population	7.48E-07**	1.21E-06**
Same Circuit	-0.0560**	-0.0715**
4 km/1.5 km	0.1610**	--
3.5 km/1 km	--	0.1659**
Pseudo R-squared	0.1043	0.1319
Observations fitted	405	604
Towns fitted	9	14

Table 16: Duopolies fitting max-min equilibrium

Town	Year	Population	abs-abs	abs-rel	mix-mix
Algeciras	1998	101,972	x		x
Almería	2008	187,521	x	x	x
Alzira	1998	40,390	x	x	x
Andorra la Vella	2001	20,845	x	x	x
Aranjuez	2001	40,113	x	x	x
Arrecife	1998	40,770	x		x
Ávila	1998	47,650	x	x	x
Avilés	1998	84,835	x	x	x
Barbastro	2001	14,382	x	x	x
Basauri	2001	46,669	x		x
Cáceres	1998	78,614	x		x
Castelldefels	2004	53,964	x	x	x
Castell-Platja d'Aro	2001	7,112	x	x	x
Ceuta	2004	74,654	x		x
Ciudad Real	1998	61,138	x		x
Collado Villalba	2001	44,872	x		x
Coslada	1998	73,732	x		x
Cuenca	2004	47,862	x		x
Figueres	2001	34,493	x		x
Huesca	1998	45,485	x	x	x
Huesca	2004	47,923	x		x
Igualada	1998	32,526	x	x	x
Linares	2001	57,796	x		x
Logroño	1998	125,617	x	x	x
Majadahonda	1998	41,642	x		x
Majadahonda	2004	58,377	x		x
Medina del Campo	1998	20,023	x		x
Melilla	2008	71,448	x		x
Palamós	2001	15,203	x	x	x
Pontevedra	2004	78,715	x	x	x
Puerto de la Cruz	2004	30,088	x	x	x
Sant Feliu de Llobregat	1998	35,958	x	x	x
Santa Cruz de Tenerife	2008	221,956	x	x	x
Santa Lucía de Tirajana	2001	47,161	x	x	x
Sitges	2004	23,172	x	x	x
Soria	1998	33,882	x	x	x
Terrassa	1998	165,654	x	x	x
Teruel	1998	29,320	x		x
Toledo	1998	66,989	x		x
Vielha e Mijaran	2001	4,233	x	x	x
Vilafranca del Penedès	2008	37,364	x	x	x
Vilanova i la Geltrú	2004	59,409	x		x
Zamora	2008	66,672	x	x	x
Median	2001	--	--	--	--
Average	--	58,562	--	--	--
Number of Duopolies	--	--	43	25	43

Table 17: Duopolies fitting min-max equilibrium

Town	Year	Population	abs-abs	abs-rel	mix-mix
A Coruña	2008	245,164	x		x
Alcobendas	2004	100,307	x	x	x
Alzira	2008	43,892		x	
Avilés	2004	83,899			x
Badalona	2004	214,874	x		x
Gandía	2008	79,958	x	x	x
Getafe	2001	150,532			x
Getafe	2008	164,043	x	x	x
Gijón	2008	275,699	x		x
Las Rozas de Madrid	1998	47,922			x
Leganés	2008	184,209	x	x	x
Marbella	1998	98,377			x
Marbella	2004	117,353	x	x	x
Oviedo	2008	220,644	x	x	x
Sant Cugat del Vallès	1998	50,529		x	
Toledo	2008	80,810	x	x	x
Median	2006	--	--	--	--
Average	--	134,888	--	--	
Number of Duopolies	--	--	10	9	14

Table 18: Results of multinomial probit model for max-min and min-max equilibria (with distance measured in km)

	max-min	none	min-max
diameter	-0.4705**	--	0.4924*
constant	1.9121**	--	-3.8367**
duopolies fitted	43	46	10

Table 19: Results of multinomial probit model for max-min and min-max equilibria (with distance measured as a percentage of town's diameter)

	max-min	none	min-max
diameter	-0.3581**	--	0.1365
constant	0.6827	--	-2.1913**
duopolies fitted	25	66	9

Table 20: Results of multinomial probit model for max-min and min-max equilibria (including both observed and predicted values of variables)

	max-min	none	min-max
diameter	--	0.4591**	0.8226**
constant	--	-1.9360**	-4.6780**
duopolies fitted	43	43	14

Table 21: Distribution of percent of movies in both cinemas over the sum of movies screened in both (for different values of the dependent variables, unit of observation: duopoly-week)

	Observations	Mean	Std. Dev.	Min	10%	Q1	Median	Q3	90%	Max
Total	4000	11.94	12.77	0.0	0.0	0.0	8.3	21.4	31.3	50.0
Year 1998	1200	6.21	9.02	0.0	0.0	0.0	0.0	11.1	20.0	40.0
Year 2001	760	6.42	9.94	0.0	0.0	0.0	0.0	9.8	23.5	40.0
Year 2004	1000	15.64	12.42	0.0	0.0	0.0	16.1	24.6	33.3	47.6
Year 2008	1040	19.03	13.78	0.0	0.0	15.3	20.9	30.0	37.2	50.0
Same circuit	1320	5.16	9.48	0.0	0.0	0.0	0.0	6.7	21.1	42.9
Different circuit	2680	15.28	12.86	0.0	0.0	0.0	14.3	25.0	33.3	50.0
Sreens small =1	840	0.95	4.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3
Sreens small: 2 - 3	840	3.59	5.82	0.0	0.0	0.0	0.0	7.4	12.5	25.0
Sreens small: 4 - 5	1000	11.77	10.34	0.0	0.0	0.0	10.34	20.0	26.3	50.0
Sreens small: 6 - 7	640	21.53	10.58	0.0	11.3	18.5	26.1	30.0	35.0	47.6
Sreens small >7	680	27.04	9.28	4.2	15.0	20.0	26.8	34.5	39.5	45.8

Table 22: Results of probit model for max-min equilibrium (with distance measured in km and the percent of movies calculated over the sum of movies screened in both cinemas)

	Percent of Movies					
	0%	0%	below 5%	below 5%	below 10%	below 10%
Year 2001	0.0345	0.0380	0.0843**	0.1063**	0.1205**	0.1156**
Year 2004	-0.1013**	-0.0995**	-0.0800**	-0.0815**	-0.1686**	-0.1656**
Year 2008	-0.0699**	-0.0677**	-0.0446	-0.0286	-0.0702*	-0.0693*
Screens Small	-0.1591**	-0.1595**	-0.1635**	-0.1690**	-0.1744**	-0.1745**
Screens Big	-0.0386**	-0.0374**	-0.0285**	-0.0258**	-0.0171**	-0.0169**
Population	-2.48E-08	7.78E-08	7.11E-08	-2.46E-08	-5.59E-07*	-5.50E-07*
Same Circuit	0.0208	0.0109	0.0251	0.0176	-0.0058	0.0096
Distance<1 km	0.0084	--	--	--	--	--
Distance<1.5 km	--	0.1025**	0.1192**	--	--	--
Distance<2 km	--	--	--	0.1395**	0.1179**	--
Distance<2.5 km	--	--	--	--	--	0.1127**
Pseudo R-squared	0.5192	0.5239	0.4878	0.4907	0.4692	0.4685
Observations fitted	710	971	986	1110	1270	1554

Table 23: Results of probit model for min-max equilibrium (with distance measured in km and the percent of movies calculated over the sum of movies screened in both cinemas)

	Percent of Movies					
	above 15%	above 15%	above 20%	above 20%	above 25%	above 25%
Year 2001	-0.1016**	-0.1113**	-0.0106	0.0013	0.0240	0.0211
Year 2004	0.1201**	0.1067**	0.0722**	0.0775**	0.0683**	0.0422*
Year 2008	0.1058**	0.1054**	0.1600**	0.1558**	0.1260**	0.1281**
Screens Small	0.1395**	0.1419**	0.0995**	0.1000**	0.0593**	0.0607**
Screens Big	0.0093**	0.0092**	-0.0027	-0.0023	-0.0094**	-0.0106**
Population	1.05E-06**	1.05E-06**	1.07E-06**	9.58E-07**	7.06E-07**	6.27E-07**
Same Circuit	0.0086	0.0197	0.0479*	0.0318	-0.0140	-0.0084
Distance>5 km	0.1938**	--	--	--	--	--
Distance>4.5 km	--	0.2059**	0.2213**	--	--	--
Distance>4 km	--	--	--	0.1508**	0.1283**	--
Distance>3.5 km	--	--	--	--	--	0.1423**
Pseudo R-squared	0.4424	0.4447	0.4038	0.3980	0.3819	0.3885
Observations fitted	345	374	326	395	323	403