DOCUMENT DE TREBALL

XREAP2008-5

JOB ACCESSIBILITY AND EMPLOYMENT PROBABILITY

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XARXA DE REFERÈNCIA EN ECONOMIA APLICADA

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Abstract:

The objective of this paper is to estimate the impact of residential job accessibility on female employment probability in the metropolitan areas of Barcelona and Madrid. Following a “spatial mismatch” framework, we estimate a female employment probability equation where variables controlling for personal characteristics, residential segregation and employment potential on public transport network are included. Data used come from Microcensus 2001 of INE (National Institute of Statistics). The research focuses on the treatment of endogeneity problems and the measurement of accessibility variables. Our results show that low job accessibility in public transport negatively affects employment probability. The intensity of this effect tends to decrease with individual’s educational attainment. A higher degree of residential segregation also reduces job probability in a significant way.

JOB ACCESSIBILITY AND EMPLOYMENT PROBABILITY

1. Introduction

The relationship between urban structure and labour market outcomes has been the subject of a long-standing debate in North America in the literature on the *spatial mismatch hypothesis*. According to the hypothesis, selective population and employment decentralization since the 1950s has led to a "disconnection" between residential and job location in the case of racial and ethnic minorities, especially for Afro-Americans, who are residentially concentrated in the "inner city". Since Kain's (1968) seminal contribution, a large number of studies have proved that this spatial mismatch is a determining factor in the poor labour market outcomes for these groups (for a review, see the surveys of Ihlandfeldt and Sjoquist, 1998 and Gobillon *et al*., 2007.

The origin of this literature lies in the estimation of an empirical relationship between some individual outcome in the labour market (participation, unemployment or worked hours) and variables featuring residential location. These variables have to do with two basic aspects supposedly affecting outcomes, namely job accessibility and residential segregation.

While most empirical studies have a US focus, the underlying mechanism to this relationship holds general validity. In recent decades, European cities have experienced decentralization processes affecting all countries at varying intensity and timing (Cheshire, 1995). This decentralization may well also give rise, within a different context, to "spatial mismatch". So far, only a few studies have been carried out for European cities, obtaining less conclusive results than in the American case (see

Fieldhouse, 1999, Houston, 2005 and Patacchini and Zenou, 2005 for British cities; Aslund *et al*, 2006 for Swedish cities; Gobillon and Selod, 2006 on Paris and Dujardin *et al*, 2007 on Brussels).

This paper widens the scope of the European studies to the case of Southern European cities. The objective of the research is to determine the effect that the urban structure of Barcelona and Madrid has on the probability of employment, given the population and employment decentralization that both cities have experienced in the last two decades. Specifically, we study the impact that job accessibility by public transport has on the female employment probability.

Women are a relatively disadvantaged group in comparison to men in terms of labour market outcomes, suffering both a lower participation rate and higher unemployment. Furthermore, car accessibility is lower for women, which results in dependence on public transport for commuting and, consequently, higher time costs.

Accessibility is measured in terms of public transport time. The reason is that decentralization in Barcelona and Madrid has given rise, as in other European cities, to low density and discontinuous development across large parts of their areas, negatively affecting the quality of the public transport network serving newly developed areas. The main problem is that not all the metropolitan space can be properly served by public transport. As a consequence car dependence increases. The lack of public transport supply reduces the potential job opportunities in the territory for all those groups with lower car ownership. From this point of view, it seems relevant to study the extent to which low accessibility to public transport affects employment probability.

Additionally, our study addresses the problem of potential endogeneity bias due to the simultaneity of the residential location decision and labour market outcomes.

After the introduction, the second section describes the decentralization process in the two study areas. The third section is devoted to the related literature on spatial mismatch. A fourth section explains the job accessibility measure used here, while the fifth section describes the data. The sixth section explains the econometric strategy and presents the estimated equations. The results are discussed in the seventh section, and summary and conclusions are derived in a final section.

2. The study areas

The study focuses on the metropolitan areas of Barcelona and Madrid. Barcelona has a relatively dense metropolitan area of 3,000 sq km and 4.4 million people, which implies a density of 1,380 inhabitants per sq km. The central city comprises only 99 sq km of land and concentrates a little more than a third of the population, with a density of 15,150 inhabitants per sq km. The metropolitan area had 1.8 million jobs in 2001 and 768,000 of them were located in the central city. As a result, average job density per sq km amounts to 476, while in the city of Barcelona it climbs to 7,828 jobs per sq km.

The Madrid metropolitan area hosts a population of 5.4 million in an area of 8,000 sq km, with a density of 692 inhabitants per sq km. The municipality of Madrid covers an area of 600 sq km with a population of around 3 million, which implies a density of roughly 5,000 inhabitants per sq km and 52% of the population of the area. The weight of Madrid in the metropolitan employment is high, amounting to 64%. Metropolitan average job density is 293.7 jobs per sq km while, in the city of Madrid itself, it reaches 2,420.

In recent decades, a process of employment and residential decentralisation has taken place in both areas. As Tables 1 and 2 show, the central city has lost both population and jobs as a percentage of the entire metropolitan area.

Table 1. Residential suburbanisation (% population in central city)

	1981	1991	2001	2006
Barcelona	41.3%	38.5%	34.3%	33.2%
Madrid	67.4%	60.8%	54.2%	52.1%

Table 2. Employment decentralisation (% jobs in central city)

	1981	1991	1996	2001
Barcelona	53.7%	48.1%	43.5%	42.0%
Madrid	n.a.	n.a.	67.0%	63.8%

Different segments of population and employment have decentralized at differing rates. Table 3 shows the percentage of resident population in the central city of each area by income percentile in 2001. As can be seen, the population in the highest 25% of the income distribution was overrepresented in the central city of both areas. As regards employment, jobs filled by population with post-compulsory education levels were located in the cities of Barcelona and Madrid at levels above their respective means.

Table 3. Share of population in central city by income quantile in 2001.

	0-10%	10%-25%	25%-50%	50%-75%	75%-90%	90%-100%
Barcelona	27.10%	23.80%	26.20%	34.50%	44.60%	54.70%
Madrid	41.30%	44.50%	47.50%	54.30%	63.70%	68.20%

Source: 2001 Population Census and the 2002 Wage Structure Survey.

Table 4. Share of jobs in central city by education level in 2001.

	Barcelona	Madrid
No degree	33.9%	56.5%
Primary	32.9%	55.5%
Compulsory education	34.1%	55.6%
Upper secondary	44.2%	64.9%
Tertiary education	56.0%	73.3%

Source: 2001 Population Census.

The decentralization process has had the effect of increasing the disequilibrium in the location of population and employment. One of the visible results is the decrease in municipal self-containment percentages. For example, the average self-containment percentage of resident population in Barcelona in 1986 was 67.6% and in 2001 it fell to 52.7%.

3. Spatial mismatch hypothesis: some explanatory factors

The literature dealing with the relationship between residential location and labour market outcomes appears in the United States in a context of rapid and intense population and employment decentralization as well as the concentration of the Afro-American population in the inner cities. The seminal paper of Kain (1968) developing the “spatial mismatch hypothesis” is the point of departure after which an extensive empirical literature has followed. In the last few years, some European studies have tried to adapt the spatial mismatch hypothesis to the characteristics and context of European metropolitan areas.

Only recently have theoretical models been developed to explain spatial mismatch. Gobillon *et al* (2007) review the theoretical mechanisms underlying the spatial mismatch hypothesis which have been formally developed in urban labour-market models. In the case of the Spanish metropolitan areas, we consider relevant the following causes of spatial mismatch:

1. Workers may refuse job opportunities that require commuting costs which are too high in relation to the offered wage. The main theoretical models that develop this point are Brueckner and Martin (1997), Brueckner and Zenou (2003), and Coulson *et al* (2001).
2. Job search efficiency decreases with distance because information flows on job opportunities are subject to a distance decay effect. This particularly affects unskilled unemployed workers because of their dependence on informal methods of search. A second cause may explain search intensity decay as well. The unemployed may incur increasing transport costs as distance increases. Again, this affects the most disadvantaged groups differentially. Their dependence on public transport leads to higher time costs. As a consequence, search efficiency decreases with distance but at a rate that differs according to worker qualification. The theoretical development of this point can be found in Ortega (2000), Wasmer and Zenou (2002) and Patacchini and Zenou (2005).

According to the review conducted by Gobillon *et al* (2007), sufficient empirical evidence exists on the negative contribution made by commuting costs to labour market outcomes, especially for the most disadvantaged workers. However, the channel by which commuting costs negatively affect those outcomes has still not been identified empirically.

A second spatial factor which can also negatively contribute to explain poor labour market performance is residential segregation. To the extent that disadvantaged neighbourhoods are far from job opportunities, segregation and distance effects can become intermingled. Segregation may have an effect in two ways.

1. Segregation may hamper human capital investment. The concentration of residents with low education levels in some neighbourhoods may generate negative externalities on the academic performance of resident youth.
2. Segregation may deteriorate social networks. In particular, segregation affects the capacity of people with low education and ability levels to find a job using social networking within the community (For both mechanisms, see the literature on *neighbourhood externalities*. A recent survey is provided by Durlauf (2004)). The separation from the labour market experienced by most residents in the most disadvantaged neighbourhoods makes it difficult to obtain information on job opportunities through social networks (Holzer, 1987 and 1988).

It is not difficult to see the possible interaction between the two mechanisms, distance to job and social networks. The lower search efficiency due to distance explains unemployment concentration in neighbourhoods with poor job accessibility, which in turn deteriorates residents' social networks and increases their difficulties in finding a job.

4. Measuring job accessibility

A key issue in spatial mismatch studies is how to measure residential accessibility to job opportunities. Following Rogers (1997), this variable has to take into account the spatial distribution of jobs and the distance or access cost to reach them.

The variable used here is the employment potential for each residential zone computed for all municipalities in the metropolitan area. As our objective is to analyze the extent to which the lack of public transport can diminish job opportunities potential, the accessibility measure is defined in terms of public transport time. The relevant variable in this case would be the number of vacancies but, as our data do not supply such a variable at this level of spatial disaggregation, the total number of jobs located in each zone serves as a proxy for vacancies. We should expect that zones with a higher number of jobs also generate a larger number of vacancies (Rogers, 1997).

The job accessibility formula for an individual resident in zone i is given by:

$$ACCEMP_i = \sum_j \frac{EMP_j}{t_{ij}} \qquad (1)$$

where: EMP_j is the number of jobs in municipality/district j

t_{ij} is the travel time by public transport between i and j [1]

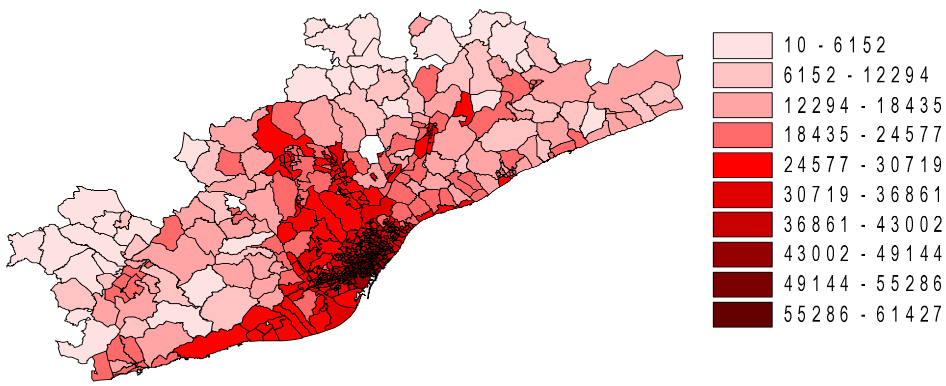
i, is the household zone of residence

j, is the destination zone

Regarding the destination zone, the municipality is the smallest spatial unit for which the number of jobs is available. However, in order to improve the accuracy of the accessibility measure in the cities of Barcelona and Madrid, jobs are computed at the level of districts[2]. The index is computed using job locations from the 2001 Population Census and the commuting times by public transport are obtained from the official travel time matrices.

In order to better approach individuals' job opportunities, accessibility is computed by education level. Five education levels are considered: no degree, primary education, compulsory education, upper secondary education and university degree. An accessibility value is allocated to each individual in the sample according to education level.

Fig 1. Total employment accessibility. Barcelona



Figures 1 and 2 map for both areas the behaviour of total employment[3] accessibility by public transport.

Fig 2. Total employment accessibility. Madrid

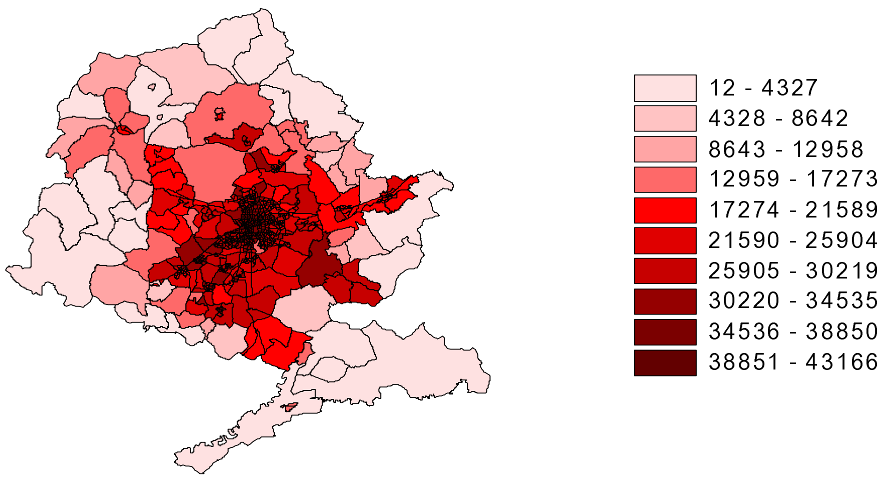
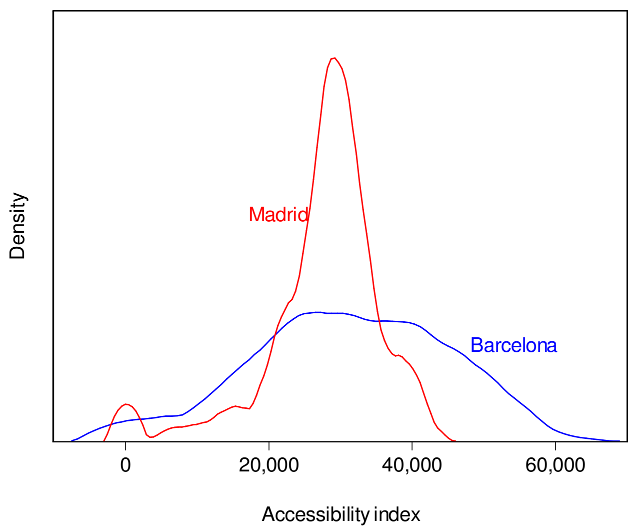


Figure 3 which plots the density distribution of job accessibility in both cities reinforces the perception of these differences. As can be seen, the variance of the accessibility distribution in the area of Barcelona is notably higher than in Madrid. Differences are highest in the upper tail of the distributions

Figure 3. Accessibility to employment index



5. **The data**

The data used in this study come from the 2001 Spanish Micro-census. The main advantages of this dataset are its sample size (5% sample of the Census population) and the level of spatial disaggregation of the information, which makes it possible to define the variables using very small spatial units (census tract level). The dataset contains the usual individual and household socio-economic information. Given that our aim is to analyse female employment probability, the sample has been restricted to women aged between 16 and 64 years old. The sample comprises 61,997 observations in Barcelona and 80,842 in Madrid. According to the Micro-census data, the employment rate for women was 64.4% in the Barcelona metropolitan area and 61.1% in the Madrid metropolitan area.

Explanatory variables have been selected according to the standard literature and can be grouped into three categories: individual characteristics, residential segregation measures and job accessibility variables, as presented in Table 5. Individual characteristics include: age, marital status, number of children, years of education, citizenship and the labour status of the spouse (employed, unemployed or retired).

We approximate residential segregation using a set of variables defined at census tract level: unemployment rate, distribution of working-age neighbourhood residents by education level, distribution of working-age neighbourhood residents by citizenship, distribution of dwellings by age of construction and distribution of dwellings by size. A statistical analysis of these variables showed a high level of correlation among them. Given that the estimated coefficients for the variables in the model were robust to the segregation variable included in the equation, we chose to include only the unemployment rate as it provided the highest level of fit.

Finally, the third category of variables are those related to accessibility to job opportunities. As explained in section 4, accessibility by public transport has been approximated by the employment potential for each residential zone measured according to the level of education possessed by each individual in the sample. With respect to accessibility by private transport, the variable used is the number of cars per adult in the household. In some preliminary estimations, we included the employment potential defined in terms of time spent in private transport. However, the results showed that the relevant variable was not the time cost to access jobs but rather the car availability in the household. This result agrees with other studies (Raphael and Rice, 2002 and Ong and Miller, 2005) and reflects that private transport is sometimes the only option to connect residential places and job opportunities.

Table 5. Descriptive statistics of the explanatory variables

	Barcelona Mean	**Madrid Mean**
Individual characteristics		
Age	39	39
Married	67.3%	64.1%
Number of children	0.53	0.57
Years of education	9.5	10.1
Labour status of spouse		
Employed	82.6%	84.3%
Unemployed	4.1%	4.4%
Retired	13.2%	11.3%
Citizenship		
EU-15 other than Spanish	0.8%	0.7%
African	0.9%	0.8%
Latin American	2.9%	5.5%
Other	0.7 %	1.5%
Segregation variables		
Unemployment rate	10.9%	12.3%
Job accessibility variables		
No degree	1492.4	1053.9

Primary education	4238.7	2928.3
Compulsory education	8251.0	6621.0
Upper secondary education	10047.3	8155.2
University degree	8058.8	8622.1
Number of cars per adult	0.44	0.43

6. The estimated model

With the objective of investigating the impact of residential segregation and accessibility to jobs on employment, we estimate an employment probability equation for women, taking into account individual characteristics, segregation variables and a measure of job accessibility, using the following probit specification:

$$P(E=1)=\Phi(X^{'}\beta)$$

where Φ is the standard normal cumulative distribution function, X is the set of explanatory variables and β the parameters to be estimated. The dependent variable, E, takes value 1 when the individual is employed and 0 when unemployed or out of the labour force.

To estimate the previous equation we have to take into account that there is a potential problem of simultaneity between the decision of a woman to join the labour force and the number of cars in the household. Although it is true that car ownership increases the probability of employment, causality also runs in the opposite direction. That is, working women increase the number of cars in a family. If this is so, the estimated coefficient for car ownership in the employment equation will be biased upward. The existence of simultaneity between the two decisions can be verified by estimating the structural equations of female employment and number of cars per adult.

On the one hand, a probit model for female employment probability has been estimated including as explanatory variables those defined in Table 5. As can be observed in Table 6, the number of cars per adult has a positive and very significant effect on employment probability.

Table 6. Estimation results of the structural form of the employment equation

	Barcelona		Madrid	
Dependent Variable=1 if employed, 0 otherwise				
	Coefficient	**z-statistic**	**Coefficient**	**z-statistic**
Constant term	-0.69518	-9.31	-1.11258	-16.88
Individual characteristics				
Age	0.06426	17.27	0.08280	25.56
Age squared	-0.00103	-22.37	-0.00121	-30.23
Years of education	0.08967	41.93	0.07337	38.79
Number of children	-0.17379	-23.43	-0.15179	-25.14
Married	-0.51626	-35.70	-0.62291	-50.35
Spouse retired	-0.38282	-12.82	-0.32285	-13.65
Spouse unemployed	-0.12411	-3.76	-0.16713	-5.73
Citizenship				
UE-15 other than Spai	-0.37304	-5.88	-0.10161	-1.76
African	-0.28009	-4.94	0.05223	1.00
Other countries	-0.01192	-0.39	0.29456	14.49
Segregation variables				
Unemployment rate	-2.59770	-15.17	-2.41018	-15.22
Job accessibility variables				
No degree	0.000242	12.61	0.000288	11.98
Primary education	0.000046	8.92	0.000048	7.11
Compulsory and over	0.000011	5.68	0.000020	8.73
Cars per adult	0.282292	14.34	0.278486	16.16
Observations	61997		80842	
Pseudo R^2	0.1747		0.1832	

On the other hand, the number of cars per adult has been estimated using a Tobit model to account for the fact that the dependent variable is zero for a nontrivial fraction of the population and takes strictly positive values for the rest. The explanatory variables for car ownership are the same as in the employment equation, plus two additional variables—housing size per capita[4] and housing tenure—included to better approximate the level of household income[5]. In addition, we introduce a dummy variable that takes value 1 when women work and 0 otherwise. The results presented in Table 7 clearly show that working women increase the number of cars per adult.

Table 7. Estimation results of the structural form of the car ownership equation

	Barcelona		**Madrid**	
Dependent variable: Number of cars per adult				
	Coefficient	**t-statistic**	**Coefficient**	**t-statistic**
Constant term	0.2893673	15.74	0.2048417	12.17
Individual characteristics				
Age	0.00296	3.17	0.00215	2.58
Age square	-0.00007	-5.61	-0.00006	-5.35
Years of education	0.00998	20.04	0.01801	38.13
Number of children	0.04809	25.26	0.04723	29.58
Married	0.16260	45.89	0.181500	57.70
Spouse retired	-0.02912	-3.96	-0.03398	-5.83
Spouse unemployed	-0.03610	-4.14	-0.04642	-5.98
Employed (yes=1)	0.03302	10.10	0.03286	11.41
Dwelling characteristics				
Housing size per adult (sq m)	0.00422	58.89	0.00400	67.77
Housing tenure (rented=1)	-0.13301	-31.48	-0.14867	-36.64
Citizenship				
UE-15 other than Spain	-0.05741	-3.54	-0.02202	-1.49
African	-0.17727	-11.35	-0.22057	-14.49
Other countries	-0.29282	-33.23	-0.29786	-49.66
Segregation variables				
Unemployement rate	-0.62094	-14.22	-0.97975	-23.96
Job accessibility variables				
No degree	-0.000130	-26.28	-0.000070	-11.32
Primary education	-0.000048	-36.24	-0.000038	-21.73
Compulsory and over	-0.000022	-48.34	-0.000019	-33.39
Pseudo R^2	0.2366		0.2518	
Observations	61997		80842	

Hence, the structural equations show that labour status and car ownership are endogenous variables. In both equations and metropolitan areas, the rest of the coefficients take the expected sign and are statistically significant[6].

The endogeneity problem in the employment equation can be addressed by estimating the system of equations using maximum likelihood, given that when dealing with discrete dependent variables the *standard* two-step estimator is inconsistent

(Wooldridge, 2002, pp 472-478). However, in our case, this procedure resulted in non-robust estimators. A possible explanation for this outcome is the sensitivity of the maximum likelihood function to the fulfilment of hypotheses underlying its formulation.

Some recent literature addresses the endogeneity problem of the number of cars in the employment equation. However, we still lack conclusive results. Raphael and Rice (2002), instrumenting for car ownership, obtained estimates of effects on employment rates and weekly hours worked that were very close to those obtained when using OLS. However, concerning wages, instrumenting eliminates the positive impact of auto ownership. Ong and Miller (2005) use an instrumental-variable approach to correct for the simultaneity of employment and car ownership. The estimation results show slightly lower coefficients for the instrumented equation. Nonetheless, in one of the four specifications tested, the difference has the opposite sign.

Our decision has been to approximate the reduced form of both equations[7]. Moreover, it can be seen that the identification problem vanishes when dealing with reduced forms. Since our interest lies in the employment probability, the reduced form of the car ownership equation is presented only in the annex (Table A.1).

Estimation results of the reduced-form equations for employment probability are given in Table 8. In both metropolitan areas, the variable “housing size per capita” was statistically significant, whereas this was not so for “housing tenure”. Hence, this last variable was excluded from the equation. From the comparison of Tables 7 and 8, it follows that the estimated coefficients in the structural and reduced forms are very similar. Nevertheless, regarding the accessibility variables, we observe a decrease in the estimated coefficient which is more pronounced for the highest level of education.

Table 8. Estimation results of the reduced form of the employment probability equation

	Barcelona		Madrid	
Dependent variable=1 if occupied, 0 otherwise				
	Coefficient	**z-statistic**	**Coefficient**	**z-statistic**
Constant term	-0.68351	-9.13	-1.0826040	-16.39
Individual variables				
Age	0.06401	17.20	0.08312	25.65
Age square	-0.00104	-22.61	-0.00123	-30.59
Years of education	0.08980	41.80	0.07607	40.06
Number of children	-0.15495	-20.83	-0.13772	-22.79
Married	-0.47091	-32.89	-0.58023	-47.70
Spouse retired	-0.38847	-13.02	-0.32949	-13.93
Spouse unemployed	-0.13352	-4.05	-0.17916	-6.15
Citizenship				
UE-15 other than Spain	-0.40532	-6.37	-0.12116	-2.10
African	-0.31850	-5.63	0.00462	0.09
Other countries	-0.05661	-1.88	0.23814	11.95
Segregation variables				
Unemployment rate	-2.55399	-14.83	-2.51571	-15.80
Job accessibility variables				
No degree	0.000223	11.68	0.000279	11.61
Primary education	0.000039	7.66	0.000043	6.27
Compulsory and over	0.000008	4.06	0.000017	7.44
Reduced-form variables				
Housing size (sq m)	0.003322	10.70	0.00202	8.18
Pseudo R^2	0.1735		0.1832	
Observations	61997		80842	

A second simultaneity problem we need to address is that residential location can be an endogenous variable. As has been well documented, the choice of residential location influences and, at the same time, is influenced by the individual labour market outcome. Moreover, there are unobserved factors (for instance, different worker productivity levels) that simultaneously affect both the residential location choice and employment probability. As a result, the accessibility variable will be correlated with the disturbance term and the coefficients will be inconsistent. The estimated coefficients will be biased upward or downward depending on whether neighbourhoods with a lower probability of being employed are located further from or nearer to the centres of employment.

Dealing with this endogeneity problem is a difficult task given the lack of robust instruments, and an ideal solution does not exist. The economic literature has addressed this problem by developing various strategies. Weinberg et al. (2004) address it by using a panel dataset and controlling for fixed effects and unobserved individual characteristics which vary over time. Their study concludes that estimates that do not account for endogeneity overstate the effect of neighbourhoods but understate the effect of job accessibility, because individuals with lower employment probability are located around central business districts.

Alternatively, some authors rely on situations that can be compared to natural experiments. Holzer et al. (2003) use the construction of a new railway link to evaluate accessibility improvements to jobs in the case of minority workers. Aslund et al. (2006) exploit a Swedish refugee dispersal policy in which the location of people was decided by the Swedish government. Hence, individual residential location could be considered exogenous.

A third and frequently used alternative is to restrict the sample to individuals whose location choice can be considered exogenous to their employment status. The most common option is to restrict the sample to young adults living with their parents. This is the strategy adopted by Dujardin *et al* (2008) in the metropolitan area of Brussels. Gobillon and Selod (2007) use a subsample of unemployed workers living in public housing, whose location choice was therefore likely to be exogenous. Moreover, both studies apply a sensitivity analysis in order to evaluate whether there is any potential remaining endogeneity bias arising from the effect of unobserved characteristics which influence both the residential location and the employment outcome of the individuals in the subsample. The results obtained in these studies were quite robust to the presence of potential endogeneity.

In this study we adopt the third alternative to check the robustness of our results to the potential endogeneity problem. The strategy consists in re-estimating the model only for the subsample of women that have not changed their residence location in at least the last ten years. For this subsample the residential location choice can be thought of as fairly exogenous to present employment status. The sample size has been reduced by 19% in the Barcelona area and 21% in the Madrid area. The results are given in Table A.2 in the annex. From that table, it can be observed that the estimated coefficients are quite similar to those obtained with the full sample. In fact, according to a t-test, the null hypothesis of equality of coefficients between the full sample and the reduced one cannot be rejected in any of the two metropolitan areas.

According to the previous reasoning, we can conclude that the estimation is not affected by significant endogeneity problems. Therefore, the equations presented in Table 8 are a valid approximation for analysing the impact of job accessibility on employment probability.

7. Estimation results

Table 8 shows that the coefficients related to individual characteristics are highly significant. For a woman, the employment probability increases with her level of education and decreases with number of children. The age effect is not linear; employment probability reaches a maximum at around 30 years of age in Barcelona, and 33 in Madrid. Regarding the labour status of spouse, for married women, the probability of being employed decreases when the spouse is either retired or unemployed. Moreover, citizenship also has an effect on employment probability.

The results confirm that residential segregation has a negative effect on employment. Residents in neighbourhoods with a high unemployment rate have a lower probability of finding a job. As suggested by the theory, this relationship operates through two main channels: deteriorating local social networks and higher difficulties in acquiring human capital. It has to be noticed that the results are robust to the choice of neighbourhood characteristics included in the equation. For instance, the results hold when the unemployment rate is replaced by the proportion of neighbourhood residents with higher levels of education or by the proportion of dwellings constructed in the last decade. In both cases, these variables reflect neighbourhoods occupied by young and educated people. Our results agree with results obtained for other European cities. Gobillon and Selod (2007) conclude that residential segregation prevents unemployed workers from finding a job in the Paris metropolitan area, whereas Dujardin et al. (2008) confirm that residing in a poor neighbourhood increases the probability of being unemployed in Brussels.

According to the estimates, the main variable of interest in this study—job accessibility by public transport—has a significant impact on employment probability. In both metropolitan areas, a higher accessibility to jobs by public transport increases the employment probability of women. As may be expected, the magnitude of the effect decreases with the level of education.

Although available literature on spatial mismatch has not paid particular attention to the impact of public transport quality on employment, some recent work provides valuable results. The study of Kabawata (2003) demonstrates that, for workers living in the metropolitan areas of Los Angeles and San Francisco, improved transit-based job accessibility significantly drives up both the probability of being employed and the number of hours worked, with the effect being higher for workers without cars. Holzer et al. (2003) find that the expansion of a railway line in the San Francisco Bay Area, which improves the accessibility of inner-city minority workers to a suburban employment centre, has a positive effect on employment for people residing near the new station.

Regarding available evidence on European cities, the results are not conclusive. Gobillon and Selod (2007) provide only slight evidence of a negative effect of job accessibility on the probability of finding a job in Paris. Additionally, when they examine accessibility and educational level jointly, they find that only in the case of less-educated workers does accessibility improve job finding.

Dujardin et al. (2008) find that the distance to jobs is not significant in explaining employment probability in Brussels. As the authors argue, this result is coherent with the spatial structure of this city, where the unemployed reside close to the jobs.

Conversely, Patacchini and Zenou (2005) provide evidence favouring the spatial mismatch hypothesis in England. Specifically, job search intensity decreases with job accessibility time, and is higher for car-owning individuals. Aslund et al. (2006), after controlling for residential location endogeneity, find that job accessibility has a positive impact on employment.

Elasticities and simulations

In order to quantify the effect of policy variables included in the equation, we have computed the elasticity of employment probability with respect to years of education, neighbourhood unemployment rate and job accessibility. Elasticity values correspond to aggregate values for the whole sample and are computed by simulating a unit percentage increase in the explanatory variable. As can be observed in Table 9, the highest magnitude for elasticity corresponds to years of education. This is a well known result in the literature. One of the most effective policies for increasing the female employment rate is improving women's level of education. The contribution of our study is to confirm two additional possibilities. Firstly, reducing residential segregation will lead to a rise in the employment rate. Secondly, improving job accessibility in terms of time costs will also be an effective policy, mainly for less-educated women.

Table 9. Elasticities of employment probability

	Barcelona	Madrid
Years of education	0.366	0.366
Unemployment rate	-0.133	-0.157
Job accessibility		
No degree	0.310	0.294
Primary education	0.128	0.112
Compulsory and over	0.027	0.059

Comparing the elasticities for Barcelona and Madrid, it can be observed that the estimated values are very similar between the two metropolitan areas. Therefore, we can conclude that the observed differences in employment location described in section 4 do not lead to different individual responses to changes in accessibility levels.

Additionally, the effect of accessibility on employment probability is illustrated through a simulation exercise in which the level of job accessibility for all the individuals in the sample is set at least equal to the average value of this variable for the zones in the highest decile. The assignment of the accessibility value has been made by taking into account the level of education of the individual. On average this simulation implies increasing job accessibility by 61% in Barcelona and 43% in Madrid. The reason for the lower percentage in Madrid is the lower variance in the accessibility distribution in that area.

The results are given in Table 10. For each area, the first column corresponds to the predicted value of the employment rate in each group at the observed values for accessibility, and the second column is the predicted growth in the employment rate derived from the accessibility increase. The second column is the predicted rate after increasing accessibility and the third gives the difference between them. As can be observed, improving job accessibility would achieve a positive effect on the employment rate. This effect is greater for less-educated woman and decreases with education. In the Madrid area, the impacts are less significant because of the lower increase in the simulated accessibility index.

Table 10. Impact of accessibility increases on the female employment rate

	Barcelona			Madrid		
	Observed value	Simulated value	Difference	Observed value	Simulated value	Difference
No degree	34.3	41.3	7.0	30.7	34.1	3.4
Primary education	45.0	48.7	3.7	37.7	39.3	1.6
Compulsory education	59.0	60.4	1.4	53.5	55.1	1.6
Secondary education	76.6	78.0	1.4	70.7	72.5	1.8
University degree	87.1	87.7	0.6	82.8	84.1	1.3

8. Conclusions

Using data from the Spanish 2001 Micro-census, we have tested the spatial mismatch hypothesis for the metropolitan areas of Barcelona and Madrid.

The results of our study show that, after controlling for individual variables, residential location affects female employment probability in two ways. Firstly, we confirm that neighbourhood segregation is a significant factor in explaining labour outcomes. Secondly, lower job accessibility by public transport decreases employment probability. Furthermore, the magnitude of the second effect declines as educational level rises.

According to estimated coefficients and elasticities, the observed differences in the location of employment between Barcelona and Madrid do not translate into different individual responses to changes in accessibility. Nonetheless, given the observed higher dispersion of accessibility in Barcelona, a simulation exercise that sets accessibility for all individuals in the sample at the average of the highest decile results in a greater impact on employment in the Barcelona area. According to this simulation, the female employment rate in Barcelona would increase by 20% for less-educated women, by 8.2% for those with primary studies, by 2.4% for those with compulsory education and by 1.8% for upper secondary education. In Madrid the corresponding percentages are: 11.0%, 4.2%, 3.0% and 2.5%.

We should remark that our results are robust to potential simultaneity problems related to residential location. In this study endogeneity has been controlled for by estimating the reduced form of the employment probability equation and by re-estimating the model for a subsample whose residential location choice is likely to be exogenous with respect to any job decision.

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Table A.1 **Estimation results of the reduced form of the car ownership equation**

	Barcelona		Madrid	
Dependent variable: number of cars per adult				
	Coefficient	**t-statistic**	**Coefficient**	**t-statistic**
Constant term	0.30026	16.34	0.21151	12.56
Individual characteristics				
Age	0.00362	3.88	0.00296	3.56
Age square	-0.00008	-6.57	-0.00007	-6.57
Years of education	0.01082	22.01	0.01882	40.25
Number of children	0.04659	24.52	0.04581	28.74
Married	0.15805	44.93	0.17558	56.54
Spouse retired	-0.03347	-4.56	-0.03736	-6.41
Spouse unemployed	-0.03780	-4.33	-0.04848	-6.24
Dwelling characteristics				
Housing size (sq m)	0.0042563	59.34	0.0040229	68.07
Housing tenure (rented=1)	-0.1334212	-31.54	-0.1487008	-36.60
Citizenship				
UE-15 other than Spain	-0.06117	-3.76	-0.02324	-1.57
African	-0.18126	-11.59	-0.22121	-14.51
Other countries	-0.29355	-33.27	-0.29542	-49.23
Segregation variables				
Unemployment rate	-0.64862	-14.87	-1.00592	-24.61
Job accessibility variables				
No degree	-0.000128	-25.92	-0.000068	-10.93
Primary degree	-0.000048	-36.00	-0.000038	-21.59
Compulsory and over	-0.000022	-48.05	-0.000019	-33.07
Pseudo R^2	0.2352		0.2505	
Observations	61997		80842	

Table A.2. Estimation results of the reduced form of the employment probability equation for subsample

	Barcelona		Madrid	
Dependent variable=1 if occupied, 0 otherwise				
	Coefficient	**z-statistic**	**Coefficient**	**z-statistic**
Constant term	-0.69532	-8.33	-1.20046	-16.00
Individual variables				
Age	0.062836	15.29	0.08734	23.87
Age square	-0.00102	-20.26	-0.00126	-28.12
Years of education	0.09209	37.16	0.07820	34.49
Number of children	-0.12672	-14.60	-0.11755	-15.94
Married	-0.47604	-29.00	-0.62825	-43.63
Spouse retired	-0.37499	-12.10	-0.30983	-12.46
Spouse unemployed	-0.09575	-2.58	-0.11415	-3.41
Citizenship				
UE-15 other than Spain	-0.25686	-2.67	-0.06094	-0.70
African	-0.18737	-1.94	0.24017	2.33
Other countries	-0.04506	-0.79	0.16834	4.13
Segregation variables				
Unemployment rate	-2.58321	-13.68	-2.35476	-13.34
Job accessibility variables				
No degree	0.000202	9.73	0.000246	9.08
Primary education	0.000034	6.09	0.000028	3.56
Compulsory and over	0.000006	2.62	0.000016	5.28
Reduced-form variables				
Housing size (sq m)	0.003905	10.64	0.002117	7.12
Pseudo R^2	0.1823		0.1970	
Observations	50306		63563	

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[1] Public transport time was also weighted with parameters between 0.5 and 2, giving very similar results. So we chose not to use weightings for the definitive computation of the potential.

[2] The cities of Barcelona and Madrid are divided into 12 and 21 districts, respectively.

[3] Employment including all education levels

[4] Housing size per capita has been computed by dividing the number of square meters by the number of members in the household, adjusted by the Oxford equivalence scale.

[5] One drawback of census data is that no information is provided about the level of household income. Given that income is a crucial determinant of car ownership we have approximated it by using the housing size per capita and housing tenure, along with the labour status of the spouse.

[6] It can be noticed that, if we were dealing with a standard linear regression, we would face an identification problem in the structural equation for car ownership, because the number of coefficients to be estimated exceeds the number of exogenous variables in the model formed by the two equations. Nonetheless, in our case, because we are dealing with a non-linear equation, the usual identification condition does not apply directly.

[7] We use the term “approximate” because the non-linear models may be lacking a reduced form.

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