Supplementary file

The Uneven Price Impact of Energy Efficiency Ratings on Housing Segments. Implications for Public Policy and Private Markets

1. The aim of this document:

This document is aimed to implement the resulting marginal prices from the market-segmented hedonics models contained in the paper in the valuation of 3 subjects using the Comparison Approach. In doing so, the methodology suggested by De Ruggiero et al (2017) has been followed.

2. Methodology

The methodology for each of the identified segments (i.e. Cluster 1, 2 and 3) in the main body of the paper the following stages have been used:

1) First, departing from the semi-elasticities found the respective hedonic models the average marginal price, in Euro, per unit has been computed.

2) Second, a subject for each of the segments has been designed. In designing it, special care has been taken so as to approximate it to the typical features and location dominant in each of the segments.

3) Third, following the Spanish main legislation governing the Comparison Approach (OM Eco 805/2003) six comparable have been selected among the original dataset. As it has been in the main body, actual transaction prices are not public in Spain, for that reason the aforementioned legislation allows for the use of listing data in the valuation of real estate. Also, a new inquiry in present listing data has been discarded, since in the last two years the price of real estate has increased following the general recovery of the macroeconomic indicators. In selecting the comparable cases, close attention has been paid to the necessity to find cases as close as possible as the subject, especially to what is regarded to the locational attributes. This recommendation comes from what is usual in the practice and from the national legislation regulating valuations in Spain (e.g. RD 1020/1993 on cadastral valuation, RD 1492/2011 on urban valuation).

4) We have adjusted the price of each of the 6 comparables by each of the 3 segments following the procedure contained in De Ruggiero et al (2017), namely in section 5.3. In our case, due to the fact that marginal prices come from semi-elasticities it has been no necessary to calculate the coefficient r_j. In fact, if such a coefficient is used, in our case, the adjusted prices do gain dispersion (i.e. the variation coefficient increases).

5) Finally, for each of the 3 segments, the assessed value has been calculated as the arithmetic media.

3. Results

The following subsections contain the results for each of the segments.

3.1 Results for segment 1 (older dwellings in wealthy zones)

Table S1 Data Description for segment 1 (older dwellings in wealthy zones)

Asking Price and Real Estate Features	Comparable A	Comparable B	Comparable C	Comparable D
Asking price (euros)	295,000	355,000	330,000	300,000
Area (m2)	110	116	114	114
Air conditioner (dummy: Yes=1; No=0)	1	0	1	1
Area^2 (sq. m2)	12,100	13,456	12,996	12,996
Lift x floor level	1	4	3	3
A (dummy: Yes=1; No=0)	0	0	0	0
% people holding university degree	41.21	56.47	44.68	31.76
CP high socioeconomic level	0.75	0.65	0.54	0.51

Asking Price and Real Estate Features	Comparable E	Comparable F	Comparable G	Subject
Asking price (euros)	290,000	280,000	290,000	?
Area (m2)	108	106	115	110
Air conditioner (dummy: Yes=1; No=0)	0	1	0	1
Area^2 (sq. m2)	11,664	11,236	13,225	12,100
Lift x floor level	2	1	2	2
A (dummy: Yes=1; No=0)	0	0	0	1
% people holding university degree	46.00	40.16	38.80	42.00
CP high socioeconomic level	0.76	0.76	0.76	0.60

Source: Own elaboration

Table S2 Adjustment process for segment 1 (older dwellings in wealthy zones)

Asking Price and Real Estate Features	Comparable A	Comparable B	Comparable C	Comparable D
Asking price	295,000	355,000	330,000	300,000
Area	6,067.44 x (110-110)=0	6,067.44 4 x (110-116)= -36,404.63	6,067.44 x (110-114)= -24,269.76	6,067.44 x (110-114)= -24,269.76
Air conditioner	20,696.29 x (1-1)=0	20,696.29 x (1-0)=20,696.29	20,696.29 x (1-1)=0	20,696.29 x (1-1)=0
Area^2	-12.22 x (12,100-12,100)=0	-12.2 x (12,100-13,456)=16,575.33	-12.22 x (12,100-12,996)=10,952.43	-12.22 x (12,100-12,996)=10,952.43
Lift x floor level	5,218.06 x (2-1)=5,218.06	5,218.06 x (2-4)= -10,436.12	5,218.06 x (2-3)= -5,218.06	5,218.06x (2-3)= -5,218.06
A	42,031.54 x (1-0)=42,031.54	42,031.54 x (1-0)=42,031.54	42,031.54 x (1-0)=42,031.54	42,031.54 x (1-0)=42,031.54
% people holding university degree	3,124.66 x (42-41.21)=2,461.75	3,124.66 x (42-56.47)= -45,198.27	3,124.66 x (42-44.68)= -8,377.82	3,124.66 x (42-31.76)= 32,005.19
CP high socioeconomic level	-53,735.96 x (0.60-0.75)=8,109.75	-53,735.96 x (0.60-0.65)=2,626.50	-53,735.96 x (0.60-0.54)= -3,098.44	-53,735.96 x (0.60-0.51)= -4,775.39
Corrected Price	352,821	344,891	342,020	350,726

Asking Price and Real Estate Features	Comparable E	Comparable F	Comparable G
Asking price	290,000	280,000	290,000
Area	6,067.44 x (110-108)= 12,134.88	6,067.44 x (110-106)= 24,269.76	6,067.44 x (110-115)= -30,337.20
Air conditioner	20,696.29 x (1-0)=20,696.29	20,696.29 x (1-1)=0	20,696.29 x (1-0)=20,696.29
Area^2	-12.22 x (12,100-11,664)= -5,329.53	-12.22 x (12,100-11,236)= -10,516.27	-12.22 x (12,100-13,225)=13,751.66
Lift x floor level	5,218.06 x (2-2)= 0	5,218.06 x (2-1)= 5,218.06	5,218.06 x (2-2)= 0
A	42,031.54 x (1-0)=42,031.54	42,031.54 x (1-0)=42,031.54	42,031.54 x (1-0)=42,031.54
% people holding university degree	3,124.66 x (42-46)= -12,511.83	3,124.66 x (42-40.16)= 5,757.74	3,124.66 x (42-38.80)= 9,990.43
CP high socioeconomic level	-53,735.96 x (0.60-0.76)= 8,842.14	-53,735.96 x (0.60-0.76)= 8,842.14	-53,735.96 x (0.60-0.76)= 8,842.14
Corrected Price	355,863	355,558	354,975

Unadjusted average value (Euro)	305,714	Unadjusted standard deviation (Euro)	26,837
Adjusted media value (Euro)	350,979	Adjusted standard deviation (Euro)	5,501

Source: Own elaboration

3.2 Results for segment 2 (recent apartments in upper-middle class zones)

Table S3 Data Description for segment 2 (recent apartments in upper-middle class zones)

Asking Price and Real Estate Features	Comparable A	Comparable B	Comparable C	Comparable D
Asking price (euros)	170,000	165,000	165,000	165,000
Area (m2)	91	75	85	85
Air conditioner (dummy: Yes=1; No=0)	1	1	1	1
Number of bathrooms	2	1	2	2
Heating	1	1	1	1
Quality-retrofit indicator	0	0	1	0
Area^2	8,281	5,625	7,225	7,225
Construction year between 1982 and 2006	1	0	1	0
Construction year after 2007	0	1	0	0
Lift x floor level	0	3	2	1
Communal swimming pool	0	0	0	0
Floor/area ratio	1.44	1.68	0.91	1.27
% people holding university degree	12.42	21.66	9.69	18.70
CP high socioeconomic level	-0.84	-0.08	-1.18	-0.23

Asking Price and Real Estate Features	Comparable E	Comparable F	Comparable G	Subject
Asking price (euros)	160,000	162,000	160,000	?
Area (m2)	80	97	75	84
Air conditioner (dummy: Yes=1; No=0)	0	0	1	1
Number of bathrooms	2	2	1	1
Heating	1	1	1	1
Quality-retrofit indicator	0	0	1	1
Area^2	6,400	9,409	5,625	7056
Construction year between 1982 and 2006	1	1	0	1
Construction year after 2007	0	0	1	0
Lift x floor level	4	2	3	2
Communal swimming pool	1	0	0	1
Floor/area ratio	1.00	1.27	2.06	1.30
% people holding university degree	11.10	13.70	11.43	14.00
CP high socioeconomic level	-0.85	-0.90	-0.60	-0.60

Source: Own elaboration

Table S4 Adjustment process for segment 2 (recent apartments in upper-middle class zones)

Asking Price and Real Estate Features	Comparable A	Comparable B	Comparable C	Comparable D
Asking price	170,000	165,000	165,000	165,000
Area	3,145.69 x (84-91)=-22,019.83	3,145.69 x (84-75)=28,311.21	3,145.69 x (84-85)= -3,145.69	3,145.69 x (84-85)= -3,145.69
Air conditioner	23,127.61 x (1-1)=0	23,127.61 x (1-1)=0	23,127.61 x (1-1)=0	23,127.61 x (1-1)=0
Number of bathrooms	17,365.38 x (1-2)=-17,365.38	17,365.38 x (1-1)=0	17,365.38 x (1-2)= -17,365.38	17,365.38 x (1-2)= -17,365.38
Heating	14,224.97 x (1-1)=0	14,224.97 x (1-1)=0	14,224.97 x (1-1)=0	14,224.97 x (1-1)=0
Quality-retrofit indicator	9,417.14 x (1-0)=9,417.14	9,417.14 x (1-0)=9,417.14	9,417.14 x (1-1)=0	9,417.14 x (1-0)=9,417.14
Area^2	-8.65 x (7,056-8,281)=10,530.62	-8.65 x (7,056-5,625)=-12,371.57	-8.65 x (7,056-7,225)=1,461.07	-8.65 x (7,056-7,225)=1,461.07
Construction year between 1982 and 2006	16,021.06 x (1-1)=0	16,021.06 x (1-0)=16,021.06	16,021.06 x (1-1)=0	16,021.06 x (1-0)=16,021.06
Construction year after 2007	19,110.34 x (0-0)=0	19,110.34 x (0-1)= -19,110.34	19,110.34 x (0-0)=0	19,110.34 x (0-0)= 0
Lift x floor level	3,149.27 x (2-0))=6298.54	3,149.27 x (2-3)= -3,149.27	3,149.27 x (2-2)=0	3,149.27 x (2-1)=3,149.27
Communal swimming pool	24,758.56 x (1-0)=24,758.56	24,758.56 X (1-0)=24,758.56	24,758.56 x (1-0)=24,758.56	24,758.56 X (1-0)=24,758.56
Floor/area ratio	10,759.85 x (1.3-1.44)= -1,460.17	10,759.85 x (1.3-1.68)= -4,048.55	10,759.85 X (1.3-0.91)= 4,146.41	10,759.85 x (1.3-1.27)= 273.98
% people holding university degree	1,057.36 x (14-12.42)=1,672.75	1,057.36 x (14-21.66)=-8,096.45	1,057.36 x (14-9.69)=4,557.10	1,057.36 x (14-18.70)= -4,965.38
CP high socioeconomic level	14,588.97 X (-0.60-(-0.84))=3,545.25	14,588.97 X (-0.60-(-0.08))=7,634.29	14,588.97 X (-0.60-(-1.18))=8,494.95	14,588.97 X (-0.60-(-0.23))= -5385.81
Corrected Price	185,437	189,097	187,907	189,219

	Comparable E	Comparable F	Comparable G	
Asking price	160,000	162,000	160,000	
Area	3,145.69 x (84-80)= 12,582.76	3,145.69 x (84-97)= -40,893.96	3,145.69 x (84-75)= 28,311.21	
Air conditioner	23,127.61 x (1-0)=23,127.61	23,127.61 x (1-0)=23,127.61	23,127.61 x (1-1)=0	
Number of bathrooms	17,365.38 x (1-2)= -17,365.38	17,365.38 x (1-2)= -17,365.38	17,365.38 x (1-1)= 0	
Heating	14,224.97 x (1-1)=0	14,224.97 x (1-1)=0	14,224.97 x (1-1)=0	
Quality-retrofit indicator	9,417.14 x (1-0)=9,417.14	9,417.14 x (1-0)=9,417.14	9,417.14 x (1-1)=0	
Area^2	-8.65 x (7,056-6,400)=-5,671.39	-8.65 x (7,056-9,409)=20,342.64	-8.65 x (7,056-5,625)= -12.37157	
Construction year between 1982 and 2006	16,021.06 x (1-1)=0	16,021.06 x (1-1)=0	16,021.06 x (1-0)=16,021.06	
Construction year after 2007	19,110.34 x (0-0)= 0	19,110.34 x (0-0)= 0	19,110.34 x (0-1)= -19,110.34	
Lift x floor level	3,149.27 X (2-4)= -6,298.54	3,149.27 X (2-2)=0	3,149.27 X (2-3)= -3,149.27	
Communal swimming pool	24,758.56 x (1-1)=0	24,758.56 x (1-0)=24,758.56	24,758.56 x (1-0)=24,758.56	
Floor/area ratio	10,759.85 X (1.3-1.00)= 3,265.24	10,759.85 X (1.3-1.27)=282.79	10,759.85 X (1.3-2.06)= -8,146.90	
% people holding university degree	1,057.36 X (14-11.10)= 3,070.20	1,057.36 x (14-13.70)= 318.71	1,057.36 X (14-11.43)= 2,722.30	
CP high socioeconomic level	14,588.97 X (-0.60-(-0.85))= 3,580.85	14,588.97 X (-0.60-(-0.90))= 4,308.77	14,588.97 X (-0.60-(-0.60))=21.94	
Corrected Price	185,709	186,297	189,057	

Unadjusted average value (Euro)	163,857		Unadjusted standard deviation (Euro)	3,532
Adjusted media value (Euro)	187,532		Adjusted standard deviation (Euro)	1,683

Source: Own elaboration

3.3 Results for segment 3 (deficient apartments in working-class zones)

Table S5 Data Description for segment 3 (deficient apartments in working-class zones)

Asking Price and Real Estate Features	Comparable A	Comparable B	Comparable C	Comparable D
Asking price (euros)	165,000	110,000	95,000	120,000
Area (m2)	80	73	68	77
Area^2	6,400	5,329	4,624	5,929
Construction year between 1982 and 2006	0	0	0	0
Construction year after 2007	0	0	0	0
A	1	0	0	0
C	0	0	1	0
D	0	0	0	0
Floor/area ratio	0.58	0.98	1.48	1.49
Centrality indicator	11.18	11.14	9.94	12.13
CP high socioeconomic level	-0.24	-0.63	-0.59	-0.74
% buildings with doorman service	2.21	3.54	2.21	6.14

Asking Price and Real Estate Features	Comparable E	Comparable F	Comparable G	Subject
Asking price (euros)	125,000	95,000	100,000	?
Area (m2)	82	63	65	73
Area^2	6,724	3,969	4,225	5,329
Construction year between 1982 and 2006	0	0	0	0
Construction year after 2007	0	0	0	0
A	0	0	0	1
C	0	0	0	0
D	0	1	0	0
Floor/area ratio	1.57	1.60	1.71	1.30
Centrality indicator	10.40	12.81	9.54	11.00
CP high socioeconomic level	-0.22	-1.11	-0.23	-0.50
%buildings with doorman service	4.98	5.50	2.42	3.86

Source: Own elaboration

Table S6 Adjustment process for segment 3 (deficient apartments in working-class zones)

Asking Price and Real Estate Featu	Comparable A	Comparable B	Comparable C	Comparable D
Asking price	165,000	110,000	95,000	120,000
Area	3,271.45 x (73-80)= -22,900.15	3,271.45 x (73-73)=0	3,271.45 x (73-68)=16,357.25	3,271.45 x (73-77)= -13,085.80
Area^2	-8.75 x (5,329-6,400)=9,506.91	-8.75 x (5,329-5,329)=0	-8.75 x (5,329-4,624)= -6040.30	-8.75 x (5,329-5,929)=5,383.75
Construction year between 1982 and 2006	13,070.92 x (0-0)=0	13,070.92 x (0-0)=0	13,070.92 x (0-0)=0	13,070.92 x (0-0)=0
Construction year after 2007	40,001.60 x (0-0)=0	40,001.60 x (0-0)=0	40,001.60 x (0-0)=0	40,001.60 x (0-0)=0
A	50,562.20 x (1-1)=0	50,562.20 x (1-0)=50,652.20	50,562.20 x (1-0)=50,652.20	50,562.20 x (1-0)=50,652.20
C	-13,131.92 x (0-0)=0	-13131.92 x (0-0)=0	-13131.92 x (0-1)=13,131.92	-13131.92 x (0-0)=0
D	11,889.69 x (0-0)=0	11,889.69 x (0-0)=0	11,889.69 x (0-0)=0	11,889.69 x (0-0)=0
Floor/area ratio	3,556.57 x (1.3-0.58)=2,551.646	3,556.57 x (1.3-0.98)=1,147.35	3,556.57 x (1.3-1.38)=-651.67	3,556.57 x (1.3-1.49)= -664.29
Centrality indicator	1,118.75 x (11-11.18)= -203.23	1,118.75 x (11-11.14)= -152.70	1,118.75 x (11-9.94)= 1,190.29	1,118.75 x (11-12.13)= -1,259.97
CP high socioeconomic level	15,487.24 x (-0.5-(-0.24))=-3,963.78	15,487.24 x (-0.5-(-0.63))=1,997.83	15,487.24 x (-0.5-(-0.59))=1,334.23	15,487.24 x (-0.5-(-0.74))=3,663.13
%buildings with doorman service	1,599.05 x (3.86-2.21)=2,638.68	1,599.05 x (3.86-3.54)=517.69	1,599.05 x (3.86-2.21)=2,644.47	1,599.05 x (3.86-6.14)= -3,643.10
Corrected Price	152,630	164,294	173,618	161,046

	Comparable E	Comparable F	Comparable G
Asking price	125,000	95,000	100,000
Area	3,271.45 x (73-82)= -29,443.05	3,271.45 x (73-63)= 32,714.50	3,271.45 x (73-65)= 26,171.60
Area^2	-8.75 x (5,329-6,724)=12,343.22	-8.75 x (5,329-3,969)= -11,774.21	-8.75 x (5,329-4,225)= -9,533.17
Construction year between 1982 and 2006	13,070.92 x (0-0)=0	13,070.92 x (0-0)=0	13,070.92 x (0-0)=0
Construction year after 2007	40,001.60 x (0-0)=0	40,001.60 x (0-0)=0	40,001.60 x (0-0)=0
A	50,562.20 x (1-0)=50,652.20	50,562.20 x (1-0)=50,652.20	50,562.20 x (1-0)=50,652.20
C	-13131.92 x (0-0)=0	-13131.92 x (0-0)=0	-13131.92 x (0-0)=0
D	11,889.69 x (0-0)=0	11,889.69 x (0-1)= -11,889.69	11,889.69 x (0-0)=0
Floor/area ratio	3,556.57 x (1.3-1.57)= -961.61	3,556.57 x (1.3-1.60)= -1,052.76	3,556.57 x (1.3-1.71)= -1,455.95
Centrality indicator	1,118.75 x (11-10.40)= 6667.38	1,118.75 x (11-12.81)= -2,022.76	1,118.75 x (11-9.54)= 1,628.98
CP high socioeconomic level	15,487.24 x (-0.5-(-0.22))= -4,277.72	15,487.24 x (-0.5-(-1.11))= 9,390.59	15,487.24 x (-0.5-(-0.23))= -4,207.91
%buildings with doorman service	1,599.05 x (3.86-4.98)= -1,796.77	1,599.05 x (3.86-5.50)= -2,630.34	1,599.05 x (3.86-2.42)=2,301.41
Corrected Price	152,184	158,388	165,557

Unadjusted average value (Euro)	115,714		**Unadjusted standard deviation (Euro)**	24,737
Adjusted media value (Euro)	161,102		**Adjusted standard deviation (Euro)**	7,587

Source: Own elaboration

Conclusions

As it is detailed in the tables containing the adjustment of prices, in all the 3 housing segments the adjusted value is closer to its average in relation to the unadjusted prices, so the dispersion of the adjusted prices regarding its average value is reduced (*i.e.* standard deviation). So, the adjustment process not only adjusts the original values in order to produce an equivalent price for each of the comparable cases if its relevant features were going to be the same that those of the subject, but also this process renders a more homogeneous price distribution. As a result, the average value calculated departing from the adjusted prices does gain representativeness of its distribution. So, despite that the aim of the paper does not build on real estate valuation, this supplementary file helps to portray the usefulness of the hedonic prices on the adjustment process of the comparison approach.