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CITIES AND THE INTERNET: THE END OF DISTANCE? (*)

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ABSTRACT

Over the last few years the Internet has widened the market potential for millions of consumers who now have access to products and services that were previously unavailable in their place of residence or in the latter's area of market influence. As a result, it can be hypothesised that the benefits ushered in with new technologies – primarily the elimination of physical distances - might reduce the advantages of economic and residential agglomeration traditionally associated with cities, by giving those who live in medium-sized or small cities and in rural areas access to a global market. However, if these new information technologies prove more attractive in large urban agglomerations than in other centres of population, the Internet may act as a complement to the big cities allowing them to strengthen further their advantages of economic and residential location. This study is based on information obtained from a survey conducted in more than 1,500 homes in the province of Barcelona and examines whether the Internet can be considered a complement to or a substitute for urban agglomerations.

1.- Introduction

Since the mid-nineties, the use of new information and communication technologies (principally *via* the Internet) has become increasingly widespread in domestic economies. Illustrative of this is the fact that between 2000 and 2002 the proportion of homes connected to the Internet in the European Union rose from 28 to 40%, while in the specific case of Spain this proportion rose from 16 to 29% in the same period. As a result of this technological advance, a whole series of studies were published that predicted that the benefits of these new technologies might reduce the advantages of locating (in the case of firms) or residing (in the case of consumers) in the most heavily urbanised areas. The literature has enumerated countless aspects, related to agglomeration economies, that can make living in a big city more attractive. Specifically, one of the advantages that consumers might value most is the access they enjoy to a full and diverse commercial offer which cannot be found in a smaller urban centre that does not generate sufficient economies of scale. However, over the last few years the Internet has widened the market potential for millions of consumers who now have access to products and services that were previously unavailable in their place of residence or in the latter's area of market influence.

In tandem with these advances in the use of new technologies, over the last few years we have witnessed an acceleration in the processes of economic and residential decentralisation from the big cities towards smaller cities located in their immediate area. In the mid-eighties a process was set in motion, becoming more intense in recent years, whereby productive activity and population were expelled from the largest cities. This process has affected all big cities in Europe and Spain¹. Several authors suggest that both processes might be related, arguing that the Internet can compensate, to some extent, the attractions of the big cities (Malecki, 2002 and Sinai and Waldfogel, 2004).

This paper seeks to determine whether the Internet might be considered a complement to or a substitute for urban agglomerations. In other words, it examines whether the geographical distribution of new technologies differs between big and small cities. If it can be shown that the use of the Internet is more intense in smaller cities, this would confirm what some authors have referred to as “the death of distance” or “the death of cities”. Consumers would have access to a full and diverse commercial offer via the Internet compensating thereby for the advantages that the big cities have traditionally enjoyed in being able to offer this full and diverse market. If this hypothesis is proved, the Internet can be considered as a substitute for the cities.

Alternatively, it might be the case that the use of new technologies, including electronic commerce, by city-dwellers increases with city size. This could occur if the contents of the Internet are above all local and provide incentives to an increase in the consumption of products and services from the local area. Were this to prove to be the case, then we should have to recognise that the Internet strengthens the advantages offered by the big cities. Therefore, the new technologies can be seen as a complement to the cities.

We should point out that the results of this analysis will not provide direct evidence concerning the impact of the use of the Internet on the degree of residential decentralisation. However, our results should give some indication as to whether the Internet compensates or not for the commercial disadvantages suffered by small municipalities located at some distance from the urban agglomeration. This aspect constitutes a necessary, but on its own insufficient, condition for the Internet to have some impact on the location of the population's residence.

¹ Viladecans (2002) and Solé and Viladecans (2004) undertake in-depth analyses of the changes in the Spanish urban model.

The empirical analysis performed in this study is undertaken with data gathered from a survey conducted in more than 1,500 homes in the Barcelona province². As we shall show later, the use of the Internet in this province and, in particular, the electronic commerce, has increased greatly in recent years. Similarly, the diversity of urban sizes is particularly great and, since the beginning of the eighties, the city of Barcelona has undergone a constant loss of population at the expense of the smaller municipalities in its immediate area³. Therefore, it would appear to constitute a good analytical framework in which to examine the relationship of complementarity or substitutability between cities and the Internet.

Our paper is organised as follows. In section two we undertake a review of contributions in the literature that have looked at the relationship between an increase in the use of new technologies and its geographical impact. In section three we develop a model for analysing the relationship of complementarity or substitutability between the Internet and cities. This model is estimated using a discrete choice model. The results of these estimates should allow us to conclude whether the Internet complements or substitutes the attractions of the big cities. In the last section we draw the conclusions.

2.- Cities and the Internet: a review of the literature

The literature that studies the territorial concentration of economic and residential activity attributes the cities with a series of advantages that makes them attractive for the location of economic activities and residents. The residents place a high value on living in a city if the quality of life it provides, measured by a range of diverse factors, is high and if the cost of enjoying these factors is not too great. Traditionally people have preferred to locate

² Spain is divided in 50 administrative areas denominated provinces, which are equivalent to the European Union NUTS3 classification. The province of Barcelona is the second biggest province with 4,806.000 inhabitants (2001) and its central city –the city of Barcelona- has 1,505,000 inhabitants.

³ The shift in the urban model which began in the seventies has become even more marked in recent years. This shift has seen the city of Barcelona lose almost 250,000 inhabitants between the censuses of 1981 and 2001.

their homes in big cities because of the advantages that they offer as places of residence. In the last few years a number of theoretical and empirical studies have been published that analyse these factors (Glaesser 1998 and 2000 and Glaeser *et al* 2001). Living in cities means a saving in the transport costs involved in commuting from the place of residence to work. Secondly, cities can offer a wide range of services and consumer goods supplied by private firms or the public sector as the economies of scale produced by the demographic size of the city mean that the market size is sufficiently large. This diversity is translated into a greater offer of consumer and leisure goods (theatres, cinema, music, sport). A further reason, more sociological in nature, is concerned with the population of young people and is related to the fact that big cities facilitate social relations. Similarly, the young can access a higher level of human capital which, in turn, can result in a higher salary, thanks to the ease of accessing information in big cities.

However, despite the advantages of living in big cities, in recent decades in Spain and throughout Europe, a process has begun, becoming more accentuated in the last few years, whereby a part of the population has started to abandon the cities. Illustrative of this is the fact that between 1981 and 2001 the six biggest cities in Spain (with more than 500,000 inhabitants) recorded growth rates below that of the national mean and, more specifically, the annual growth rates of Madrid, Barcelona and Valencia, the three biggest Spanish cities, were negative. It would therefore seem clear that the advantages attributed *a priori* to the big cities can become disadvantages when they exceed a size that might be considered too big. These disadvantages include a series of factors that undermine the attractions of a city location. In general, these factors can be summarised as higher levels of contamination, traffic congestion and greater social problems. Similarly, we should stress the increase in land prices due to the restrictions in supply that are brought about by excessive land occupation. This increase in land prices means more expensive housing.

As a result of these processes of residential shift, the population, understood as agents of consumption, has to renounce some of the aforementioned advantages of living in a big city. One of the advantages that is most clearly sacrificed by living in a smaller city is the reduction in the diversity of the commercial offer. The smaller size of the city means that the economies of scale generated are insufficient to increase and diversify this offer.

However, it might be hypothesised that new technologies can serve as an amenity of the smaller cities. Thus, while living in a small city deprives the consumer of access to the quantity and variety of products and services available in the big city, the Internet makes an even wider, if this is possible, quantity of consumer products available. The Internet overcomes the local dimension as it widens the variety of products without a need to generate physically the economies of scale that the agglomeration economies generate in big cities. This hypothesis raises the possibility that new technologies might be, in the case of access to commercial products via electronic trade, a substitute for urban agglomerations. In fact, in the United States sales by catalogue has traditionally been one of the ways of substituting the lack of commercial offer in the more isolated urban centres. The Internet, therefore, might, in the case of the United States, increase or, in the case of Europe, create access to a variety of products without the need of travelling to or of having to live in a big city.

It is self-evident, therefore, that there might exist a relation between the use of new technologies and the territory. In fact, as a result of the development of these technologies at the beginning of the nineties there appeared a considerable number of studies analysing the link between the Internet and economic geography. Castells (1989) was a pioneer in this trend. As the new technologies became more widespread, there appeared a series of studies, taking a similar approach to that adopted by Cairncross (1997), which predicted that the Internet was going to eliminate the significance of geography and the cities as it would allow the smaller cities to gain access to the advantages hitherto enjoyed only by the big cities.

However, since the end of the nineties the evidence shows that the use of the Internet has become concentrated in the developed countries and urban agglomerations and that, therefore, the effect of the Internet on geography needs to be reconsidered and studied in greater depth.

Most of these empirical studies have examined the relationship between the use of new technologies in the firm and its geographical location. Most seek to determine whether these technologies can become a good substitute for face-to-face relations which, among other reasons, have underpinned the concentration of firms within urban agglomerations. Therefore, they focus their analyses on the relations that are established between firms and whether these can be maintained at a distance so that the cost of delocalisation of the firms towards areas with less economic activity can be reduced. Examples of such studies include Gaspar and Glaeser (1998), Jourdenais and Desrochers (1998), Kolko (2000), Zaheer and Manrakhan (2001), Malecki (2002), Sohn *et al.* (2003) and Giovanetti *et al.* (2003). With the exception of this last study, they all report applied analyses of the situation in the United States. This is due to the fact that the statistical information describing the use of new technologies, and which emphasises its territorial characteristics, is much more widely available. The conclusions reached by these studies vary although, in general, in the case of firms they tend to point to a relationship of complementarity between the Internet and economic agglomerations. Particular mention should be made of the recent studies undertaken by Forman *et al.* (2002 and 2003) which also examine the use of new technologies in the firm by analysing separately the participation of new technologies (the most common use of these such as electronic mail) in those uses that result in an improvement in the competitive position of the firm. Both these studies are of interest because they examine whether the various uses made of the Internet, and their varying intensities, differ between US metropolitan areas of different size. Their conclusions suggest that as regards the connection and the most basic uses of the Internet there are few differences between metropolitan areas. However, they show that the more

advanced uses of the Internet are more intense in the larger metropolitan areas. These findings seem to point, once more, towards a relationship of complementarity between the Internet and urban agglomerations. Forman *et al.* (2002 and 2003) comment that this greater intensity in the more advanced uses of the Internet in more densely populated areas is related basically to the sectoral structure of these areas. In fact, it has been widely shown that the most advanced economic activities, i.e. the most intensive in their use of these technologies, are located in the most densely populated areas.

However, few studies have analysed the relationship between the domestic use of new technologies and city size in an attempt to provide data that, in line with the studies applied to the firm, examine whether the use of the Internet has any relationship with the urban setting. One exception to this is the recent study conducted by Sinai and Waldfogel (2004) which examines the relationship of the substitutability or complementarity of the new technologies with the cities in the United States (via the connection to the Internet and via the electronic commerce). They argue that a relationship of substitutability will exist if access to the Internet results in an increase in the on-line commerce options of consumers who, in this way, will have access to a full and diverse product offer which they would only otherwise have if they were to live in a big city. Thus, the Internet can reduce the advantages of agglomerations by reducing the importance of geography and distance. Alternatively, the relationship of complementarity will exist if the Internet has a predominance of locally-targeted online content and, therefore, it serves to provide incentives for the off-line trade of the residents in their cities. In this way, the consumers obtain information via the Internet that allows them to take greater advantage of the quantity and diversity of the commercial offer in their city. According to this hypothesis, there will be a positive relationship between the Internet and the cities, increasing the advantages of the latter. Sinai and Waldfogel (2004) are aware that both effects, complementarity and substitutability, might occur simultaneously and that, therefore,

it might be difficult to determine which of the two is more intense. Their results though point to a relationship of complementarity.

3.- Internet, substitute for or complement to cities: the model

3.1 Specification of the empirical model

Following Sinai and Waldfogel (2004), we propose the following equation to explain the decision to connect to the Internet:

$$INTERNET_i = \mathbf{a} + \mathbf{b}.LOCAL_j + \mathbf{g}.OFFER_j + \mathbf{f}.X_i + \mathbf{e}_i \quad (1)$$

where $INTERNET_i$ is a fictitious variable equal to 1 if the individual i has an Internet connection at home and equal to zero if he does not; $LOCAL_j$ is a measure of the locally-targeted on-line contents for individuals resident in municipality j , $OFFER_j$ is a measure of the off-line offer or commercial diversity available for individuals resident in municipality j , X_i is a vector of individual variables (e.g., age, education, economic level, etc.), and $\mathbf{e}_i$ is a random error term that incorporates other influences affecting the decision to connect to the Internet not considered by equation (1). Following again Sinai and Waldfogel (2004), a positive effect of local on-line contents ($\mathbf{b} > 0$) is interpreted as evidence that the Internet is a complement to cities, while a negative effect of the off-line offer ($\mathbf{g} < 0$) is interpreted as evidence that the Internet is a substitute for cities.

Sinai and Waldfogel (2004) also consider that local contents increase with the off-line commercial offer, and that the off-line commercial offer increases with city size. These two relationships can be expressed as:

$$LOCAL_j = \mathbf{u} + \mathbf{n}.OFFER_j \quad (2)$$

$$OFFER_j = \mathbf{m} + \mathbf{h}.POPULATION_j \quad (3)$$

where, it is expected, therefore, that $\mathbf{n} > 0$ and $\mathbf{h} > 0$. Substituting (3) in (2) we also obtain the relationship whereby local contents increase with city size:

$$LOCAL_j = (\mathbf{u} + \mathbf{n.m}) + \mathbf{n.h} POPULATION_j \quad (4)$$

And by substituting (3) and (4) in (1) we obtain the reduced form that relates the decision to connect to the Internet with city size and the characteristics of the individuals:

$$INTERNET_i = \mathbf{s} + \mathbf{r.POPULATION}_j + \mathbf{f.X}_i + \mathbf{e}_i \quad (5)$$

where $\mathbf{s} = \mathbf{a} + \mathbf{b.(u + n.m)} + \mathbf{g.m}$ and $\mathbf{r} = \mathbf{h.bn} + \mathbf{h.g}$.

Equation (5) shows that the effect of city size on the decision to obtain an Internet connection is uncertain ($\mathbf{r}$ can be positive as well as negative), since the positive effect of complementarity ($\mathbf{h.bn} > 0$) can be countered by the negative effect of substitutability ($\mathbf{h.g} < 0$).

The data available allow us to estimate equation (5) and to obtain some initial results concerning the effect of city size on the decision to connect to the Internet in Spain. Note that this equation does not enable us to identify the complementarity and/or substitution effects between the Internet and cities, rather it only provides information about the net effect. The identification of these two effects would require the estimation of equation (1), though this is not possible given the lack of data concerning the local contents of the network in Spain. We hope to tackle this matter in future extensions of this study.

Here, we present some additional results, which reflect the need to consider the specific characteristics of our sample. Whereas Sinai and Waldfogel (2004) use data for a set of urban areas in the USA, our data are drawn from a single urban area (i.e., the Barcelona province). We believe that our sample – by including individuals resident in highly urbanised areas (i.e., the city of Barcelona and other large urban centres) as well as those resident in areas that are not so heavily urbanised and in rural zones – is perhaps more appropriate than that used by Sinai and Waldfogel (2004) for analysing the question of whether the Internet

improves consumer options for those that live outside the centre of a large urban agglomeration. However, while the sample might be more suitable, the variable used to quantify the off-line commercial offer (i.e., the population, used by these authors) might not be the most appropriate. In fact, what we see in our sample is that there exists a certain commercial hierarchy of cities that does not always coincide with their size in terms of population⁴.

For this reason, and by way of an alternative to using the variable *POPULATION_j*, we shall use more direct measures of accessibility to the off-line commercial offer at the municipal scale. Specifically, the measures we use are:

- (i) The number of commercial establishments in the municipality (*COMMERCIAL CENTRES_j*).
- (ii) The number of employees in the commercial sector in the municipality (*EMPLOYEES_j*) as an alternative to commercial establishments.
- (iii) The number of commercial establishments per inhabitant (*COMMERCIAL CENTRES_j/POPULATION_j*), so as to take into consideration the possible congestion of commercial amenities as the municipality grows⁵. This variable could be interpreted as the commercial density of the municipality.

⁴ For example, among the municipalities that make up the Barcelona Metropolitan Region, while it is true that the city of Barcelona has a clear commercial specialisation, the same cannot be said for the other municipalities, which find themselves in a subordinate position to the commercial strength of the central city. Note, however, that although there is not a great commercial offer in many of the suburbs of Barcelona, their size in terms of population is much greater than that of many municipalities located within the province but outside the Metropolitan Region. Furthermore, even when a comparison is made between municipalities located in the suburbs of the Metropolitan Region of similar population size (or even municipalities in the rest of the province), we find that some of them have a residential specialisation, while others specialise in industrial or commercial land uses.

⁵ It is unclear as to whether the variable that describes the commercial offer should be introduced in absolute terms or relative to the population or the users of the sector. In principle, the theory predicts that the variety of services grows with market size, which suggests that the variable should be the number of commercial establishments or the number of employees in the sector. However, for a fixed commercial capacity, an increase in the number of users reduces the quality of the service, which suggests that a measure of commercial density such as the number of commercial establishments or employees per inhabitant or user might be more appropriate. As a last resort the empirical results should provide evidence as to which of the two specifications is most suitable.

- (iv) The number of employees per inhabitant in the municipality ($EMPLOYEES_j / POPULATION_j$).
- (v) The distance from the central city (Barcelona) in terms of time ($DISTANCE_j$), so as to take into consideration the possible influence of the off-line commercial offer in the centre of the urban agglomeration, since this constitutes a complement to (or perhaps a substitute for) the off-line commercial offer in each of the municipalities in the province⁶. This variable should be seen as a measure of off-line commercial offer that complements the variables (i) to (v) and which, therefore, should be included in the equation with the others.

When we use direct measures of commercial offer, equation (3) becomes, for example, in the case of the number of commercial establishments:

$$OFFER_j = \mathbf{m} + \mathbf{h}COMMERCIALCENTRES_j + \mathbf{p}.DISTANCE_j \quad (6)$$

And substituting (6) in (2) and the result in (1) we once again obtain the reduced form of the equation for connecting to the Internet:

$$INTERNET_i = \mathbf{s} + \mathbf{r}.COMMERCIALCENTRES_j + \mathbf{k}.DISTANCE_j + \mathbf{f}.X_i + \mathbf{e}_i \quad (7)$$

$$\text{where } \mathbf{s} = \mathbf{a} + \mathbf{b}(\mathbf{u} + \mathbf{n}.\mathbf{m}) + \mathbf{g}.\mathbf{m}, \quad \mathbf{r} = \mathbf{h}.\mathbf{b}.\mathbf{n} + \mathbf{h}.\mathbf{g} \text{ and } \mathbf{k} = \mathbf{p}.\mathbf{b}.\mathbf{n} + \mathbf{p}.\mathbf{g}$$

Note that similarly equation (7) does not allow us to investigate independently the existence of factors of complementarity or substitutability between the Internet and cities. The only conclusion to be drawn from the results provided by equation (7) is the net effect: if $\mathbf{r}$ and $\mathbf{k}$ are positive we can conclude that the Internet and the off-line commercial offer are complementary, while if these parameters are negative we can conclude that a substitution

⁶ Clearly, the greatest commercial diversity in the province is to be found in the central city, which fulfils a number of unique functions in the commercial hierarchy of the cities in the province, which suggests that its commercial offer is basically complementary to that located in the smaller municipalities.

effect exists. If both coefficients are not statistically significant then the factors of complementarity and substitutability offset each other.

Finally, it should be pointed out that equations (5) and (7) are also estimated by using the decision of whether or not to buy online as the dependent variable (i.e., *E-COMMERCE_j*, a fictitious variable that takes the value 1 if the individual has chosen to buy on line and 0 if not). In principle, it might seem that analysing the decision to buy on-line should provide more evidence regarding the effects of complementarity and substitution between the on-line and the off-line offer than an analysis of the decision to connect to the Internet. However, note that if there is a relationship of complementarity, the connection can take on much greater importance even if the individual does not go ahead with his on-line purchase. This is because the Internet fulfils a function of providing information about the available off-line commercial offer⁷. The conclusion to be drawn from this is that it is as important to analyse the decision to connect as it is to analyse the decision to buy.

3.2 Data

In undertaking the estimations for equations (5) and (7) we had access to a survey conducted in 2002 by the Catalan Institute of Statistics) which was concerned with the extent to which new technologies have penetrated Catalan society. The empirical analysis is limited to the municipalities of the province of Barcelona since this enables us to analyse in more detail the impact of the Internet and city size. The sample drawn from the province of Barcelona is made up of 1,506 homes. We also had access to data concerning the socio-economic characteristics of these homes including factors of age, the education of the head of the family, the number of family members, the economic level and the municipality in which

⁷ Note that the Internet can provide information that facilitates consumer access to the city's commercial establishments and, therefore, it can increase the city's advantages. For example, portals such as www.barcelona.com provide information about the city's events, restaurants, what can be seen in the cinemas

the family was resident. From the various questions asked in the survey, we chose two: “Do you have an Internet connection at home?” and “Have you ever bought anything via the Internet?”. Of those responding to the questions, 31% said they had an Internet connection and 7% said they had, at one time or another bought something via the Internet. It should be pointed out that in recent years there has been a great increase in the use of new technologies linked to the use of the Internet. Thus, according to data provided by the Catalan Institute of Statistics, the number of homes in the Barcelona province with an Internet connection rose from 18 to 31% between 2000 and 2002. According to data supplied by the European Commission, this figure is still much lower than that recorded in countries such as Holland, Denmark, Sweden while in United States the figure stands at around 64%. Similarly, the figure is still below the average for the EU which stands at 40%⁸. However, it should be highlighted that the increase in this percentage has been much greater in the case of the province of Barcelona (72%). Therefore, it is clear that although the initial number of connections was much lower, a process of convergence is taking place in the use of new technologies.

In addition to information regarding the use of the Internet, the survey also provided details of the socio-economic profile of the respondents. These included the age of the head of the family, his or her level of education (classified as “Higher education”, “Secondary education”, “Primary education” and the reference category “No formal education”), the economic level (classified as “Income over 4,000 euros/month”, “Income between 2,500 and 4,000 euros/month”, “Income between 1,250 and 2,500 euros/month”, “Income between 1,250 and 750 euros/month” and the reference category “Income below 750 euros/month” and the number of family members.

and theatres, etc. Similarly, the commercial establishments themselves can give details of their products on their own web pages so that consumers can be better informed when completing their purchases.

The variables describing the geographical characteristics of the municipality of residence of the respondents were obtained from different sources. The population variable was taken from the 2002 Population Census Up-date (Catalan Institute of Statistics). In addition to this variable, we established six categories that group the municipalities according to their size (“Over 500,000 inhabitants”, “Between 75,000 and 500,000 inhabitants”, “Between 25,000 and 75,000 inhabitants”, “Between 6,000 and 25,000 inhabitants” and the reference category “Below 6,000 inhabitants”). In this way we sought not to condition the functional relationship between the population and the decision to connect to the Internet. The numbers of commercial establishments and employees in this sector in 2002 were taken from the Register of Firms and Affiliates to Social Security. Finally the distance-time of the municipalities of the province from the city of Barcelona was taken from the web page, *www.mobilitat.net*, constructed by the Catalan Government, which gives the shortest route between two municipalities, in this case, including motorways.

3.3 Results

Equations (5) and (7) can be estimated using a probit. The results provided by the two models are shown in Tables 1 (Factors determining connection to the Internet) and 2 (Factors determining on-line commerce). It should be pointed out that from the results presented it is not possible to infer directly the probability that the variation in the explanatory variables affects the dependent variable.

TABLE 1

⁸ The country data is provided by the Gallup survey (European Commission) and the methodology used was the same as that adopted by the Institut d'Estatística de Catalunya, which makes it possible to compare the results in the two samples.

In the case of the first model, which contrasts the relationship between the availability of the connection to the Internet and the cities (Table 1), we included 1,024 observations⁹. In the last rows of the table we show various results testing the robustness of the estimates. In all cases, the test values corroborate their robustness. The explanatory capacity of the model stands in all cases at around 30%. In the six columns of Table 1, we record the results of the various estimates. In the first and second columns, we record the results of the estimate of equation (5). In addition to the socio-economic variables, the first column includes the population of the municipality in which the respondent was resident as part of the explanatory variable. This variable was found to be non significant. This result does not allow us to conclude whether the relationship between being connected to the Internet and the cities is one of complementarity or substitutability. This is because both effects might exist but being of opposite signs, as was discussed in the description of the model in section 3.1, they offset each other. Alternatively, it might be the case that such effects do not exist and, therefore, the decision to connect to the Internet does not depend on the cities but rather on other variables such as socio-economic characteristics.

In fact, the control variables that include these characteristics of the respondents are significant and show the signs that are to be expected according to most studies conducted to-date into the typical profile of the Internet user. Thus, the older the head of the family, the lower is the likelihood of connecting to the Internet. The level of education has a positive effect whereby the higher the education, the more likely the respondent is to connect to the Internet. Likewise, the economic level of the household has a positive effect on the probability of connecting to the Internet. Finally, the number of members in the family also has a positive effect. The results of the socio-economic variables are repeated in the other

⁹ In fact, the total survey population comprised 1,506 observations but we chose to eliminate those observations for which information concerning the economic level of the home of the resident was unavailable, given that some of the respondents preferred not to answer this question. Although the number of observations eliminated

estimates recorded in Table 1. The second column of Table 1 shows the results of equation (5), but instead of introducing the population variable directly, we constructed some discrete variables which group the municipalities according to their size. In this way, we seek to avoid conditioning the functional form of the relationship between connecting to the Internet and the cities. Following the estimation, these variables were also found not to be significant.

In the remaining four columns of Table 1, we record the results of the various estimates obtained for equation (7). As explanatory variables of the decision to connect to the Internet, the third column includes the number of commercial establishments in the municipality in which the respondent is resident and the distance of this municipality from the central city (in this case, the city of Barcelona). Both variables were non significant. In the fourth column, the variable incorporated instead of the number of commercial establishments is that of the number of employees in the commercial sector in the municipality in which the respondent is resident. This variable was also non significant. Therefore, as with the population variable before, on the basis of this evidence it is not possible to determine whether there is a relationship of complementarity or substitutability between the decision to connect to the Internet and the cities.

Finally, as the explanatory variable, the fifth and sixth columns in Table 1 include what we have chosen to call the commercial density and the distance from the city of Barcelona. In the fifth column, we record the results of the estimate where the variable that includes the commercial density of the municipality in which the respondent is resident is the ratio between the number of commercial establishments and the population of the municipality. In the estimate in column six, commercial density is measured by the ratio between the number of commercial employees and the population of the municipality. In both

is high, we chose to retain this variable. Various tests were in fact run including the eliminated observations and the results remained the same.

cases, the distance variable proved to be non significant while the commercial density, measured in terms of number of establishments and employees per inhabitant, was significant and showed a positive coefficient. This seems to suggest that when the commercial capacity is fixed, an increase in the number of users reduces service quality, and, therefore, measuring commercial density in terms of the number of establishments or employees per inhabitant or user is more appropriate. The positive coefficient of both variables indicates that there might exist an effect of complementarity between the decision to connect to the Internet and the cities. Similarly, it cannot be denied that a certain effect of substitution also exists, although, according to our results, the effect of complementarity is greater. This result is in line with that obtained by Sinai and Waldfogel (2004).

TABLE 2

In the estimates in Table 2, we record the results of the relationship between the decision to buy on-line and the cities. For this model, we have 307 observations¹⁰. In the last rows of the table, the tests of robustness demonstrate their validity. The explanatory power is much lower than that of the estimates in Table 1 and never rises above 6-7%. The six columns in Table 2 record exactly the same estimates as in Table 1, the only difference being the endogenous variable. The first two columns include the socio-economic control variables as well as the population of the municipality (in absolute terms and grouped according to size). The population variable in both cases was non significant. Therefore, as in the first model, these results do not allow us to conclude whether the relationship between buying on-line and the cities is one of complementarity or substitutability. The same evidence is obtained in the estimates recorded in columns 3 to 6 which measure the commercial offer as the number of

commercial establishments (column 3), the number of commercial employees (column 4) and the commercial density (columns 5 and 6). The distance variable was also non-significant.

It should be pointed out that the results obtained concerning the effect of the socio-economic variables on the decision to buy on-line differ from those obtained when analysing the decision to connect to the Internet. Thus, the age of the head of the household is not significant; the level of his or her education has a positive effect on the likelihood of making an on-line purchase; as regards economic level, the second category (income between 2,500 and 4,000 euros/month) proved significant; the number of household members was also significant and showed a negative coefficient indicating a negative relationship of this variable with the likelihood of buying on-line. Therefore, with this evidence it can be seen that the socio-economic variables have a diverse effect on the decision to connect to the Internet and to make an on-line purchase.

4.- Conclusions

This study set out to examine the relationships of complementarity or substitutability between cities and the Internet. The analysis was inspired by the existence of a growing body of literature that studies the relationship between new technologies and the territory. The hypothesis propounded in most of these studies was that new technologies would reduce the advantages of living in big cities since the Internet would grant everyone access to these benefits. One of the main advantages of living in a big city is the access city-dwellers enjoy to a large, variety-laden commercial offer - the result of the economies of scale to which they give rise. In recent years the Internet has widened the market potential for consumers who now have access to products and services that were previously unavailable in their place of residence or in the latter's area of market influence. From this perspective, the relationship

¹⁰ In fact, this includes that part of the population with an Internet connection at home plus those who have purchased on-line from another connection. Clearly the lower number of observations might condition the

between the Internet and cities would be one of substitutability. Alternatively, the Internet might strengthen the advantages enjoyed by urban agglomerations and, as a result, the relationship would be one of complementarity.

The empirical analysis, conducted on the results of a survey examining the adoption of the Internet among the residents of the municipalities in the province of Barcelona, seems to indicate that as far as the decision to connect to the Internet is concerned, the relationship with the off-line commercial offer of the cities is one of complementarity. However, the model shows that a substitution effect cannot be entirely ruled out, although this effect is less intense than the former. On the other hand, as far as the decision to buy goods or services on-line is concerned, the results from our empirical analysis do not allow us to determine whether this decision is independent of the cities or rather whether the factors of complementarity and substitutability are of the same intensity and, therefore, offset each other.

In each of the estimates, we introduced the socio-economic characteristics of the survey respondents as control variables. Our results confirm that these characteristics have a clear impact on the decision to connect to the Internet. Thus, the lower the age, the higher the levels of education and income and the greater the number of family members, the more likely the individual is to connect to the Internet. These results appear to point to what is being described in the literature as the "digital divide". In other words, new technologies tend to marginalise a sector of the population as their socio-economic characteristics do not allow them to gain access to these technological advances. As for the decision to make an on-line purchase, the socio-economic characteristics have a diverse effect. Thus, age is no longer significant, while a greater number of family members reduces the probability of making on-line purchases.

Finally, it should be recognised that certain aspects of the methodology adopted in our analysis could be improved, such as seeking to increase the sample size (in the case of on-line

purchases, the number of observations is particularly low) and to improve the definition of the area of the off-line commercial offer of the municipalities.

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Table 1: Internet connection determinants. Estimation method: Probit

	[1]	[2]	[3]	[4]	[5]	[6]
<i>C</i>	-1,503 ^a (0,000)	-1,405 ^a (0,003)	-1,499 ^a (0,001)	-1,512 ^a (0,000)	-1,792 ^a (0,000)	-1,645 ^a (0,000)
<i>POPULATION_j (x 10⁶)</i>	0,049 (0,519)	--.--	--.--	--.--	--.--	--.--
<i>POPULATION > 500,000 inhab.</i>	--.--	0,045 (0,779)	--.--	--.--	--.--	--.--
<i>POPULATION between 75,000 and 500,000 in hab.</i>	--.--	-0,244 (0,169)	--.--	--.--	--.--	--.--
<i>POPULATION between 25,000 and 75,000 inhab.</i>	--.--	0,110 (0,537)	--.--	--.--	--.--	--.--
<i>POPULATION between 6,000 and 25,000 inhab.</i>	--.--	-0,049 (0,780)	--.--	--.--	--.--	--.--
<i>DISTANCE_j</i>	--.--	--.--	0,010 (0,845)	0,011 (0,800)	0,013 (0,790)	0,014 (0,757)
<i>COMMERCIAL CENTRES_j (x 10⁶)</i>	--.--	--.--	4,66 (0,406)	--.--	--.--	--.--
<i>EMPLOYEES_j (x 10⁶)</i>	--.--	--.--	--.--	0,350 (0,486)	--.--	--.--
<i>COMMERCIAL CENTERS_j / POPULATION_j</i>	--.--	--.--	--.--	--.--	34,078 ^b (0,011)	--.--
<i>EMPLOYEES_j / POPULATION_j</i>	--.--	--.--	--.--	--.--	--.--	2,312 ^c (0,088)
<i>Age</i>	-0,020 ^a (0,000)	-0,021 ^a (0,000)	-0,020 ^a (0,000)	-0,020 ^a (0,000)	-0,021 ^a (0,000)	-0,020 ^a (0,000)
<i>Higher education</i>	1,370 ^a (0,000)	1,347 ^a (0,000)	1,363 ^a (0,000)	1,358 ^a (0,000)	1,337 ^a (0,000)	1,359 ^a (0,000)
<i>Secondary education</i>	0,961 ^a (0,001)	0,957 ^a (0,008)	0,956 ^a (0,001)	0,947 ^a (0,001)	0,939 ^a (0,008)	0,959 ^a (0,007)
<i>Primary education</i>	0,706 ^b (0,041)	0,697 ^b (0,046)	0,704 ^b (0,042)	0,699 ^b (0,045)	0,684 ^b (0,048)	0,695 ^b (0,046)
<i>Income > 4,000€/month</i>	1,911 ^a (0,000)	1,882 ^a (0,001)	1,908 ^a (0,000)	1,905 ^a (0,000)	1,890 ^a (0,000)	1,900 ^a (0,000)
<i>Income between 2,500 and 4,000€/month</i>	1,124 ^a (0,000)	1,108 ^a (0,000)	1,124 ^a (0,000)	1,139 ^a (0,000)	1,119 ^a (0,000)	1,132 ^a (0,000)
<i>Income between 1,250 and 2,500€/month</i>	0,777 ^a (0,000)	0,771 ^a (0,000)	0,777 ^a (0,000)	0,775 ^a (0,000)	0,772 ^a (0,000)	0,786 ^a (0,000)
<i>Income between 1,250 and 750€/month</i>	0,332 ^b (0,045)	0,328 ^b (0,048)	0,333 ^b (0,045)	0,323 ^b (0,046)	0,333 ^b (0,045)	0,337 ^b (0,043)
<i>Number of family members</i>	0,210 ^a (0,000)	0,209 ^a (0,001)	0,210 ^a (0,000)	0,211 ^a (0,000)	0,214 ^a (0,000)	0,216 ^a (0,000)
<i>R² McFadden</i>	0,306	0,310	0,306	0,309	0,311	0,307
<i>Akaike</i>	0,845	0,846	0,845	0,844	0,841	0,845
<i>Schwarz</i>	0,898	0,914	0,898	0,896	0,899	0,902
<i>χ²</i>	371,192 ^a (0,000)	376,191 ^a (0,000)	371,471 ^a (0,000)	370,458 ^a (0,000)	377,806 ^a (0,000)	373,606 ^a (0,000)
<i>N</i>	1.024	1.024	1.024	1.024	1.024	1.024
<i>INTER=1</i>	287	287	287	287	287	287
<i>INTER=0</i>	737	737	737	737	737	737

Note: The figures in parentheses are the significant levels (p-values)

(a) Significant at 1%.

(b) Significant at 5%.

(c) Significant at 10%.

Tabla 2: E-commerce determinants. Estimation method: Probit

	[1]	[2]	[3]	[4]	[5]	[6]
<i>C</i>	-1,047 ^c (0,089)	-0,850 (0,202)	-1,051 ^c (0,087)	-1,030 ^c (0,078)	-1,419 ^a (0,004)	-1,507 ^a (0,004)
<i>POPULATION_j (x 10⁶)</i>	-0,042 (0,732)	--.--	--.--	--.--	--.--	--.--
<i>POPULATION > 500,000 inhab.</i>	--.--	-0,116 (0,673)	--.--	--.--	--.--	--.--
<i>POPULATION between 75,000 and 500,000 in hab.</i>	--.--	-0,318 (0,314)	--.--	--.--	--.--	--.--
<i>POPULATION between 25,000 and 75,000 inhab.</i>	--.--	0,276 (0,365)	--.--	--.--	--.--	--.--
<i>POPULATION between 6,000 and 25,000 inhab.</i>	--.--	-0,212 (0,476)	--.--	--.--	--.--	--.--
<i>DISTANCE_j</i>	--.--	--.--	-0,210 (0,390)	-0,199 (0,450)	-0,008 (0,970)	-0,002 (0,857)
<i>COMMERCIAL CENTRES_j (x 10⁶)</i>	--.--	--.--	-3,680 (0,678)	--.--	--.--	--.--
<i>EMPLOYEES_j (x 10⁶)</i>	--.--	--.--	--.--	-0,325 (0,741)	--.--	--.--
<i>COMMERCIAL CENTERS_j /POPULATION_j</i>	--.--	--.--	--.--	--.--	-0,070 (0,902)	--.--
<i>EMPLOYEES_j/POPULATION_j</i>	--.--	--.--	--.--	--.--	--.--	1,438 (0,570)
<i>Age</i>	-0,006 (0,356)	-0,008 (0,224)	-0,006 (0,359)	-0,005 (0,412)	-0,006 (0,345)	-0,004 (0,364)
<i>Higher education</i>	0,749 ^b (0,014)	0,755 ^b (0,015)	0,753 ^b (0,013)	0,735 ^b (0,025)	0,618 ^b (0,037)	0,712 ^b (0,017)
<i>Secondary education</i>	0,604 ^b (0,044)	0,641 ^b (0,036)	0,607 ^b (0,043)	0,612 ^b (0,040)	0,727 ^b (0,015)	0,612 ^b (0,039)
<i>Income > 4,000€/month</i>	0,853 (0,133)	0,764 (0,182)	0,854 (0,132)	0,870 (0,185)	0,900 (0,108)	0,865 (0,124)
<i>Income between 2,500 and 4,000€/month</i>	0,864 ^c (0,055)	0,838 ^c (0,063)	0,863 ^c (0,056)	0,861 ^c (0,055)	0,925 ^b (0,038)	0,909 ^b (0,041)
<i>Income between 1,250 and 2.500€/month</i>	0,542 (0,192)	0,543 (0,191)	0,542 (0,192)	0,478 (0,200)	0,615 ^b (0,032)	0,602 (0,139)
<i>Income between 1,250 and 750€/month</i>	0,337 (0,455)	0,314 (0,487)	0,338 (0,454)	0,345 (0,473)	0,426 (0,334)	0,401 (0,364)
<i>Number of family members</i>	-0,223 ^b (0,014)	-0,247 ^a (0,008)	-0,223 ^b (0,014)	-0,231 ^b (0,016)	-0,201 ^b (0,023)	-0,196 ^b (0,029)
<i>R² McFadden</i>	0,061	0,075	0,061	0,060	0,058	0,058
<i>Akaike</i>	1,089	1,092	1,088	1,088	1,084	1,084
<i>Schwarz</i>	1,210	1,250	1,210	1,201	1,194	1,193
<i>χ²</i>	20,256 ^b (0,016)	25,100 ^b (0,014)	20,314 ^b (0,016)	20,298 ^b (0,020)	19,464 ^b (0,012)	19,544 ^b (0,012)
<i>N</i>	307	307	307	307	307	307
<i>INTER=1</i>	72	72	72	72	72	72
<i>INTER=0</i>	235	235	235	235	235	235

Note: The figures in parentheses are the significant levels (p-values)

(a) Significant at 1%.

(b) Significant at 5%.

(c) Significant at 10%.