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Hedonic Price Functions for Zurich and Lugano with Special Focus on Electrosmog

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Preliminary draft

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ABSTRACT

This paper evaluates the impacts of electrosmog, noise and air pollution on the dwellings' rents in the cities of Zurich and Lugano. The hedonic price regressions are estimated using a large micro-level data set and taking into account the spatial correlation in unobserved factors. The results suggest that the presence of mobile phone antenna has a negative impact on the rent, but this effect is not statistically significant in Lugano. In addition, PM10 density and the level of noise at night have a significant negative impact on the rent. Accounting for spatial correlation has little effect on the coefficient estimates.

JEL classification: C21, Q2, R31
Key words: hedonic pricing, electrosmog, noise, air pollution.

I. INTRODUCTION

Electromagnetic pollution (i.e. non-ionizing radiation, also called electrosmog), noise and air pollution are typical negative local externalities in urban areas. They are side-effects of human and economic activity (road transport, telecommunication) and affect individuals' well-being negatively without compensation.

The economic impact of these externalities can be reflected in the lower price of dwellings located in polluted and/or noisy areas or in the vicinity of sources of electromagnetic pollution such as high voltage transmission lines or mobile phone antennas. The focus of this paper is to analyse the impact of these externalities on the rent level in two Swiss cities.

The novelty of this paper is to consider the electrosmog in the analysis. This choice is motivated by the growing concern of the population about electromagnetic pollution caused mainly by mobile telecom antennas, TV and radio transmitters and high voltage power lines.[1]

Although laboratory studies have shown that electrosmog can affect living cells, it is still unclear whether these effects are harmful. Some epidemiological studies have reported of a possible link between electrosmog exposure and cancer, however, to date no conclusive assessment can be made.[2] Current research is expected to provide more answers about potential health effects within the next few years. In terms of an application of the precautionary principle, the Swiss federal state and the mobile phone companies agreed in 2006 to enforce the controls of radiation levels of the antennas. Despite the lack of information on electrosmog and the uncertainty of its impacts on health, most people are concerned about the increasing intensity of radiated power in inhabited areas.

In economic terms, the presence of one of these emitters near residential locations, and the uncertainty of the impact on health, can generate a loss in utility to people. Indeed, independent of the results of the epidemiological studies, people seem to consider the presence of a base station a health hazard and, therefore, be negatively affected by non-ionizing radiation. For instance, studies performed by Siegrist et. al.

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1 In this study we do not consider electrosmog emitted inside a dwelling or house, since this kind of pollution cannot be considered as an externality for the household.

2 For a review of these studies see Ahlbom et. al. (2001) and Breckenkamp et. al. (2003).

(2003 and 2005) show that people viewed risks associated with cell phones or base stations as high.

The empirical literature on the economic impacts of the sources of electromagnetic fields (e.g. mobile phones, base stations, high-voltage transmission lines) on the dwellings' prices is poor. There are only few empirical studies for US and Canada that have examined the impact of the presence of electromagnetic fields on the dwellings' prices. Despite the growing importance of the topic, we are not aware of any empirical studies on this issue performed for any European countries. Of course, the empirical literature is abundant of studies analysing the impact of noise and air pollution on prices.[3]

We selected two empirical studies on the impact of electromagnetic fields on the property value that are relevant for our analysis. The first study is by Hamilton & Schwann (1995) while the second is by Des Rosiers (2002). Both studies apply the hedonic pricing approach and their results support the hypothesis that property values drop because of proximity and visual impact of electromagnetic sources. The paper of Hamilton & Schwann focuses on high voltage transmission lines and considers the sales of single detached houses over the period of 1985-1991 (Vancouver area, Canada). By splitting the database in sub-samples, according to the distance to a transmission line, it was possible to show the impact of transmission lines on the dwellings' prices. The price effect is of around -6.3% for properties adjacent to a line.

Des Rosiers also investigated the impact of high-voltage transmission lines on surrounding property values in City of Brossard, Canada. His data contain information about 507 single family houses sold over the period of 1991-1996. He concludes that being adjacent to the easement will not necessarily cause a house to depreciate but a direct view on a pylon does exert a significantly negative impact on property prices, which is roughly 10% of the mean house value.

In this paper we have analysed in addition to electrosmog also the impact of air pollution and noise on the dwellings' rents. Despite significant improvements in the air quality since the coming into force of the Clean Air Legislation in the mid-1980's, air pollution remains one of the most important environmental issues in Switzerland. The reaching of critical pollution levels (especially of particulate matter) during the winter

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3 For a recent study on the impact of noise on rents in Switzerland see Baranzini & Ramirez (2005). For a meta-analysis of the impact of airport noise on property values see Nelson (2004). Literature overview of thirty-seven US-studies, which implemented the hedonic model to estimate the marginal willingness to pay for air pollution reductions, can be found in the paper of Smith & Huang (1995).

months 2005/6 in urban centres, has again triggered an intense discussion on further measures[4] that need to be taken in order to reduce harmful emissions, mainly caused by passenger and freight transport through the combustion of fossil fuels, followed by industry. Air pollution has significant negative effects on the built and natural environment and ecosystems as well as on human health (in particular respiratory illnesses).

In order to examine the impact of these externalities on the prices of properties, we have estimated hedonic price functions using revealed data for the cities of Zurich and Lugano. The choice of these two cities allows the identification of potential cultural differences in the evaluation of pollution between cities in the Italian and the German part of Switzerland. Further, both cities are highly affected by air pollution and noise, so that for these two types of externalities it should be possible to identify an impact on the dwellings' rents. The dataset used for the hedonic regression comprises a representative sample of about 6'750 flats (6'200 for Zurich and 550 for Lugano).

The paper is organized as follows: the next section presents a short model specification; description of the data is given in section three; section four presents the empirical results and finally, section five concludes with a brief discussion and summary of the results, and a presentation of further working steps.

II. MODEL SPECIFICATION

The major problem for most environmental and public goods is that no markets and prices for such goods exist. The consequence is that the production of negative externalities exceeds the socially optimal level. Therefore, techniques have been developed to price environmental goods (see for example Bateman & Willis, 1999, or Garrod & Willis, 1999).

The techniques to value the benefits of environmental quality improvements can broadly be split in stated and revealed preference revelation approaches. Revealed preference approaches are based on the actual (economic) behaviour of individuals. They rely on a link between the observable behaviour and the value of an environmental good or service. Stated preference methods ask individuals directly on their choices or

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[4] For example, tighten the criteria of fuel efficiency and low-emission cars, engagement at European level in order to achieve a reduction in emission level of vehicles, application until 2007 of the best technology available for reducing emissions of diesel busses.

Willingness To Pay (WTP) for the continuing existence of a given environmental quality or for a change in environmental quality.

The Hedonic Price Method (HPM), first mentioned in the work of Court (1939) and Griliches (1961), belongs to the group of revealed preference approaches which can be used for the valuation of a change in air quality by analysing the impact of different pollution levels on rental or house prices. The same logic applies to noise and electromagnetic fields. HPM is an indirect method, where the fundamental idea is that a dwelling's rent reflects the value of its attributes to the tenant. In the general form it can be represented as:

$$P_i = f(X_i) \qquad [1]$$

where P is the price of the observation i , in our case rental price of a dwelling i and $X = (x_1, x_2, x_3, x_4, \ldots)$ is the set of explanatory variables (both continuous and discrete), that is the set of dwelling's attributes. Attributes are of structural nature (number of rooms, age of the building, etc.), concern the neighbourhood (proximity to schools, public transports, etc.) and the surrounding environment (parks or water bodies nearby, air quality, noise level, etc.). The characteristics or attributes of a dwelling are assumed to be capitalized into the value of the house and land and, consequently, in the rents. Then, the HPM allows splitting the value of the dwelling into its various attributes for the purpose of assigning values to particular attributes such as air quality (see for example Chattopadhyay, 1999; Zabel & Kiel, 2000).

Following the model specifications used in previous studies and taking into account the availability and quality of data for the cities of Zurich and Lugano, we decided to specify the following hedonic price model:

lnP=f(SM, Ro, Fl, Age, PM10, NoiseN, DistCe, Dist200, built1980, built1970, built1960, built1945, KI, WC, BAL, GAR, LI, Ren, Own_PR, Own_INS) [2]

Where

lnP	= Natural logarithm of the monthly gross rent of the dwelling
SM	= Surface of the dwelling (in m^2), incl. balcony, bathroom, etc.
Ro	= Number of rooms (without kitchen, kitchen corner, bathroom, toilettes, half rooms)
Fl	= Living floor
Age	= Number of years tenants are living in the dwelling
PM10	= PM10 concentrations in $\mu g/m^3$

NoiseN = Noise annoyance during the night, in dB(A); (actual noise annoyance minus 50 dB(A)[5])

DistCe = distance to the city centre, in km

Dist200 = dummy variable indicating whether there is antenna in the radius of 200 m of the dwelling

Built2002 = dummy variable indicating whether the building was constructed in the period 1981 - 2002, used as a reference group

Built1980 = dummy variable indicating whether the building was constructed in the period 1971 - 1980

Built1970 = dummy variable indicating whether the building was constructed in the period 1961 - 1970

Built1960 = dummy variable indicating whether the building was constructed in the period 1945 - 1960

Built1945 = dummy variable indicating whether the building was constructed before the year 1945

KI = dummy variable indicating whether there is a kitchen integrated

WC = dummy variable indicating whether there is a second WC in the dwelling

BAL = dummy variable indicating whether the dwelling has a balcony

GAR = dummy variable indicating whether there is a garden/ terrace

LI = dummy variable indicating whether the building has a lift

Ren = dummy variable indicating whether the dwelling was renovated

Own_PR = dummy variable indicating whether the owner of the dwelling is a private person

Own_INS = dummy variable indicating whether the owner of the dwelling is an Insurance company/ Pension fund

Own_Other = dummy variable indicating whether the dwelling is property of canton, federation/ housing association, used as a reference group

III. DATA

The main data source used in this paper is the survey about the structure of the rent in Switzerland[6] conducted by the Swiss Federal Statistical Office in the year 2003.

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5 The noise exposure of 50 dB(A) during night corresponds to the imission threshold set by Swiss law.

The survey collects rich information on the structure of rent and different quality and quantity characteristics of the dwellings commonly used in the hedonic analysis.

For our paper we only selected the data for tenants in Zurich and Lugano, together this accounts for more than 9'000 observations (unbalanced data). This number is further reduced by omitting a number of invalid or inappropriate observations including, for instance, those where square footage and gross rent were missing. After removing such observations and depending on variables taken into the estimation, the final dataset was reduced to 6'751 dwellings (out of which 6'204 were for Zurich and 547 for Lugano).

To carry out the final analysis we combined this data set with the data on noise, air pollution and electrosmog and also created a new accessibility variable measuring the distance to the city centre.

Information with regard to the traffic noise and electrosmog (the location of all mobile phone base stations in the two cities) was obtained from the cantons of Zurich and Ticino. The noise level data are available only for those buildings located on the street or street sections where the noise limit values (during the night) have been exceeded or where this overrun is possible. After the matching of the data, one third of our observations had some indications on the noise level. Using only these observations would not only reduce the sample size but also induce selection bias on our estimation results for omitting the dwellings not exposed to noise. In order to create a continuous variable for noise exposure, following Navrud (2002) and Bjørner (2003), we assigned a zero value for the observations without the noise level, for other observations, the difference between this level and cut-off point of 50 dB(A)[7].

A variable measuring the distance to the closest antenna in meters was used as a proxy for the electromagnetic pollution. This distance was derived using Geographic Information Systems (GIS) techniques. The average distance to the nearest antenna was in both cities approx. 210 meters and the median 190 meters. Finally, this distance variable was not included in our estimation but was used to create dummy variables indicating the presence of an antenna within 50, 100, 150 and 200 (DIST200) meters from the dwellings. The Table 3 shows the cumulative number of the dwellings with antenna within the different distances to the dwelling and the average and means

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6 Mietpreis-Strukturerhebung, BFS, 2003. Data have been collected for more than 230'000 Swiss households.

7 Cut-off point 50 dB(A) means zero impact on the rent of noise below these levels.

distance values. It can be seen that only 5% of the dwellings have the antenna within 50 meter radius. An antenna is present within 200 meter radius for more than half of the dwellings with average distance of 117 meters.

Table 1: Cumulative numbers of the dwellings with antenna within 50, 100, 150 and 200 meters with the average and median distance

ZH+LG, N=6'751	Cum. N	Cum. %	Average Distance	Median
Antenna < 50 m	360	5.3	30	33
Antenna < 100 m	1'306	19.3	64	67
Antenna < 150 m	2'487	36.8	93	97
Antenna < 200 m	3'549	52.5	117	121

From the Federal Office for the Environment, we obtained raster[8] data on fine particles (PM10) measured at fixed and mobile stations and then extrapolated. We decided to use the PM10 indicator because the threshold values[9] for this pollutant are often exceeded for both cities in question (as shown in Table 1) which could have serious effects on residents' health.

Another variable derived using the GIS technique was a variable measuring the shortest distance to the city centre in km, with the average distance of 3 km for Zurich and 1.4 km for Lugano.

Table 1 provides a summary statistics of our sample. In the sample as a whole, the average dwelling was approximately 79 square meters large with 3 rooms, a monthly rent of 1'424 SFr (Swiss Francs) and built in the period 1946-1960. Almost half of the dwellings are owned by private persons, one fourth is owned by insurance companies or pension funds and one-fourth is property of the canton or the city. The dummy variable for the period of construction indicates that most buildings were built before the year 1945.

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8 The grid size is 200x200 meters.

9 The Ordinance on Air Pollution Control specifies for PM10 a limit value of 20 μg/m^3 for the annual average. PM10 does not meet these quality standards on average. The PM10 concentrations are highest in the winter months, with daily maximum levels often exceeding 50 μg/m^3 (stipulated daily average level, which may only be exceeded once per year).

Table 2: Description and summary statistics of the used variables, N=6'204 for Zurich and N=547 for Lugano

Dependent variable	Sample Zurich				Sample Lugano			
	Mean	St. Dev.	Min	Max	Mean	St. Dev.	Min	Max
Gross Rent	1'438	645.5	279.4	6'600	1'280	527.1	135	4'500
Explanatory, continuous variables								
ln(Gross Rent)	7.19	0.40	5.63	8.8	7.07	0.44	4.91	8.41
Surface	78.5	29.5	12	380	89.5	32.8	20	256
Rooms	3.10	1.06	1	10	3.31	1.06	1	10
Floor	1.90	2.01	0	30	2.40	1.78	0	10
Age	14.01	12.81	0	60	14.88	12.07	0	53
PM10	26.6	2.7	20.2	37.4	32.7	2.2	15.7	35.8
Noise Night	2.14	4.09	0	20	2.71	4.60	0	28.5
Distance to City Centre	3.15	1.43	0.13	6.50	1.41	0.61	0.07	4.47
Explanatory, dummy variables								
Antenna < 200 m	0.53	0.50	0	1	0.52	0.50	0	1
Built before 2002	0.12	0.33	0	1	0.13	0.34	0	1
Built before 1980	0.09	0.29	0	1	0.28	0.45	0	1
Built before 1970	0.12	0.32	0	1	0.26	0.44	0	1
Built before 1960	0.23	0.42	0	1	0.29	0.46	0	1
Built before 1945	0.43	0.50	0	1	0.03	0.17	0	1
Integrated Kitchen	0.85	0.35	0	1	0.75	0.44	0	1
Second WC	0.16	0.37	0	1	0.31	0.46	0	1
Balcony	0.71	0.45	0	1	0.80	0.40	0	1
Garden	0.19	0.39	0	1	0.19	0.39	0	1
Lift	0.27	0.44	0	1	0.65	0.48	0	1
Renovation	0.65	0.48	0	1	0.55	0.50	0	1
Ownership_Private	0.48	0.50	0	1	0.75	0.43	0	1
Ownership _Insur	0.27	0.44	0	1	0.22	0.41	0	1
Ownership _Other	0.25	0.43	0	1	0.03	0.16	0	1

IV. ESTIMATIONS RESULTS

Estimation of the hedonic function [2] requires the specification of a functional form. The theory gives little guidance with respect to the appropriate functional form. In the hedonic regression literature the most commonly used functional forms are the log-log, and the semi-log.[10] In this paper, we estimated semi-log model.[11]

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[10] For a discussion on this issue see Champ et al. (2004), Forrest (1991) and Navrud. (2002).

The estimation results obtained by using an OLS approach are reported in Table 3. The second and fourth columns present the results obtained using the data for the two cities.[12] To test for the presence of heteroskedasticity we used the White test. Based on the results we can reject the null hypothesis of homoskedastic error for Zurich whereas for Lugano not. Therefore, the t-values presented in Table 3 are then calculated from (White's) heteroskedastic-consistent variance-covariance matrix. Another problem that could arise estimating the hedonic price function is spatial correlation. For this reason, we tested the presence of spatial correlation using Moran's I test.[13] Based on the results of this test we cannot reject the null hypothesis (no spatial autocorrelation) for Lugano. However, for Zurich we have to reject this null hypothesis. For this reason, in the third column of Table 3 we present the empirical results of the model that incorporate spatial effects. This model was obtained using a spatial two-stage least-square (S-2SLS) estimation procedure.[14] The spatial autoregressive parameter (ρ) is significant and positive. This result suggests that the S-2SLS model should be preferred to the OLS model, at least for Zurich. Nevertheless, from Table 3 is clear that the estimated results obtained using the S-2SLS approach, are similar to those obtained using OLS method.

As can be observed, the explanatory performances of the two models are satisfactory, with an adjusted R2 of 0.64 for Zurich and 0.48 for Lugano. All of the coefficients show the expected sign and are statistically significant. To note, that the model for Lugano shows a lower level of the adjusted R2 with respect to model for Zurich and part of the coefficients of this model are not statistically significant. One possible reason for these differences can be due to the relatively low number of observations included in the sample of Lugano.

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[11] The semi-log specification was chosen because it allows for non-linear price-quality relations and variable semi-elasticities (as opposed to a log-log form).

[12] In a preliminary analysis we estimate original model by pooling these two samples. However, by using standard statistical tests for structural change we refused the hypothesis that all coefficients obtained using the separate samples are the same.

[13] See for a presentation and discussion of this test Anselin (1998) and for an application Kim (2003).

[14] We have estimated spatial-lag model (using Spatial Two-Stage Least-Square estimation and Maximum Likelihood approach), which implicitly assumes that spatially weighted average of housing prices in a neighborhood affects the price of each house in addition to the standard explanatory variables of housing and neighborhood characteristics. For more detailed explanation see Anselin (1998). We have experimented with different spatial weights matrices based on the Euclidean distance between dwellings. We selected spatial weight matrix with the cutoff value at 1000 m, based on a comparison of the different models in terms of fit. However, the estimated results of spatial-lag model provided by S-2SLS and ML method are very similar so we present only the results of the S-2SLS estimation.

The coefficients of the explanatory variables can be interpreted as the percentage change in the rent in response to a marginal change of the characteristics of the flat. For instance, if the surface of the flat is increased by 10 m^2, the rent of the flat increases by 4% if we consider the Zurich sample and 2.6% in the case of Lugano. An additional room increases the rent by 10% on average for Zurich, and by almost 15% for Lugano. The floor in which a flat is located has a small positive impact on the rent in Zurich: The increase of the rent by going one floor higher is about 0.8%. This variable was not significant for Lugano. The years since a person is living in a flat has a slight negative impact on the rent of -0.5% per year for Zurich and the double impact of -1% in Lugano.

The environmental variables have, as expected, a negative sign. An increase by 1 $\mu g/m^3$ of the particulate matter level (PM10) reduces the rent by 0.5%. This coefficient is above 2% for Lugano. The coefficient for the noise level during night is also highly significant and shows that an increase by 1 dB(A) above the threshold value set by law decreases rents by 0.3% in Zurich. This coefficient is slightly higher in Lugano, 0.6%, but significant only on 10 percent significance level. It appeared that the size of this coefficient is fairly robust with respect to inclusion or omission of different explanatory variables, but the estimated noise coefficient is sensitive to the noise measure and the cut-off level chosen with respect to noise.[15]

The coefficient for the dummy variable indicating if there is an antenna in the proximity of the dwelling has a negative and significant coefficient for Zurich. The presence of an antenna decreases the rent by around –1.8% in Zurich. The coefficient was not significant for Lugano. Thus, the results of the econometric estimations show that the presence of antenna can have a significant impact on the rent level and therefore on the value of properties. It would be interesting to confirm this result by considering other cities. The distance from city centre also affects the rent level: we can observe that an increase of 1 km from the city centre reduces rents by 2% in Zurich and by 8% in Lugano. This difference can be explained by the different size of the two cities. A flat located one kilometer from the city in Zurich is still very centrally located, which is not the case in Lugano.

To be able to compare our estimates with the results from a recent study carried out for Geneva (Baranzini et al. 2005) we have also estimated the implicit prices of the

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[15] Models with lower cut-off levels yielded a lower noise estimate and models with higher cut-off levels yielded a higher noise estimate, while the estimate for the noise during the day produced lower estimates for the same cut-off levels.

noise during the day[16] using the same equation. The results show that increase of 1 dB(A) in the noise level during the day leads to 0.23% decrease in the rents for Zurich and 0.46 per cent for Lugano. Both coefficients are statistically significant; first at 1% level and second on 5% level. If we compare our results with those of Baranzini et al. (2005) for the whole canton of Geneva, where the impact of noise during the day is 0.27% for an additional dB(A), we can observe a similar impact on rents. The impact in Lugano is higher, which could be explained by the higher average noise levels during the day for Lugano than for Zurich.

As an indicator for air quality Baranzini et al. take the exposure to NO_2. The effect on rent is of about 0.8% per $\mu g/m^3$. Taking the exposure to PM10 in Zurich and Lugano we obtain a rent increase of around 0.5 - 2% per an increase of 1 $\mu g/m^3$. These results have the same order of magnitude, although the studies consider two different pollutants.

The period in which the building was constructed has a highly significant impact on the rent. The reference category is formed by recently constructed buildings (construction period after the 1980). The negative impact of the building period on the rent increases with the age of the house (coefficient increases with growing age of the building). An exception is given by houses built before 1945 which show a slightly higher coefficient as those built between 1945 and 1960. One reason could be the need of expensive renovation or the presence of a surcharge for particularly old buildings/flat.

Further, we integrated in the regression several variables indicating the interior finishing of the flat, like the presence of a modern kitchen with all appliances like washing machine, fridge, oven etc. integrated, the presence of a second toilet, of a balcony, garden and lift. All these variables are significant positive for Zurich. For Lugano, only the high standard of the kitchen has a significant positive impact, the other variables are not significant. A modern kitchen and a second toilet have the most important impact on rent: The presence of a modern kitchen increases rents by around 15%, the second toilet by 13.5%. It could be that these two variables catch the effect of a high construction and finishes standard.

The ownership of the building has a central effect on the rent level. Buildings privately owned or owned by insurances are significantly more expensive (between 20 and 30%) than those publicly owned respectively owned by cooperatives. It has to be

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[16] We created continuous variable using the cut-off point of 55 dB(A).

considered that in Zurich the share of buildings owned by cooperative or the city/canton is considerable (25%). This effect is again not significant for the flats located in Lugano.

Table 3: The estimation results for the semi-log model specification

Variables (lnGross Rent)	Sample Zurich				Sample Lugano	
	Coeff. OLS	Robust t-stat.	Coeff. S-2SLS[a]	Robust t-stat.	Coeff. OLS	Robust t-stat.
ρ^b	-	-	0.393***	*(10.0)*	-	-
Surface	0.004***	*(13.60)*	0.004***	*(12.9)*	0.0026***	*(3.41)*
Rooms	0.103***	*(14.86)*	0.105***	*(15.3)*	0.149***	*(6.23)*
Floor	0.007***	*(4.45)*	0.008***	*(5.07)*	0.006	*(0.77)*
Age	-0.005***	*(-19.02)*	-0.005***	*(-18.8)*	-0.009***	*(-6.05)*
PM10	-0.017***	*(-11.63)*	-0.005**	*(-2.53)*	-0.020**	*(-1.95)*
Noise Night	-0.003***	*(-4.01)*	-0.003***	*(-3.87)*	-0.006*	*(-1.79)*
Distance to city centre	-0.035***	*(-11.38)*	-0.018***	*(-5.23)*	-0.081***	*(-2.55)*
Antenna < 200 m	-0.019***	*(-2.80)*	-0.018***	*(-2.73)*	-0.029	*(-1.08)*
Built before 1980	-0.114***	*(-8.49)*	-0.102***	*(-7.74)*	-0.089**	*(-2.52)*
Built before 1970	-0.122***	*(-9.36)*	-0.110***	*(-8.62)*	-0.122***	*(-2.90)*
Built before 1960	-0.141***	*(-11.87)*	-0.127***	*(-10.7)*	-0.189***	*(-4.26)*
Built before 1945	-0.131***	*(-10.78)*	-0.123***	*(-10.1)*	-0.061	*(-0.65)*
Integrated Kitchen	0.150***	*(15.10)*	0.148***	*(15.1)*	0.074*	*(1.77)*
Second WC	0.138***	*(12.44)*	0.135***	*(12.3)*	0.053	*(1.29)*
Balcony	0.023***	*(2.77)*	0.028***	*(3.34)*	0.003	*(0.08)*
Garden	0.048***	*(4.98)*	0.049***	*(5.14)*	-0.001	*(-0.03)*
Lift	0.051***	*(6.33)*	0.050***	*(6.18)*	-0.018	*(-0.59)*
Renovation	0.019***	*(2.69)*	0.017**	*(2.36)*	0.013	*(0.45)*
Private ownership	0.300***	*(38.06)*	0.287***	*(36.3)*	0.009	*(0.17)*
Insurance ownership	0.214***	*(24.39)*	0.205***	*(23.5)*	0.008	*(0.15)*
Constant	6.894***	*(138.9)*	3.699***	*(11.6)*	7.311***	*(18.72)*
AdjR2	0.636		0.645		0.48	
N	6'204		6'204		547	

***Significant at 0.01 level. **Significant at 0.05 level and *Significant at 0.10 level

[a] The spatial two-stage least-squares estimation based on the use of the spatially lagged rent as instrument

[b] The spatial autoregressive parameter

V. CONCLUSION AND SUMMARY

This paper analyses the impact of electromagnetic pollution, noise and air pollution on the rent level in the two Swiss cities of Zurich and Lugano. Air pollution and noise are two crucial sources of external effects in urban areas. Besides these two well known types of external effects, the paper focuses particularly on electrosmog caused by mobile phone antennas. The negative impact of radiation coming from antennas has not been proven yet, nonetheless people are concerned about possible long term risks associated with the exposure to electromagnetic radiation. This risk perception may affect the price of dwellings located close to antenna. The paper tries to find some empirical evidence for such an impact.

The hedonic price regression has been carried out for a sample of about 6'750 dwellings. The explanatory variables considered in the regression are several characteristics of a dwelling such as size, number of rooms, year of construction, ownership, etc. In addition, the regression considers different environmental variables such as noise at night (above the limit values set by law), air pollution measured through the PM10 level, the presence of a mobile phone antenna within a radius of 200 meters and the distance to the city centre. Different regressions were carried out for the two cities.

The regression results show that the variables with the main impact on rents are, as expected, the size, the number of rooms, the age of the building and some characteristics related to the standard of interior finishing of the flat like the presence of a modern kitchen or of a second toilet. Finally, the type of ownership of the building influences significantly the rents.

The environmental variables considered in the regressions noise level, air pollution measured with the PM10 concentration, presence of an antenna in the proximity of the flat have the expected sign and are all significant, with exception of the presence of the antenna for the sample of Lugano.

The paper shows that in particular the presence of mobile phone antennas affects rents. This effect can be determined by the fear of electromagnetic radiation or by the loss of esthetics due to the presence of an antenna near the building. Some more research is necessary in order to ascertain these two effects. Further, it would be interesting to extend the research to other cities in order to detect whether the results can be generalized.

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