Universitat de les Illes Balears

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AIR QUALITY INFLUENCE ON REAL ESTATE PRICES IN THE MUNICIPALITY OF PALMA

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Degree in Economics

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ABSTRACT

This investigation presents a micro econometrical analysis that links up air quality levels with real estate prices in the Municipality of Palma de Mallorca. Several studies evidence the negative relationship between high contaminated air with housing prices in cities like Concepción in Chile or Beijing in China. This evidence seems not to be enough clear in areas with continued low levels of air pollution as the Balearic Islands. This work reveals a null influence of this variable in economic agents to acquire a house in a market where the abundance or the lack of stock controls the price.

Key words: Air quality, housing price, Municipality of Palma.

Esta investigación presenta un análisis micro econométrico que pone en relación los niveles de calidad del aire y el precio de la vivienda en el Municipio de Palma de Mallorca. Muchos estudios evidencian una relación negativa entre altos niveles de contaminación del aire y precios del hogar en ciudades como Concepción en Chile o Pequín en China. Esta evidencia parece no ser tan clara en áreas con niveles de contaminación del aire normalmente bajos. Este trabajo revela una influencia nula de esta variable para los agentes económicos en el momento de adquirir una vivienda donde la abundancia o la falta de stock controla el precio en este mercado.

Palabras clave: Calidad de aire, precio de la vivienda, Municipio de Palma.

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INTRODUCTION

Air pollution by the AEMET can be defined as ‘’the presence of a greater or lesser extent of pollutants in the atmosphere that may be harmful to human health, to the environment as a whole and to other goods of any nature.’’. Pollutants can be classified in two groups, visible and invisible and smog would be part of the visible group whilst Ozone and Nitrogen would belong to the invisible group. Another classification can be between primary and secondary, depending if they are directly emitted to the atmosphere or are result of the interaction with another component in the air. On the one hand carbon dioxide is a clear example of a primary polluter, which can be clearly linked to vehicle traffic. On the other hand, Ozone is an example of a secondary one, since one of its main formation sources is its reaction with Nitrogen oxides. Exposition to polluted air for a long time can be the cause of acute respiratory diseases as pneumonia or the reason for chronic ones, as lung cancer or cardiovascular diseases, as stated by the World Health Organization, from now on WHO.

Housing market is the set of movements of supply and demand that involves real estate. This market has correlation with macroeconomic variables within the territory, having a high sensibility to fluctuations. Real estate can be residential, commercial, industrial, and so on, but this investigation will focus only in residential ones, and specifically, in selling transactions.

Contamination can be a crucial factor or a significant problem to acquire a house, when reaches high levels of it. Generally, this is a long-term product market, and that’s the reason for considering this type of characteristics of the area where the house is situated. Cities that constantly have high levels of pollution in their atmosphere, as can be Beijing, presents a clear negative correlation between presence of CO, NO2 or PM10 and housing prices, while O3 shows a positive relationship, increasing home values. (Mei, Y., Gao, L., Zhang, J., & Wang, J. (2020).

Agents consider several variables to purchase a house, as can be geographical situation, proximity to urban, maritime, or green territories, number of rooms or area in square meters. This study aims to link a relationship between air quality in the Municipality of Palma, and real estate price in the territory.

Balearic Islands presents significantly lower levels of air pollution, and not seems to be a variable that economic agents take into account to acquire a house, taking low contamination as a presupposed quality.

This is the question that this investigation tries to elucidate, if air quality has influence on real estate prices in the territory or not.

Expected results on the model calculated following are the non-influence of this variable in real estate price variation as an attribute considered by buyers.

THEORETICAL BACKGROUND

2.1. Air Pollutants

The WHO describes clean air as a ''basic requirement for human health and well-being''. Burning of solids fuel and other reasons that worsen air quality is the cause of nearly 2 million of premature deaths each year, and more than a half of them impact on developing countries. (WHO, Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide, 2005).

Four pollutants were observed by the WHO in 2005 to perform its guidelines: particulate matter PM, Ozone, Nitrogen Dioxide and Sulfur Dioxide. Three of them will be considered to decide whether the air quality could be qualified as good or bad in Palma. These will be, in first place the Nitrogen oxides (NO2).It is a gaseous yellowish chemical compound that can be the cause of pulmonary diseases, bronchitis, asthma or of allergic processes. It is formed by one particle of nitrogen and two of oxygen, and the main sources of NO2 in Balearic Islands are the traffic of vehicles and the power plants like the ''Central tèrmica de Cas Tresorer'' and ''Central Tèrmica de Son Reus'' in Palma. Referring to NO2, only Palma shows up elevated data in the Island of Mallorca. Law fixes three quality objectives to interpret this pollutant levels, a critic value for vegetation protection, and two values for health protection, an annual one and an hourly limit value, that cannot be overpassed more than 18 times a year. The second contaminant is suspended particles that have less than 10 μm in diameter, that are called PM10. The main origin of this kind of particle are activities like combustion processes or traffic road, but another big source of this pollutant is Saharan dust from North Africa brought by the winds, a common effect in the Mediterranean. Two type of limit values are considered to evaluate air quality in terms of PM10, an annual one and a dairy limit one, both focused on health protection. For last, Ozone (O3), a gaseous component naturally present in the atmosphere in low quantities. The presence of this component in high atmospheric layers blocks UV rays from the sun protecting us from radiation, but in levels closer to the ground it can be harmful for health, causing irritations in the respiratory system, or aggravate pathologies such as asthma or allergies. Ozone is a contaminant that is not directly emitted to the atmosphere, which means that is not a primary contaminant. The presence of Ozone is mainly related with his interaction with NO2 because of activities as can be residual burning, or thermal power like ''Central tèrmica de Cas Tresorer'' for example, as mentioned above. (GOIB, 2013-2019).

Official daily and monthly data from the environmental portal of ''Govern de les Illes Balears'' about the forementioned pollutants in the period between 2013 and 2019 will be made used of in the model, obtained from four control stations, situated in Foners, Parc Uib, Bellver and in Hospital Sant Joan de Déu. The municipality has two additional control stations. In one hand ''La Misericòrdia'' that only controls PM2,5 particles (the ones with diameter of less than 2,5μm) and in the other hand, the station of Mallorca Airport, that is not used to evaluate air quality, both of them were discarded from this study.

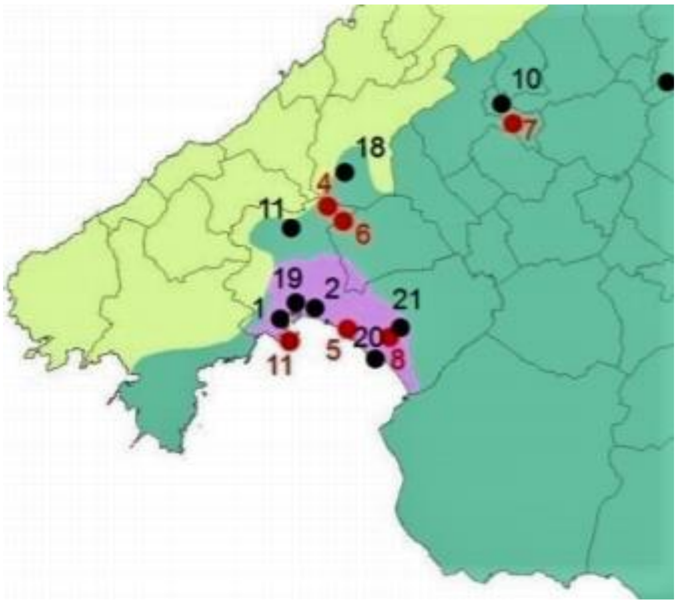

Image 1: Municipality of Palma's Station Control

1. Bellver
2. Foners
11. Parc Bit
20. Sant Joan de Déu

(Source: GOIB)

2.2. Municipality neighbourhoods.

The evolution of home sales prices in the different neighbourhoods of the municipality of Palma, 14 in total, will be crucial to determine the dependent variable in the investigation, and will be obtained from sales portal of Idealia. Different locations of the municipality are present in the model, from maritime population areas as can be Playa de Palma, Portitxol-El Molinar, or Gènova-Sant Agustí. Centric towns as Ciutat Antiga or Santa Catalina, and populations close to mountainous areas as can be Son Vida. Then other neighbourhoods of Palma inside the model are located in-between these key zone characteristics, as La Vileta-Son Rapinya, Rafal-Son Forteza or Plaza de Toros neighbourhood, that can be situated close to the centre of the city, to a green/mountainous area, to a maritime one or between two or more of these differential zones. Then the areas of population of Establiments-Son Sardina-Son Dametó, Es Fortí-Son Cotoner, Rafal-Son Forteza, Sa Indioteria-Son Castelló and Son Ferriol-Sant Jordi complete the model.

Data from Gross disposable income per capita in the Municipality
and construction licenses monthly awarded in the territory and periods previously mentioned will be added to the model. This data was obtained from IBESTAT portal.

METHODOLOGICAL REVIEW

3.1. Panel data approach

Several studies performed Hedonic models to observe the air quality influence on the price of a determined good as the ones by Smith, V. K., & Huang, J. C. (1995) or Palmquist, R. B., & Israngkura, A. (1999), for example and explains a particular good, houses in this case, as a good with a bunch of specific attributes as surface, location, green areas, number of rooms, urbanisation security, infrastructures, externalities and so on. The study below tries to link up housing prices in a determined territory (Municipality of Palma in this case) with the air quality considering the aforementioned pollutants, from another perspective. All data from variables collected to construct the model will have variation throughout time, as the contaminant ones unlike variables like distance from the house to a green area for example, which does not vary, and will be collected in panel data form.

The econometric model of panel data includes a sample of populations with a price evolution during a determined period, combining temporary and structural data, the real estate price evolution in different neighbourhoods from 2013 to 2019.

The use of it is an extended practice in micro econometrics, allows to study questions that cannot be aborded with only a cross sectional or temporary series and permits to take into account unobservable effects, that can be correlated with other variables in the model.

Data distribution used to perform the model have the consequent form:

Table 1: Panel data distribution

Area	**Year**	Yt	$X1$	$X2$	...	Xn
A	1		X_{1A1}	X_{2A1}		X_{nA1}
A	2		X_{1A2}	X_{2A2}		X_{nA2}
	…		…	…		…
A	T		X_{1AT}	X_{2AT}		X_{nAT}
B	1		X_{1B1}	X_{2B1}		X_{nB1}
B	2		X_{1B2}	X_{2B2}		X_{nB2}
	…		…	…		…
B	T		X_{1BT}	X_{2BT}		X_{nBT}

3.2. Variables of the Model

Table 2: Explanation of Variables in the Model

Variable	Explanation
Dependent	
Price	Sale price of the house
Explanatory	
NO2	Annual average concentration in the air (µg/m3) from 2013 to 2019.
O3	Eight-hour values in the air (µg/m3) from 2013 to 2019.
PM10	Annual average concentration in therai (µg/m3) from 2013 to 2019.
Income	Annual gross disposable income per capita in eurosfrom 2013 to 2018.
Licenses	Monthly average construction licenses awarded per year in the municipality from 2013-2019.

Contaminant's data from GOIB qualifies air quality in four ratings: bad, regular, good, and excellent.

Each pollutant has its own critical value to place each value in a certain interval. In the case of NO2, this one goes from <13 as Excellent, between 14 and 27 as good, from 28 to 40 as fair and >40 as bad.

For O3, this goes from <40 as excellent, from 41 to 80 as good, from 81-120 as fair and >120 as bad.

Finally, for PM10, just as it happens with NO2, the intervals of qualification have the same values, <13 as Excellent, between 14 and 27 as good, from 28 to 40 as fair and >40 as bad.

Construction licenses variable is a result where Total=A+B-C, where:

A: New houses

B: Houses to be rehabilitated

C: Houses to demolish

3.3. Fixed Effects Model

A fixed effects model will be estimated to conduct this research. This will have variables with individual specific effects that could be correlated with the ones that appear in the model. A mean to control the bias produced by time-varying variables will be provided by this kind of framework. (Williams, R. 2015).

This kind of model suppose that differences between individuals are present in the constant term, so every α_i should be estimated.

Suppose the following linear model:

$$Y_{it} = \alpha_i + \beta \mathrm{X}_{\mathrm{it}} + u_i$$

Attributes as the ones mentioned above will be implicit in the model, and the influence of improvement or deterioration of air quality will play an important role in the study. The dependent variable of the model will be the real estate price evolution, and will be influenced by variables as contaminant ones, construction licensing and Gross disposable income of economic agents.

Dependent variable (Y_{it}) will have a linear dependence of the explanatory variables ($X1, X2, X3 \ldots Xn$)

Where the dependent variable Y_{it}, will be inflected by the explanatory variables mentioned above:

$$Y_{it}(NO2, O3, PM10, Income, Licenses)$$

Then, rewriting the equation with the variables of the model:

$$Y_{it} = \alpha_i + \beta_1 \cdot NO2_{it} + \beta_2 \cdot O3_{it} + \beta_3 \cdot PM10_{it} + \beta_4 \cdot Income_{it} + \beta 5 \cdot Licenses_{it} + u_i$$

$i = Area\ of\ study$
$t = Moment\ in\ time$
$Y = Dependent\ variable$
$\beta = Vector\ of\ k\ parameters$

3.4. Fixed effects problems

In one hand, Dummy variables can be added to explain qualitative values in the model. If N is enough large, standard errors would be very big, because of the number of parameters to estimate.

On the other hand, a transformation of the model would be a solution for this problem, in order to calculate a within estimator in the following way:

First calculating individual's temporary means in the following way: $X_{it} - \bar{X}_{\iota}$

Then, transforming variables into mean's deviation for each individual as:

$$(Y_{it} - \bar{Y}_i) = \sum_{k=1}^{N} \beta_k \cdot (X_{kit} - \bar{X}_{ki}) + u_{it} - \frac{\sum u_{it}}{T}$$

Where $\bar{X}_{ki} = \sum \frac{X\_kit}{T}$

Applying OLS to transformed model, consistent and efficient estimators are obtained (β).

Obtaining β, α_i are obtained as the within estimator:

$\hat{\alpha} = \bar{y}_i - \hat{\beta}\bar{X}_i$

(Sancho, A., & Serrano, G. (2005)

3.5. Random effects model

In addition, a random effects model will be estimated too, which is a special case of the fixed effects one, in order to conclude which kind of it fits better for this particular study. This kind of framework assumes that doesn't exists a correlation between the variables in the model and the individual specific effects in order to elucidate if this model is more efficient that a fixed effect one.

Now, α_i appears as a random variable, different for each individual, so that it would have the following form:

$\alpha_i = \alpha + \varepsilon_i \quad \varepsilon_i \sim N(0, \sigma_i^2)$

Then the previous model would look like:

$$Y_{it} = \alpha + \beta_1 X_{1it} + \varepsilon_i + u_{it}$$

With a perturbation term as: $w_{it} = \varepsilon_i + u_{it}$

The linear equation that fits the model would be:

$$Y_{it} = \alpha + \beta_1 \cdot NO2_{it} + \beta_2 \cdot O3_{it} + \beta_3 \cdot PM10_{it} + \beta_4 \cdot Income_{it} + \beta 5 \cdot Licenses_{it} + \varepsilon_i + u_{it}$$

(Sancho, A., & Serrano, G. (2005)

3.6. Hausman Test

Finally, a Hausman Test will be used to elucidate which kind of model mentioned above is closest to the objective of this investigation.

Null hypothesis states that there is no correlation between explanatory variables and individual effects, and under it, fixed effects model would be consistent, but the random effects one would be efficient and consistent.

This test is applied by the following mathematical expression:

$$H = \left(\hat{\beta}_{FE} + \hat{\beta}_{RE}\right)' \cdot \left[VAR\left(\hat{\beta}_{FE}\right) - VAR\left(\hat{\beta}_{RE}\right)\right]^{-1} \cdot \left(\hat{\beta}_{FE} + \hat{\beta}_{RE}\right) \qquad H \sim X^2_{k-1}$$

Where:

$VAR\left(\hat{\beta}_{FE}\right)$ & $VAR\left(\hat{\beta}_{RE}\right)$ $are\ variance\ and\ covariance\ matrix\ of\ FE\ and\ RE\ models.$

$\hat{\beta}_{FE}$ & $\hat{\beta}_{RE}$ $are\ vector\ of\ estimated\ coefficients\ of\ FE\ and\ RE\ models.$

Under the null hypothesis, the random effects model would be accepted, but if is rejected, fixed effects model will be accepted ($H > X^2_{k-1}$).

ECONOMETRIC ANALYSIS

4.1. Summary of Variables

Table 3: Variable’s Summary of the Model

Variable	Obs	Mean	Std. Dev.	Min	Max
price	98	2385.537	863.6663	1136.4	4990.9
no2	98	20.95918	10.93365	5	39
o3	98	106.7551	13.39569	79	128
pm10	86	21.04651	4.33293	13	28
income	84	14787.08	612.6619	14014.9	15662.3
license	98	475	381.7077	105	1175

First, differences are observed in the numbers of observations of two variables. In one hand, the variable *PM10* shows 86 observations instead of 98 like the other ones. This is due to an inactivity of monitoring in ‘’Parc Bit’’ control station from 2014. Then, data from that year to 2019 is missing in two neighbourhoods, Establiments-Son Sardina and Sa Indioteria-Son Castelló. In the other hand, *income* presents observation differences due to the missing of 2019 data in this variable. These two-little lacks of data doesn’t have a large impact in the model results.

Mean of price, the dependent variable, in 14 neighbourhoods, from 2013 to 2019 is 2385,537 €/m2, with a regular increase over the years, with a minimum value of 1136,4 and a high one in 4990,9.

The higher standard deviation of the model is shown by the price, with a value of 863,6663 €/m2 explained by the separation in the distribution of the data around the mean.

Other two variables show high standard deviation as *income* and *license. PM10* has the lower one in the model, because of the low deviation of the mean in the data recollected.

4.2. Fixed effects results

Table 4: Fixed effects model

```
Fixed-effects (within) regression               Number of obs     =         74
Group variable: neighborhood                    Number of groups  =         14

R-sq:                                           Obs per group:
     within  = 0.6696                                         min =          1
     between = 0.0001                                         avg =        5.3
     overall = 0.0351                                         max =          6

                                                F(5,55)           =      22.29
corr(u_i, Xb)  = -0.2417                        Prob > F          =     0.0000
```

price	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
no2	11.69225	26.1589	0.45	0.657	-40.73135	64.11585
o3	-1.089019	6.180495	-0.18	0.861	-13.47501	11.29697
pm10	9.806165	12.99435	0.75	0.454	-16.2351	35.84743
income	.0191483	.1023382	0.19	0.852	-.1859421	.2242387
license	1.114597	.231505	4.81	0.000	.650651	1.578544
_cons	1315.091	1947.614	0.68	0.502	-2588.014	5218.196
sigma_u	790.05877					
sigma_e	244.24263					
rho	.9127664	(fraction of variance due to u_i)				

Results of FE model reflects the affirmation of the hypothesis raised above.

Air quality does not have an important influence on housing prices in the municipality of Mallorca.

Contaminant variables does not have an important paper in price variation. NO2, O3 AND PM10 are non-significative variables having a p-value higher than 0,05 in this case.

The one that shows statistical significancy behaviour is the variable *license* with a p-value lower than 0,05.
In the results of the following model, and the final Hausman test it will be seen which model is more efficient and consistent, and which one gives more accurate results.

4.3. Random effects results

Table 5: Random Effects Model

```
Random-effects GLS regression                   Number of obs     =         74
Group variable: neighborhood                    Number of groups  =         14

R-sq:                                           Obs per group:
     within  = 0.6658                                         min =          1
     between = 0.0979                                         avg =        5.3
     overall = 0.1514                                         max =          6

                                                Wald chi2(5)      =     110.13
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000
```

price	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
no2	-5.292	15.39504	-0.34	0.731	-35.46573	24.88173
o3	-.374213	5.886416	-0.06	0.949	-11.91138	11.16295
pm10	8.694339	12.72893	0.68	0.495	-16.25391	33.64258
income	.0430652	.1009633	0.43	0.670	-.1548191	.2409496
license	1.029168	.2184832	4.71	0.000	.6009487	1.457387
_cons	1289.599	1850.789	0.70	0.486	-2337.882	4917.079
sigma_u	711.09671					
sigma_e	244.24263					
rho	.89447534	(fraction of variance due to u_i)				

Random effects model confirms what was previously observed, the non-influence of contaminants in the variation of real estate price evolution over the years.

In cities like Beijing, on May 6 of 2021 the pollutant PM10 reached levels of 128 µg / m³, while in Palma the levels were 17 µg / m³ .

This big difference between one of the most contaminated cities in terms of air quality with a hedonic relationship with housing prices and the municipality of Palma with historical good levels of pollution can be a reason of the non-influence of this variable in the real estate prices in this investigation.

Perception of regular low levels of air pollution and contamination in Mallorca plays an important role in this observation, creating an assumption by the economic agents of good air quality and not considering it as a variable at the moment of acquiring a house.

Monthly licenses granted in the municipality has a big influence in the price evolution at the moment it changes the stock of houses in the market, which in highly disturbed by these stock variations.

4.4. Hausman test

Table 6: Hausman Test

	Coefficients (b) name_consi~t	Coefficients (B) .	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
no2	11.69225	-5.292	16.98425	21.14901
o3	-1.089019	-.374213	-.7148057	1.883779
pm10	9.806165	8.694339	1.111825	2.61296
income	.0191483	.0430652	-.0239169	.0167193
license	1.114597	1.029168	.0854294	.0765482

```
                         b = consistent under Ho and Ha; obtained from xtreg
          B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        6.84
                Prob>chi2 =      0.2330
                (V_b-V_B is not positive definite)
```

Prob>chi2 in this case reflects a value of 0,2330, higher than 0,05.

Then, Ho would not be rejected and the model that has to be observed is the random effects one, that is more efficient and have lower standard errors.

CONCLUSIONS

Leaving the difficulty of easily quantifying contamination and the perception of air quality aside, this investigation looked for some kind of relationship between air pollution in Palma and housing price in the area, but knowing the real estate market characteristics, and knowing that air contamination in Mallorca is not even perceived as an environmental problem.

Balearic Islands, and in particular the municipality of Palma has different areas with a great appeal in terms of residential spaces. From coastal zones with houses separated of the sea only by a pair of meters as can be seen in Portitxol, to houses inside the centre of Palma, large urbanisations with great amenities in La Vileta or Sant Agustí or luxury residential areas as Son Vida.

The amount of characteristics to consider when choosing a home are endless. The area in square meters, number of rooms, colour of the house, green areas, if it is a first or a second floor, if it has elevator or not, presence of supermarkets, schools, shopping areas, forest, and so on close to a house are just a few of the many attributes considered by economic agents to consider a purchase.

It is clear that all these features have a clear and direct incidence in housing price, once again leaving macroeconomic environment, variation of main indicators or fluctuations in the economic cycle aside.

Low and controlled air pollution in the area of the Balearic Islands eliminates the perception of air quality as a variable, assuming these levels as inherent to the environment.

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