Spatial Agglomeration of Firms: Theory and Application for Industrial District 22@ of Barcelona

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Abstract

The goal of this paper is theoretical analysis of the complex process of agglomeration of firms into industrial districts when cities are also competing for them. Positive spillovers tend firms to locate in the same area, while congestion effects limit this process. Thus, for any given city there exists an optimal number of firms. If there are fewer firms, we face competition under increasing returns to scale, with path dependence effects, described by W.B.Arthur (1994) and R.Camagni (2005). Hence, if firms are relatively scarce, not all cities would be occupied by firms at optimal level. The problem of a firm is to choose an optimal city expecting rational behaviour of other firms. Such factor as office rent depend on city size, while wage cost and spillover effects depend also on the number of firms there. Firms choose to agglomerate in those cities where after optimal entry their profits will be maximized. Under certain conditions for parameter set, there exists an equilibrium allocation, where all firms are located in the cities with better parameters. Since cities are different, their attractiveness also differ. The second goal of this paper is the empirical analysis of advantages and disadvantages of emerging industrial district 22@ in Barcelona in comparison with other European industrial districts (like Greater London, Ille de France, Dublin, etc). At present, London is the leader in attractiveness among European cities. But this situation is unstable and depends on city development. At present, Barcelona needs state intervention that would create critical mass of firms in this area. On empirical side, we analyse the potential effect of investment in infrastructure in Barcelona to improve its attractiveness. In particular, we are interested in the factors that can be responsible for growing density of firms located in 22@ district. The methodology of empirical part includes survey for firms potentially interested in location in this district.

Keywords: Location of firms, External economies, Hierarchy of cities.
JEL Classification: L6, R3, R12.

1. Introduction

This article combines theoretical and empirical approaches. At the first, theoretical part we study the process of concentration of firms and the factors that can be responsible for growing density of technological firms in a particular industrial district. In the second, empirical part we attempt to make some statements about the future of technological district 22@ in Barcelona.

In reality, we have different types of firms (local, national and international) and there is heterogeneity across the cities (not only size, but also other factors matter). We try to figure out what factors, different from its size, can give an advantage to a city and then to apply this approach for the case of Barcelona city and its technological district 22@.

1.1. Practical importance

At the present time, there exists an opportunity for rapid technological development of the area of Barcelona. City development is a very complex process, because in the epoque of globalization the competition between world cities for attracting multinational firms represents a disequilibrium and path dependent process. We observe a continuously changing pattern of more attractive cites for location of high-tech industries. The goal of this paper is to determine the factors that are favourable for Barcelona city and which can indicate the potential success of such project.

The question of spatial concentration of firms in particular spatial areas has high practical importance. There exist extensive empirical studies (see, for example, Henderson, 1999, 2000; Trullen, 1999) but there exists no complete theoretical model describing this process. The goal of this study is to suggest some model for the process which could also have some testable formulae.

The empirical part of the paper presents the results of questionary for the firms, where they determine factors that are important for their location. According to Healey & Baker (2001), in 2001 Barcelona was sharing 7-8th positions in the attractiveness of industrial location among European cities. Only London represents a stable leading position, while the advantage of other locations, including Paris, are not much different from one for Barcelona.

1.2. Basic literature

On one hand, there exists literature about the micro mechanisms of functioning of increasing returns to scale in a dynamic framework. W.B.Arthur (1994) has several articles related to urn mechanism that produces path-dependent effect. In other words, when several firms (or locations) start some kind of competition in similar conditions, it is nopt clear which firm will win it, but it is clear that long-run outcome will be quite asymmetric and depend on the history of random shocks.

On the other hand, there exists extensive literature in urban economics, related to optimal sizes of cities (see Henderson, 1985, Duranton and Puga, 2004).

This literature mostly deals with static problems, but at the same time accounts for typical effects produced by geographical space.

Another branch of literature is related to the influence of externalities on productivity and costs. It starts from the works of Marshall (marchallian externalities) with later elaboration by Marshall (1890), Becattini (1979), Camagni (2005), Trullen (1999), etc.

Our goal would be to combine these approaches. The urban economic literature would be useful for determination of the effects that are responsible to scale economies, which the works of Arthur would help us to predict the pecuniarities of dynamic mechanism.

2. Theoretical Model

In the presence of scale economies and externalities the structure of economic outcomes differs from those trraditionally considered in economic literature. Firms clustering in the presence of scale economies leads to new patterns of equilibria that are better described by using concepts from physics (Yegorov, 2005). For example, in quantum mechanics there exists "atomic levels" that can be either occupied by electrons or be free. In a similar manner, each city may have several "vacant levels" for locations of technlogical firms but not all of them are necessarily occupied. As time goes, there might be shift of some firms between cities and emergence of new firms with location in particular cities, so that the pattern has its own dynamics.

Here we have two types of interractions: a) between firm and a city (it epends on city size through mechanism emerging from CBD theory, that is described below), b) between different firms in city (Marshallian externality), depends on number of firms

2.1. Competition under increasing returns to scale

Traditional microeconomic literature typically stays away from scale economies, since they pose a problem either for an existence of equilibrium, or its stability[2]. Another, dynamic, approach to model such a competition has been proposed by B.Arthur. He focuses more on the dynamics of competition and analysis of the factors leading to the final outcome. In one of the works he considers competition between location for attracting firms, when there exists a possibility of postitive spillover. In the numerical simulation with a sequence of small random effects it is shown that the outcome is path dependent, i.e. in a symmetric initial situation the final outcome is quite asymmetrric, but it is not clear which firm has an advantage.

The approach of Arthur has been extended in the recent study by Yegorov and Helmenstein (2004), where the firms in numerical simulation were put in asymmetric conditions. The scale economies work through the intertemporary profit, while each competitor grows randomly but has a unique optimal size that brings the highest profits, It was shown that even a small difference in initial conditions can have very important effect on the final probability of competitors to win the market.

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[2] Only in the works by Krugman such an equilibirum is studied. It is necessary to assume Dixit-Stiglitz preferences and the mechanism of scale economies working through an icreasing number of varietires.

In the present model, it is important to determine the location externalities that create scale economies of Marshallian type.

2.2. Factors that determine scale effects

"What can firms and people be paying 22@ rents for, if not for being near other firms and people?"

It is well known, that high-tech industries have significant positive externalities from location. The most known example is related to the phenomenon of Silicon valley, where we observe a growing concentration of firms in one location. The reason for such concentration is related to positive spillovers for the firms that are located in one neighbourhood.

Not necessarily all firms will be located in one neighbourhood, because there are also congestion effects. But if the optimal number of firms in one location is finite, still there will be winning and losing locations.

What factors might be important for spillover effects among high-tech firms? At the level of managerial costs, there are clear savings from less distance, but with the development of internet and mobile connection this factor becomes less important. The concentrated pool of diversified skill labour becomes more important. It looks like London got its leading position in location of "white-collar" offices also because of its large population and concenration of knowledge. Barcelona seems to loose London at present time both in the population, but it seems to have high concentration of knowledge per capita.

If we look at the congestion effects, hey are related not only to traffic jam, but also to housing and office rental prices. London seem to have them at very high level, and firms are thus obliged to pay very high wages, which still do not bring high utility to workers due to high living costs. In this aspect, before 1998 Barcelona was a very attractive place, but the housing price boom in Spain during the recent 6 years have been eroding this advantage.

 The empirical part of the paper presents the results of interview for the firms, where they determine factors that are important for their location. Results show that the differences in taxation laws across cities is an important source of heterogeneity (in this factor Barcelona is a loser, for example, to Bilbao and Dublin); Barcelona also has less experience and state support for innovative and technological applied research; Barcelona has advantage in quality of life and possibilities of leisure; Barcelona still has relatively low prices for office space, but the positive price trend in housing prices since 1998 has lowered its former advantage as a cheap city, where lower wages can be paid. Others Results of consultancies show Barcelona was sharing 10 positions in the attractiveness of industrial location among European cities. Only London and Paris represents a stable leading position, while the advantage of other locations is not much different from one for Barcelona.

2.3. Modelling the competition of cities for technological firms

This model is highly stylized, as it keeps firms as identical a priori and introduce only he unique heterogeneity across cities, that is related to their population N. Nevertheless, this allows us to get some analyitical results, that can be modified and adapted to solve more practical problem (section 3). We start from a static problem, where we have cities of different population and number of technlogical firms, both given as exogeneous numbers. While both cities populations and total number of firms evolve over time, this evolution is relatively slow, so that in the short run we can concentrate on static problem, linked to some kind of equilibrium. In order to approach it, we assume freedom of firms to choose their location and inputs, as well as rational expectations of firms where the other firms can be located. There will be two-stage optimization process, when in the first stage firms calculate the optimal number of firms M=M(N) in each city of cize N. Due to Marshalllian externalities, if this number is curretly below M, the growth until M is mutually beneficial for firms. Th second stage is finding a city with such popupation N, that profit of each of M firms there is maximized. While this number is found using continuous optimization, in reality the problem is discrete, so that firms would start to agglomerate in the city of optimal size, then further firms would cluster in the second-best city, etc. If the total number of firms is not too large, some cities would remain either without technlogical firms, or with unsufficient number of them.

While in the model we do not specify different types of firms, it is more useful for technological firms, that are more subject to Marshallian externalities. The profit of a firm is the difference between revenues and costs, that depend on externalities. Since transport and trade costs became very small in globalized world, especially for high-tech products, the difference in profit emerges at cost level. What costs do depend on location? It seems that the main effects come from office rent, wages and cost saving by spillover.

We assume that the costs (per unit of output, or worker) of a representyative high-tech firm in a city have three components: office rent C_r , wage cost C_w and communication cost (or spillover effect) C_c . The profit (per unit of output) is he revenue R minus cost:

$$\pi = R - C_r - C_w - C_c.$$

Let **N** be the population of a city, and let **M** denotes number of firms in one location. As it was shown in [5], price index for housing in city depends on its population as **P=a+bN$^{1/2}$**. If we assume that the major part of real estate is occupied by residents, firms should take this housing price P as given.[3]

Now we should determine the wage for skilled labour in a city as a function of its population N and the number of firms M. At the first step, we abstract from presence of international firms and define the wage index for labour only on the basis of city size N; this will be a benchmark. As it was shown in [5], basic wages are related to the city population as **w =const - F/N**. The brief derivqation of the formulae for prices and wages as the function of city size is provided in Appendix.

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[3] Clearly, if there are as many firms as in Silicon valley, rental price for office space would be mostly defined by firms

Now we assume that wage costs for high-tech firms represent the sum of base wage bill (emerging from he market for unskilled labour) and mark-up from the competition of high-tech firms for skilled labour. This mark up (or skill labour wage premium) depends positively on number of high-tech firms per capita, i.e. on M/N. The simplest function with this property is linear. Thus, we assume that wage costs of a representative high-tech firm in a city with N inhabitants and M firms of this type is given by expression:

$$C = c2 + \alpha M/N = c1 - F/N + \alpha M/N, \quad \text{with } \alpha > 0.$$

Finally, we assume that communication costs (Marshallian externalities) inversely depend on M: $C_c = \beta/M$. Thus,

$$\pi(M,N) = \pi_0 + F/N - bN^{1/2} - \alpha M/N - \beta/M.$$

Proposition 1. *Scale economies work in such a way that profit of a firm depends both on city size and the number of firms located there.*

2.4. Solution to optimization problem

Here we proceed in two stages. At the first stage, firms take city size N as given and enter until the total number of firms M becomes optimal. Intuitively, if we have too few firms, the Marshallian positive externality is too small, while if there are too many firms, congestion effects (high rents for office space, high wages due to competition for skilled workers) dominate. Formally, we solve the equation

$$d\,\pi(M,N)/dM = 0.$$

Differentiation gives the optimal number of firms M, depending parametrically on city size N:

$$M^* = (\beta N/\alpha)^{1/2}.$$

Since the second derivative is always negative, we have here a unique maximum.

Proposition 2. *For each city of particular size N there exists an optimal number of firms, when profit of each of them is maximized (for given city size). If there are too few firms, all of them are interested in further entrants, until the number would reach an optimal level.*

From a practical point of view, there are many factors that influence profitss of firms, beside city size. They cannot be modelled analytically. The section 3 of this paper will dealwith this issue on empirical level.

Now we substitute this expression and find profit as the function of N:

$$\pi(M,N) = \pi_0 + F/N - bN^{1/2} - 2(\alpha\beta/N)^{1/2}.$$

The new differentiation w.r.t N gives the equation for the optimal size of a city (we introduce new variable x to have natural power in equation, $x = N^{1/2}$):

$$b\,x^3/2 - (\beta\alpha)^{1/2}x + F = 0.$$

This equation may have 1 or 3 solutions, depending on parameters. If we have a unique maximum, there exists an optimal city size N, that **M=M(N)** technological firms would enter there and gain maximal profit.

Numerical analysis of roots. The numerical analysis shows that we have one negative root and 0 or 2 positive roots. For example, for parameter values **b=1, β=1, α=1, F=0.25**, the roots are: $x_1 = -1.52, x_2 = 0.258, x_3 = 1.267$. The second derivative at x2 is positive (we get minimum) and is negative at x3 (we have maximum). Hense, x3 represents the optimal value of x, and N.

Comparative statics. An increase of parameter F from 0.25 to 0.5 (the rest parameters are kept as before) moves the roots: now $x_1 = -1.61, x_2 = 0.618, x_3 = 1.00$. Again, x_3 is the location of maximum. Further increase in fixed cost F leads to disappearance of both positive roots. What does it mean?

Different number of roots. Only positive roots have economic sense. There are at most 3 roots, and one of them is always negative. This is easy to see graphically, looking at equation $x^3 = ax-c$, which is topologically equivalent for **b>0, F>0**. If there are two positive roots, only one of them is maximum, and we have a unique optimal city size N, from firm's perspective. Bt there might be the case, when there are no positive roots at all (F is high enough). In this case we have a corner solution: either N=0 or N=∞. In reality, there is discrete set of city sizes, and such a problem is solved by simple comparison and ordering of $\pi(M(N),N)$ w.r.t. existing set $\{N_1, N_2, ... N_k\}$.

Dynamics. Note, that when there are too few or too may firms, this is bad for firms. Thus, nobody wants to enter first, and firms would appreciate if a city has initial investment in infrastructure, so that the optimal number of firms could enter in one moment. The dynamic problem can be studied in "adiabatic" approximation, i.e. as a sequence of static equilibria, that move smoothly into each other. For this to take place, the speed of convergence to equilibrium should be faster than external changes (city growth or technological inventions, leading to emergence of firms with new technology).

Perspective of a city. Now let us look at the problem from a perspective of a city. We know that in the long run not all cities would attract optimal number of technological firms and thus become loosers. While in the model cities are assumed to be identical, in reality they are heterogeneous. The main goal of our empirical study would be to detect these sources of heterogeneity that give some cities an advantage in competition for technological firms.

3. Empirical Analysis

This model reveals only the main cost components that are important for clustering of international firms in a particular center. Sine this competition of cities for firms has scale effects, initially the final outcome is no clear and depends also on many additional factors, not always of economic origin and not always quantifiable.

It is well known that investment in Research and Development and Innovation (later abbreviated as R+D+I) is a necessary precondition of technlological growth and

development. The firms of this type are typically growing in clusters and thus are relevant for our study. The Table 1 shows that Catalonia (and even more Spain) has much weaker position than an average EU country.

Table 1: Data about R+D+I , in 2003
Source: Ministry of Science and Technlogy, Spain; EUROSTAT

	Unit	Catalonia	Spain	Sweden (max)	EU-15
R+D+I as % GDP	%	1.20	1.03	4.27	2.0

While in the USA, the private sector pays 70% of the costs of R+D+I, the average level in the EU-15 is only 65%. But the position of Spain is much worse: private sector pays there only 52.4% of corresponding costs. The leaders of EU are Sweden (with 77.6%) and Finland (with 71.1%). The role of private sector there exceeds one in the USA, and hence these countries have much greater advantege in creation of industrial districts in Europe.

On the level of **Empirical Methodology**, there exists a problem with EUROSTAT data on metropolitan areas. There exists no information relevant for our study That is why it was decided to go ahead with questionary.

In order to apply this methodology for the case of Barcelona city (and district 22@ inside it), it is necessary to employ all possible empirical matherial, including the firm surveys and consultancies of different companies.
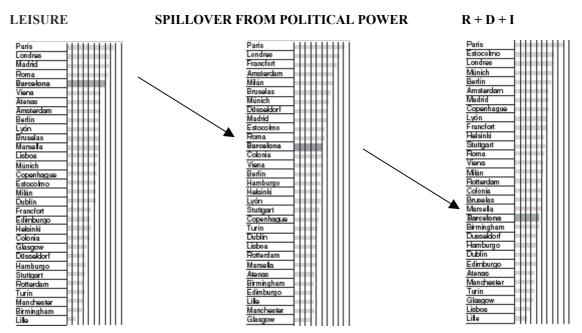
3.2. Non-Measurable Factors

The studies by Xavier Vives and Lluis Torrens (2004) are about 32 European cities that can compete for location of clusters of international firms. They focus on three factors and rank these cities with respect to it. The first factor that works as positive externlity for location s related to possibility of leisure. Here Barcelona is quite competitive and occupies the position 5 oout of 32; only Paris, London, Mdrid and Rome are above. Another source of positive externality is spillover from local power (the so called effect of capital), and here Barcelona, being only the regional center of Catalonia, is only at the 12th position. Since Catalonia is relatively large region with almost 7 mln. Of populaion, Barcelona loses only capitals of large countries. The third factor is the potential for research and development. Here, despite existence of several universities, Barcelona loses more, being only at the 21th position. Here we have the old problem of Spain, which have never been a country with high investment in scientific research and hiving good research schools. (See Table 2).

Conclusion 1. *While Barcelona has an advantage of leisure-city, its political spillovers are limited and it has disadvantage over many other cities in the lack of traditions in applied scientific research oriented on technlogical development. That is why on the first stage it is likely to attract not so many Silicon-valley type firms, but can rely initial clustering in arts and entertainment, with a promise to become a Holywood-type*

cluster. To overcome this trend, a strong regional-level investment in building applied research schools is necessary, but this takes time, and competition to other cities can be lost.

Table 2.

LEISURE	SPILLOVER FROM POLITICAL POWER	R + D + I

Font:Elaboració propia a partir de l'estudi - Estrategies de les àrees metropolitanes europees davant l'ampliació de la UE"de
Xavier Vives i Lluíí Torrens (2004)   -.

3.3. Measurable Cost/Benefit Factors.

In the model all measurable factors have been derived only from the size of a city. In reality, cities are heterogeneous, and housing price, for example, depends not only on city size, but on many other factors as well. Since renta price of an office represents an important cost factor for a firm, it is worthwhile to compare different cities with respect to this factor. In year 2004, office rent in Barcelona was well below one in other cities (see Table 3). Here Paris and London occupy first positions. This means that their advantage in non-measurable factors over Barcelona is at least partly offset by high prices for office space.

Table 3.

City	Rent price for office space, 2004
London, WE	926
Paris	675
London, City	671
Zurcí	517
Milan	490
Rome	425
Frankfurt	420

Stocholm	378
Munich	360
Athens	360
Amsterdam	315
Madrid	312
Barcelona	280
Brussel	275
Berlin	264
Warsaw	259
Lisboa	240
Prague	228
Budapest	198
Bucharest	186
Stambul	145

Source: Own calculations based on data from departament d'Estadística. Ajuntament de Barcelona Departament d'Estudis Fiscals. Institut Municipal d'Hisenda. Ajuntament de Barcelona. CB Richard Ellis

Now let us think whether current office price is a good proxy for meauring firms costs in future equilibrium. Partly this low price may be driven by excess supply of offices over still moderate demand (many offices were constructed for FORUM 2004, while low position of Barcelona in R&D perspectives still keeps office demand at moderate level.

Cost of firms will include future rental prices, and if many would enter, price for office space would grow substantially. Another cost is related to salary. For an international worker (and skilled are usually of this type) the nominal wage should be corrected by the cost of living index, and here the housing prices (both to buy and to rent) matter. We cannot provide fully quantified international comparison here, but the recent trend of housing prices in Barcelona (Table 4) shows that it loses its comparative advanatage in this factor rapidly.

Table 4.
Evolution of average prices of houses in the districts of Barcelona (in Euro/sq.m)

	2000	2001	2002	2003	2004
BARCELONA	2.062	2.388	2.765	3.179	3.219
1. Ciutat Vella	1.660	2.017	2.439	3.096	3.126
2. Eixample	2.198	2.656	3.055	3.505	3.611
3. Sants-Montjuïc	1.889	2.216	2.527	2.939	3.025
4. Les Corts	2.493	2.875	3.400	3.675	3.715
5. Sarrià-Sant Gervasi	2.616	3.078	3.598	4.049	4.149
6. Gràcia	2.131	2.443	2.853	3.389	3.410
7. Horta-Guinardó	1.873	2.179	2.557	2.852	2.910
8. Nou Barris	1.647	2.038	2.239	2.544	2.678
9. Sant Andreu	1.788	2.170	2.436	2.756	2.845
10. Sant Martí (-22@)	2.075	2.155	2.528	2.965	2.998

Source: Own calculations based on data from departament d'Estadística. Ajuntament de Barcelona Departament d'Estudis Fiscals. Institut Municipal d'Hisenda. Ajuntament de Barcelona

Avarage prices to renta an apartment (in Euro/sq.m per month)

Districte	2000	2001	2002	2003	2004
BARCELONA	7,21	8,38	9,26	9,69	9,91
1. Ciutat Vella	6,73	7,99	9,95	10,84	11,45
2. Eixample	6,63	8,21	8,95	9,53	10,33
3. Sants-Montjuïc	6,22	7,67	8,35	8,96	9,25
4. Les Corts	9,01	9,27	10,66	10,48	10,89
5. Sarrià-Sant Gervasi	8,52	9,41	10,18	10,29	11,19
6. Gràcia	6,34	7,93	8,99	9,58	9,69
7. Horta-Guinardó	5,83	7,25	7,90	8,65	8,97
8. Nou Barris	5,62	6,32	7,04	8,26	8,59
9. Sant Andreu	5,57	6,57	7,40	8,28	8,68
10. Sant Martí	6,44	8,45	9,39	9,86	10,06

Source: Own calculations based on data from departament d'Estadística. Ajuntament de Barcelona Departament d'Estudis Fiscals. Institut Municipal d'Hisenda. Ajuntament de Barcelona

Conclusion 2. *While Barcelona is still cheap city for renting office space, its housing prices are already expensive, and firms will need to pay higher salaries than in some other cities (of similar size; like Vienna) to attract skilled international labor force.*

3.4. Strong and Weak Points of the Project 22@

The Table 5 represents the summary of work [7].

Table 5.

Strong points of project 22@	%
Communication	25,9%
Technological image	14,8%
Good future expectations	22,2%
Infrastructures	7,4%
Quality of life	3,7%
Perspectives for contacts and business	11,1%
Price	7,4%
Facilities donated for local Government (Ajuntamento)	7,4%
Total	**100,0%**

Weak points of project 22@	%
Public transport, mobility	26,1%
Zona en desenvolupament, futur incert	17,4%
Enivronment	4,3%
Problemes de circulació de mercaderies	4,3%
Manca de serveis	21,7%
Problems with parking	4,3%
Non sufficient infrastrructures in initial period	8,7%

High land price	4,3%
Dificulties for small firms	4,3%
Cap / Rest	4,3%
Total respostes	**100,0%**

3.5. More Detailed Results of Barcelona Survey

The work with verbal information requires different techniques of analysis. First we focus on more frequently repeated phrases in answers.

1. The majority percieve the project 22@ to be linked to new technlologies and knowledge.
2. At the same time, there exists little international contribution to this project, perhaps due to insufficient publicity and very few interantaional firms already there.
3. The best in the project 22@ is related to good expectations for future, beliefs in the emergence of networks between universities and firms with high technology, new infrastructures, emergence of "great space".
4. The percieved weakest points are related to slow process of emergence, low quality infrastructures, insufficient services and marketing, and little push to attract firms with high technology.
5. People compare this project with the role of Silicon valley, New York and Boston agglomerations in the USA, as well as with London agglomeration in UK and technlogical development in such countries like Ireland and Sweden.
6. People belieive that the following aspects are decisive for project 22@: technlogical atmosphere, prices, expectations for future, communications, space availability. (Note that the theoretical level these issues deal with scale economies and describe very vulnerable and pass-dependent environment, that can reach different equilibria depending on intertplay between these factors.)
7. The zone 22@ also competes with other locations in Barcelona functional areas (Zona Franca, El Prat, Sant Cugat, etc). Their main advantage is in land price. (Due to scale economies, only one winner is likely to emerge, and if 22@ is much stronger than competitors, it will save energy for internal competition in order to contribute to Barcelona's competitive power at the international market for attracting firms.)

What types of firms have been located in 22@ area? Answers to questionary shows that they are mostly medium-size firms, mostly related to Audiovisual sector, graphic arts, telecommunications.

The strong points of Barcelona in international competition for firms are related to good access to markets, good communications and its prestige. The lack of public sponsorship of Research and Development is listed among factors than weaken Barcelona area.

The district 22@ has good expectations for future and due to its technological image. But the uncertainty the future of the area of location in general (Poblenou, St.Marti) with respect to its currently low level of quality serives and public transport weaken this position.

It is believed that firms based on new technlogies and services for other firms would be the main contributors to the growth of this zone.

3.6. Conclusions Based on Survey [7]

1. The main goal of the project 22@ is to attract firms with high technology that would not only change the image of Barcelona as newly emerging technlogical centre, but also would put this city in higher position in the hierarchy of European industrial centres.
2. At the present time, the majority of firms that have already located in the 22@ district, are not international and do not belong to the group of high-tech firms. International firms with high technlogy require higher level of infrastructure, public services and human capital for the choice to locate in this district.
3. One of the problems of Barcelona is lack political power/capital (here it loses to Madrid). The second important problem is the advantage of first mover in establishing European district of hi-tec industry. In this sense, several European cities (like Stockholm, Helsinki, more recently Dublin) have alreadry an advantage of being in this market market before Barcelona. This is extremely important since such districts posess self-reinforcing effects coming from economies of scale created by centripetal forces.
4. Other important problem of Barcelona (and Spain in general) is too little public investment in applied research. This creates lack of human capital that international hi-tech firms are looking for despite high general level of education in this city.
5. While 10 years ago Barcelona was a very attractive place for location due to moderate housing prices, this advantage has dried out in recent years, when the index of housing price have duplicated and even triplicated. It is still lower than in London or Paris, but no longer so low to compensate for other disadvantages.
6. On the other hand, Barcelona city has a very positive image of future perspectives to become a city of this type. It is famous for its art, architechture, experience of public forums (Olympic Games 1992).
7. In this situation, it is very important fort he local government to make initial push that would attract firms of desired type in the district 22@ before the market would create conditions for further self-reinforcing growth of this cluster.

4. Conclusions

1. This article combienes both theoretical model and its empirical application for the potential concequences of the project 22@ (technological district of Barcelona). Optimal selection of locations by firms in the presence of spillover effects leads first to clustering and then to competition of metropolitan areas for these clusters. Since we have more space for firms in cities than the number of firms, in the presence of scale effects, not all cities would win such a competition. In the stylized model, only size of city matters (which acts through its influence on costs and benefits), and the cit of optimal size would attract optimal number of firms, that would form a cluster, mutually

beneficial for them and the city. At the same time, it becomes clear that some cities will be winners, while other –losers in competition for technological firms.

2. In reality, we have different types of firms (local, national and internaional) and there is heterogeneity across the cities (not only size, but also other factors matter). We try to figure out what factors, different from its size, can give an advantage to a city and then to apply this approach for the case of Barcelona city and its technlogical district 22@.

3. Results of consultanices show that:
- we can divide all factor into 3 groups: operative (quality of infrastructure, proximity of markets, labor skills) economic (fiscal and labour laws, wages, help of local government), local (quality of life, existence of specialized labour, experience and state support to R+D+I);
- the differences in taxation laws across cities is an important source of heterogeneity (in this factor Barcelona is a loser, for example, to Bilbao and Dublin);
- Barcelona also has less experience and state support for innovative and technological applied research;
- Barcelona has advantage in quality of life and possibilities of leisure;
- Barcelona still has relatively low prices for office space, but the positive price trend n housing prices since 1998 has lowered its former advantage as a cheap city, where lower wages can be paid.

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Appendices

Appendix 1: A Model of Optimal City (from [5])

We will first derive how wage depends on city size, and then will find the relationship between city size and housing price. Thus, we will obtain the attractiveness of a city as a function of its population.

How does the wage depend on city size?
We assume that each city has a firm which operates with zero profit (monopolistic competitive environment). Thus, the benefits from sales should cover fixed costs and the rest should be split across labour and capital. For Leontieff production function, it is optimal to operate with equal size of inputs; hence, $Q = K = L$. Now we will rely on a stylized fact of perfect capital and imperfect labour mobility. Due to perfect competition in financial markets and perfect capital mobility, every unit of capital receives the same return r, while labour can get different returns in different cities. Hence, we get $pL = (w+r) L + F$. Since $L=N(i)$, the expression for the wage is the following:

$$w(i) = p - r - F/N(i). \qquad (1)$$

In fact, the wage depends on city size only, $w(N) = C - F/N$. This function is concave in N: $w'>0, w''<0$. Very small cities simply cannot exist (wage should be negative), while for very large cities the wage approaches its upper limit: $w(\infty)=C$.

Housing price and city size
Consider a city as monocentric CBD, with r as the distance from the city centre (Alonso model). For simplicity, we assume linear transport cost and will abstract from distance effect on dwelling size as well as on the height of the buildings.
The housing price, P_h, is assumed to be a linear function of location rent $R(r)$:

$$P_h(r) = R(r) + H,$$

where H denotes construction cost, equal for all locations. At the edge of the city, the location rent is equal to agricultural rent R_a, which is assumed to be a constant, independently on location. Then, the location rent in the centre $R(0) = R_a + t r^*$, where

t is unit distance transport cost. Assume that a city has a radius **r***. Then its population equals to $N = \rho\pi (r^*)^2$. Hence,

$$r^* = [N/(\rho\pi)]^{1/2}.$$

The housing price in city centre, $P_h(0) = R_a + H + t\, r^*$. It will be considered as housing price index, or cost of living, for the whole city: $P(i) = P_h(0)$. The reason is that only the residents in this point do not face transport cost, and this price exactly equals the sum of housing rental price plus internal transport cost for the whole city. This cost of living in a city contains a term proportional to a square root of its population:

$$P(i) = a + b\, N(i)^{1/2}. \qquad\qquad (2)$$

It is also concave in **N**, but the shape differs from **w(N)**.

Appendix 2: Survey Questions (in Catalan)

ENQUESTA PER LES EMPRESES DE L'ÀMBIT 22@

1. Dades generals de l'empresa

1. Nom _____
2. Any de fundació _____
3. Sector d'activitat _____
4. Nombre de treballadors _____
5. És filial d'un grup multinacional? _____
6. Propietat del capital (aproximadament)
    - Espanyol _____%
    - Estranger _____% De quins país? _____
7. Estava instal·lada al districte abans del projecte 22@ (abans de juliol del 2000) ?
    - Sí
    - No

NOTA: Per les preguntes on s'ha de valorar d'1 a 10, s'entendrà que la millor puntuació possible que es pot donar és de 10.

2. Sobre la ciutat regió de Barcelona

8. Citi els *punts forts* de localitzar la seva empresa a la ciutat – regió de Barcelona respecte altres ciutats – regió (ex: Madrid, resta d'Europa, etc.)
    a. _____
    b. _____
    c. _____

9. Citi els *punts dèbils* de localitzar la seva empresa a la ciutat – regió de Barcelona respecte altres ciutats – regió (ex: Madrid, resta d'Europa, etc.)
    a. _____
    b. _____
    c. _____

3. Sobre el sector 22@ en general

10. Citi els *punts forts* de localitzar la seva empresa al districte 22@

a. _____

b. _____

c. _____

11. Citi els *punts dèbils* de localitzar la seva empresa al districte 22@

a. _____

b. _____

c. _____

12. Creu que la imatge 22@ (localitzar-se a l'àmbit 22@) aporta valor afegit a la imatge de l'empresa? (Puntuar d'1 a 10) ____

13. En quina mesura afecta positivament conèixer que altres empreses del sector decideixen instal·lar-se al districte d'activitats 22@bcn? (Puntuar d'1 a 10) ____

14. Creu que el districte d'activitats 22@ afavoreix la innovació? (Puntuar d'1 a 10) ____

15. En quina mesura creu que es dóna l'anomenat "efecte contagi o desbordament del coneixement" (és a dir, el fet de que el coneixement d'una empresa afavoreixi altres empreses)? (Puntuar d'1 a 10) ____

16. A quin tipus d'empresa (o sector) creu que beneficia en major mesura instal·lar-se a l'àmbit 22@?

a. Empreses relacionades amb les noves Tecnologies de la Informació i la Comunicació (TIC)

b. Indústria tradicional

c. Serveis a empreses

d. Serveis financers

e. Altres _____

17. Quin sector d'activitat creu que serà el de major creixement a l'àmbit 22@? (Ex: audiovisual, moda, alimentari, TIC, serveis a les empreses, serveis financers, etc.)

_____

18. Es planteja un canvi d'ubicació?

▪ Sí. En cas afirmatiu, on tindria pensat traslladar la seva empresa?

o Catalunya

o Resta d'Espanya

o Unió Europea

o Altres localitzacions _____

▪ No

19. Es planteja ampliar l'empresa?

▪ Sí. En cas afirmatiu, on es donaria aquesta ampliació?

o Al mateix districte 22@

o Resta de Barcelona

o Resta de la Regió Metropolitana de Barcelona

o Resta de Catalunya

o Resta d'Espanya

o Unió Europea

o Altres localitzacions _____

20. Quins motius han portat a l'empresa a instal·lar-se al 22@? (Puntuar d'1 a 10)

▪ Accés al consumidor / mercat _____

- ▪ Accés a serveis (logística, informàtica, màrqueting) _____
- ▪ Accés a treball especialitzat _____
- ▪ Accés a serveis públics _____
- ▪ Accés a la informació _____
- ▪ Centralitat _____
- ▪ Infrastructures _____
- ▪ Flexibilitat dels espais productius _____

21. Valorar les següents característiques de l'espai 22@: (Puntuar d'1 a 10)
    - ▪ Centralitat i accessibilitat _____
    - ▪ Massa crítica _____
    - ▪ Complexitat d'usos diversos (barreja d'usos) _____
    - ▪ Infrastructures _____
    - ▪ Flexibilitat i eficiència dels espais productius _____
    - ▪ Centres de formació, recerca, divulgació de tecnologies, etc. _____
    - ▪ Espai públic de qualitat
    - ▪ Altres _____

4. Sobre la ubicació / accessibilitat al districte 22@

22. Puntuar d'1 a 10 l'accessibilitat a la seva empresa en quant a:
    - ▪ Transport públic (autobusos, metro, tramvia, etc.) _____
    - ▪ Transport privat (en quant a tràfic, congestió, etc.) _____

23. Puntuar d'1 a 10 l'accessibilitat a altres ciutats de:
    - ▪ La Regió Metropolitana de Barcelona _____
    - ▪ Resta de Catalunya _____
    - ▪ Resta d'Espanya _____
    - ▪ Resta d'Europa _____
    - ▪ Resta del món _____

24. Ser perifèria d'Europa és un problema en quant a costos de transport i comunicació?
    - ▪ És un problema greu
    - ▪ És un problema poc important
    - ▪ No és un problema

25. Puntuar d'1 a 10 la importància que dóna la seva empresa pel seu funcionament de:
    - ▪ Arribada del tren d'alta velocitat _____
    - ▪ Existència d'aeroport amb vols transoceànics _____
    - ▪ Millora de la xarxa d'autopistes _____

5. Sobre les condicions de demanda i l'estructura de cluster

26. En quina mesura la seva producció o servei es dirigeix al:
    - ▪ Mercat regional (Regió Metropolitana de Barcelona) _____%
    - ▪ Resta mercat espanyol _____ %
    - ▪ Mercat internacional (exportacions) _____%

27. Els vostres proveïdors solen ser: (Encerclar un màxim de 2 respostes)
    - - Altres empreses de l'àmbit 22@
    - - Altres empreses de la Regió Metropolitana de Barcelona
    - - Altres empreses catalanes

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- Altres empreses espanyoles
- Empreses estrangeres

28. Existeix cooperació entre les empreses del sector?
   - Sí. De quina manera es dóna aquesta cooperació?
     - En processos d'innovació
     - Accés a informació
     - Altres _____
   - No

29. Realitza activitats de R+D?
   - Sí
   - No

30. Els treballadors de la seva empresa tenen estudis:
   - Primaris _____ %
   - Secundaris _____ %
   - Superiors _____ %
   - Sense estudis _____ %

31. Personal dedicat a R+D (indicar el número de persones):
   - Titulats superiors: _____
   - Tècnics de nivell mitjà: _____

32. Col·labora regularment en activitats de R+D amb altres empreses?
   - Si. En aquest cas, les empreses amb les que col·labora són:
     - Altres empreses de l'àmbit 22@
     - Altres empreses de la Regió Metropolitana de Barcelona
     - Altres empreses catalanes
     - Altres empreses espanyoles
     - Empreses estrangeres
   - No

33. Subcontracta regularment activitats de R+D?
   - Si. En aquest cas, les empreses subcontractades són:
     - Altres empreses de l'àmbit 22@
     - Altres empreses de la Regió Metropolitana de Barcelona
     - Altres empreses catalanes
     - Altres empreses espanyoles
     - Empreses estrangeres
   - No

34. És la vostra empresa subcontractada per realitzar R+D per a altres empreses?
   - Si. En aquest cas, les empreses que el subcontracten són:
     - Altres empreses de l'àmbit 22@
     - Altres empreses de la Regió Metropolitana de Barcelona
     - Altres empreses catalanes
     - Altres empreses espanyoles
     - Empreses estrangeres
   - No

35. Col·labora regularment amb centres universitaris o altres institucions, ja siguin privades o públiques, en matèria de R+D?

- Si. Amb quins? (indiqui la naturalesa privada o pública del centre amb el que col·labora)

  _____

- No

36. Nombre de patents concedides a la seva empresa en els darrers 4 anys _____

6. Sobre variables culturals (qualitat de vida / formació)

37. Fins a quin punt és rellevant que els treballadors de la seva empresa dominin altres idiomes? (Puntuar d'1 a 10) _____

38. Quina formació necessària per la seva empresa troba a faltar al mercat laboral català? _____

39. Han influït en la seva decisió de localització variables de tipus cultural com la qualitat de vida, l'oferta d'activitats d'oci, etc.?

- Si. Puntuar d'1 a 10 en quina mesura aquestes variables de tipus cultural han influït en la seva decisió de localització _____
- No

7. Recomanacions

40. Quines millores introduiria al districte d'activitats 22@?

a.   _____
b.   _____
c.   _____

41. Quines iniciatives polítiques proposaria?

a.   _____
b.   _____
c.   _____

Questions for Interviews:

1. Visió del projecte 22@?
2. àmbit del projecte 22@?
3. el millor d'aquest projecte?
4. I el pitjor?
5. Elements que li manquen o que caldria afegir al projecte?
6. Quins altres projectes suposen una referència?
7. tres paraules o conceptes que defineixin millor el projecte 22@.
8. motius per voler fer un trasllat de la seva seu?
9. Quins elements els van fer decidir pel Districte 22@?
10. A quines altres zones van pensar en instal·lar-se? Quins avantatges tenien les altres zones per sobre del 22@?
11. I quins desavantatges?
12. Què creu que hauria de tenir el projecte 22@ de cara a ser una zona més interessant per a la seva empresa?

Appendix 3: List of Firms Answering Questionary

1) **Firms Located in District 22@**

1. *AGÈNCIA CATALANA DE PROTECCIÓ DE DADES*
2. *CASER*
3. CELER PAWLOWSKY
4. T-SYSTEMS
5. GENERAL ELECTRIC
6. *LIBERTY SEGUROS*
7. ECOTÈCNIA
8. *GRUPO AUNA*
9. ATRÁPALO.COM
10. BAU ESCOLA DE DISSENY
11. *ALESI TECHNOLOGIES*
12. *CATALANA DE MARKETING TELEFÓNICO*
13. PICH – AGUILERA ARQUITECTOS
14. *ANTONIO MIRÓ*
15. SEDATEX
16. INDRA
17. *UNIVERSITAT POMPEU FABRA*
18. UNIVERSITAT OBERTA DE CATALUNYA
19. *GRUP ENCICLOPÈDIA CATALANA*
20. GPO INGENIERÍA

2) **Firms with Potencial Interest to Locate in the District 22@**

21. *SAR*
22. *HIDROWATT*
23. AL-PI
24. LAVINIA
25. *EL TERRAT*
26. COMUNYMEDIA
27. MASCARÓ CONSULTING
28. SOSMATIC
29. *TECH SALES GROUP*
30. DMR
31. OLIVERAS COLL
32. *MICROSOFT*
33. INTERMON
34. *FIELDING EPI*
35. ESCOLA SUNION
36. *BRITISH COUNCIL*
37. GALERIA ESTRANY DE LA MOTA
38. *KUCHINOW*
39. *COL·LEGI OFICIAL D'INFERMERIA*
40. *INSTITUT D'ESTUDIS DE LA SALUT*

3) **Promoters and Consultors**

Bouygues Inmobiliaria
Metrovacesa
Layetana
Servihabitat
Necso
Federico Ricart
Sentiu Product
Fonaments
Nubiola
Torras
Hines
Sacyr Vallehermoso
Núñez i Navarro
Grupo Sastre
Lar Grosvenor
Apex
Jones Lang Lasalle
Aguirre Newman
Atis Real Auguste-Thouard
CB Richard Ellis
Jordà & Guasch
Cushman WHP

4) **Leaders in Opinion**

Intertèxtil, Sr. Jordi Canals, Vicepresident.
Sector alimentari, (Freixenet), Sr. Josep Lluís Bonet, President.
Sector químic, Sr. Belil, Conseller Delegat de Bayer España.
Sector farmacèutic, Sr. Antonio Gallardo. Vicepresident Almirall Prodesfarma.
Sector automòbil, Sr. Rafael Boronat, Dir. Gral. Estampaciones Sabadell.
Sector turisme, Sr. Jordi Clos, Director Derby Hotels.
Col·legi Enginyers Industrials, Sr. Àngel Llovet, Degà.
Col·legi Enginyers Tècnics, Sr. Antoni Carrillo, Degà.
Col·legi Enginyers Telecomunicacions, Sr. Ferran Amago, Degà.
Col·legi Economistes, Sr. Jordi Conejos, Degà.
Col·legi Arquitectes, Sr. Jesús Alonso Sainz, Degà.
Sector periodisme Sr. Andreu Missé d'El País.
President Associació Veïns Poblenou, Sr. Clarós.
President Cambra de Comerç, Sr. Miquel Valls.
CCOO, Sr. Joan Coscubiela.
UGT, Sr. Josep Maria Álvarez.
Foment del Treball, Sr. Joan Rosell.

5) **International Firms**

Microsoft Ibérica, S.R.L. A/At: Sra. Rosa García, Dir. Gral.
Dell Computer S.A.A/At: Sr. Gabriel Cerrada, Dir. Gral. España
Hewlett –Packard A/At. Sr. Dir. Gral Catalunya

Telefónica S.A.A/At: Ricard Ruiz de Querol, Dir. Relacs. Instits. Catalunya
Jazz Telecom S.A.A/At: Sr. Joris Siroo, Dir. Gral.
Sanitas S.A. de Seguros A/At: Sr. Javier Esteras, Dir. Reg. Catalunya
BBVA S.A.A/At: Sr. Pedro Fontana, Dir. Gral Catalunya
Banco Santander Central Hispano S.A. A/At: Sr. Pablo Cigüela Ibáñez, Dir. Gral. Catalunya
ING Direct A/At: Sr. Àlex Pomares Amigó, Responsable de Catalunya
Colt Telecom España S.A. A/At: José Ramón Santocildes, Responsable de Catalunya
Honda Automóviles España S.A. A/At. Sr. Marc Serruya, Dir. Gral.
SEAT S.A. A/At: Sr. Juan Baselga, Dir. Seat España
Pfizer S.A. A/At: Sr. Dir. Gral. Catalunya
Merck Farma y Química S.A. A/At: Sr. Peter Donneweg, Dir. Gral
GlaxoSmithKline A/At: Sr. Dir. Gral. Catalunya
Roche Farma S.A. A/At: Sr. Genís Flores, Dir. Gral. Catalunya
Recoletos S.A. A/At: Sra. Aurora Catá Sala, Dir. Gral.
Grupo Anaya S.A. A/At: Sr. Eduard Cerreda Dopazo, Gerent Catalunya
Aranzadi S.A. A/At: Sr. Aurelio Aranaga, Dir. Gral Catalunya
Industria de Diseño Textil S.A. (Inditex) A/At: Sr. Fernando Martínez, Responsable Nacional de Expansión
Punto Fa S.L. (Mango) A/At: Sr. Enric Casi, Dir. Gral.
Endemol A/At: Sr. Joaquim Agut, Dir. Gral
Gestmusic Endemol A/At: Sr. Josep Maria Mainat
Manga Films S.L. A/At: Sr. Nacho Puebla, Dir. Gral.